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Toward Enhancing Ecological Validity Of Cognitive-Linguistic Assessment: The Role Of Individual Differences In Cognitive Capacity On Oral Discourse Processing

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TOWARD ENHANCING ECOLOGICAL VALIDITY OF COGNITIVE-LINGUISTIC ASSESSMENT: THE ROLE OF INDIVIDUAL DIFFERENCES IN COGNITIVE CAPACITY ON ORAL DISCOURSE PROCESSING

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

We live in a world steeped in the eclectic phenomenon of human language—taking various forms, serving many purposes, and operating at multiple levels. Few things pervade behaviors, perceptions, and socio-cultural experiences with the global salience embodied by human discourse customs. Essentially, discourse is the *beating heart* of everyday human performance; without it, we could not viably develop the factual and subjective meanings we assign to our lives. Yet this ability is often taken for granted until overt deficiencies in linguistic behaviors arise. Thus, the depth, scope, and variety of inter-and intra-individual differences in language performance form an important line of study.

Various disciplines have explored the synergistic cognitive, psychosocial, and ecologic functions that shape language behaviors; theory and evidence assert mutually harmonious and antagonistic views. This is unsurprising given the complex nature underlying each function. Linguistic information can involve a hybrid of structural units, meanings, and complexities. Formal definitions of discourse are ambiguous—ranging from functional "speech acts" (Searle, 1969), to strings of sentences that create a narrative (Kolb & Whishaw, 2009), to complex communication that is socially relevant (Cannizzaro & Coelho, 2013), and may present in written, spoken (Gee, 2014) or signed form (Liddell & Metzger, 1998). Efficient discourse processing extends beyond basic lexical or syntactic knowledge, and necessitates higher-order cognitive processes (Baddeley, 2003; Engle & Kane, 2003; Just & Carpenter, 1992; Sparks & Rapp, 2010). Any assessment of discourse should emphasize the *thinking mind*, a prolific structure that enables us to cope with variable demands by effectively allocating cognitive resources. The real-time integration of working memory, attention, and metacognitive resources, better known as executive functioning, is actively employed while processing everyday tasks (Baddeley, 2003; Cicerone, Levin, Malec, Stuss, & Whyte, 2006; Engle & Kane, 2003; Just & Carpenter, 1992; Keil & Kaszniak, 2002; Sparks & Rapp, 2010; Vas, 2015).

The overarching goal of this research was to enhance ecologically valid methods of cognitive-linguistic assessment by exploring individual differences in cognitive capacity and the corresponding effect on discourse performance under increased processing demands. In pursuit of this goal, we examined age-related performance variations in three parts as follows: 1) the effect of cognitive load on age-related performance during dual task processing; 2) the relationship between cognitive capacity and oral discourse processing under varying load in younger and older adults; and 3) the nature of limits in cognitive capacity influencing oral discourse processing under varying load. To set the theoretical stage, we will review salient characteristics of cognitive-linguistic processing, brain-behavior relationships, and age-related performance variability. Then, theoretical models of cognitive processing capacity and dual-task performance costs will be presented. Finally, naturalistic discourse processing and implications for cognitive-linguistic neurorehabilitation will be discussed in terms of ecologically valid assessment as evidence supporting the rationale for this research.

CHAPTER 2 REVIEW OF THE LITERATURE

Cognitive-Linguistic Processing

In its simplest sense, communication describes any means by which individuals share facts and ideas—whether receptive or expressive, in gestural, written, or spoken form. Accordingly, language can be described as a catalyst of functional communication. Effective language comprehension and expression involves a constellation of linguistic and cognitive systems. Linguistically, human communication encompasses the structures, functions, and rules that govern a given language: that is, form (phonology, morphology, and syntax), content (lexical semantics or meaning) and use (pragmatics and psychosocial functions). Cognitively speaking, the system responsible for processing linguistic information comprises flexible neural networks and executive functions including attentional control, working memory, and metacognitive resources (Engle & Kane, 2003; Kane, Bleckley, Conway, & Engle, 2001; Unsworth & Engle, 2007). The coordination of these systems is at the crux of our ability to acquire, retrieve, and apply new or previously learned information, and shapes behavioral performance across the life-span.

How humans actually process linguistic information is still a puzzling matter. Studies investigating both the neural and social bases of language performance have received considerable attention in multidisciplinary research. Key factors shown to influence behavioral performance involve latent constructs of cognitive capacity and active executive function resource allocation (Brunken, Plass, & Leutner, 2003; Gevins & Smith, 2000; Humphreys & Revelle, 1984; Logan & Cowan, 1984; Sweller, 1994; Unsworth & Engle, 2007; Wickens, 2008). Despite remarkable developments spanning cognitive neuroscience, psychology, learning, and language specialties, the extant literature offers mixed interpretations of terminology and methodology that contribute to gaps between theory and application (Coelho, Ylvisaker, & Turkstra, 2005;

Constantinidou, Wertheimer, Tsanadis, Evans, & Paul, 2012; Salthouse, Atkinson, & Berish, 2003). This is unsurprising given the breadth of experimental designs as well as the variability of subjects who participate in them. For the purpose of this dissertation, cognitive capacity refers the total amount of information an individual's brain can retain and manipulate at any particular moment - this includes the allocation of shared executive function resources (Engle & Kane, 2003; Kane et al., 2001; Unsworth & Engle, 2007); furthermore, cognitive load refers to the amount of cognitive resources or mental effort associated with processing task stimuli (Hart & Wickens, 1990; Lavie, 2005; Leahy & Sweller, 2011; Paas, Tuovinen, Tabbers, & Van Gerven, 2003; Sweller, 1994). Before delving into particular models of cognitive processing capacity, an overview of core concepts in brain-behavior relationships and executive functioning resources is provided. This background should serve as a prelude to age-related changes in the complex constructs of interest.

Executive Functioning and Brain-Behavior Relationships

Executive functioning is broadly described as a system representing interrelated cognitive mechanisms that regulate the human capacity to acquire, organize, retrieve and synthesize goal-directed information. Because the construct is multifaceted, established definitions and related concepts are imprecise. For the purpose of this research, the integration of executive functions is synonymous to cognitive control processes, which enable the successful completion of cognitively demanding tasks such as linguistic processing (Baddeley, 2003; Cicerone et al., 2006; Engle & Kane, 2003; Just & Carpenter, 1992; Keil & Kaszniak, 2002; Sparks & Rapp, 2010; Vas, 2015). Core mechanisms involve 1) WM (ability to encode, manipulate, and retrieve stored information; 2) attention (ability to focus, inhibit, and shift mental sets); and 3) metacognition (ability to self-regulate and adapt behaviors). Of course, separating anatomical structure-function relationships is complicated. Although behavioral and neuroscientific literature holds remarkable knowledge of the executive functioning system, current endeavors to tease apart the complexities of human cognitive architecture still generate debate (Alexander & Stuss, 2006; Duncan & Owen, 2000; Gevins & Smith, 2000; Salthouse, Siedlecki, & Krueger, 2006; Stuss & Alexander, 2000).

Contemporary understanding of brain-behavior interactions is largely based on lesion-deficit characteristics. In fact, such relations span over a century of study-- launched by the notorious history of Phineas Gage, who survived a metal rod driven through his skull, and left frontal lobe, thus becoming the 'poster child' for relatively preserved linguistic skills with dreadful psychosocial functions. Frontal lobe regulation of goal-directed linguistic behaviors has stood the test of time. Thanks to the complicated synergy between individual differences in cognitive capacity, load, and functional performance, there is less agreement relative to the specificity of frontal region recruitment as well as the interconnectivity to subcortical structures (Duncan & Owen, 2000; Goldman-Rakic, Cools, & Srivastava, 1996; Kane & Engle, 2002; Knight & Stuss, 2002; Shallice, Stuss, Picton, Alexander, & Gillingham, 2008; Stuss & Alexander, 2000). Such disputes have also stymied the widely-held concept of hemispheric lateralization.

Functional specialization of dynamic brain structures and networks is often described in terms of either "left brain" or "right brain" dominant behavioral patterns. Fundamentally, language-specific and logical reasoning skills are localized to the left hemisphere (LH), while more global visuospatial and pragmatic functions are localized to the right hemisphere (RH); though underlying factors including sex, handedness, aging, and brain injury are established sources of variability in both linguistic and non-linguistic task performance (Alexander & Stuss, 2006; Ashendorf, Vanderslice-Barr, & McCaffrey, 2009; Cabeza, Anderson, Locantore, & McIntosh, 2002; Shallice et al., 2008). Kinsbourne (1982) argues that hemispheric organization allows parallel but complementary processing, which can work in-tandem to simultaneously complete cognitive tasks of different types and complexity. He highlighted the contribution of environmental demands and adaptive responses to real-life experiences as an alternative for individual differences and performance variations.

Characteristics of Age-Related Changes

Cognitive-linguistic performance deficits that typically accompany healthy aging indicate frontal lobe and executive function degeneration advances with age (Amieva, Phillips, & Della Sala, 2003; Craik, 2006; Fristoe, Salthouse, & Woodard, 1997; Salthouse et al., 2003; Zacks, 1989). Possibly the most familiar characteristics of age-related changes, deteriorating memory interferes with the encoding, manipulation, and retrieval of linguistic information. These processing abilities are believed to hinge on functional and structural brain plasticity. Precise mechanisms and interactions subserving neuroplasticity are largely unknown; however, age-related depletion of dopamine and reduced neural connectivity in prefrontal cortical structures are recognized contributing factors (Braver et al., 2001; Craik, 2006; Rush, Barch, & Braver, 2006). Despite ever-growing inquiries of theories on cognitive aging and behavioral characteristics, uncertainties involving the synchronization of neural structures, cognitive mechanisms and resulting performance persist.

Recent evidence of neuroplastic changes substantiates experience-and activity-dependent organization during tasks germane to memory and metacognitive control (Cabeza et al., 2002; Craik, 2006; Jung-Beeman, 2005; May, 2011). Changes in brain structure and function, once thought to occur during childhood development alone, have been confirmed by a number of gerontological studies. The model introduced by Cabeza and colleagues (1997), hemispheric asymmetry reduction in older adults (HAROLD), has received considerable support. The

HAROLD model proposes age-related shifts in lateralized brain activity; cognitive-linguistic tasks typically localized to the dominant hemisphere shift to a more bilateral activation patterns in the performance of older adults. Interpretations of HAROLD have suggested that an increase in RH recruitment may reflect a loss of specialized LH function or that its activation compensates for age-related deterioration in cognitive function (Cabeza et al., 2002; Cabeza et al., 1997; Logan, Sanders, Snyder, Morris, & Buckner, 2002; Reuter-Lorenz et al., 2000). Using positron emission tomography (PET), Cabeza and colleagues (2002) investigated aging effects of frontal lobe activation during performance of two memory tasks with different linguistic processing demands: recall, which is less demanding and typically LH localized- and context (source) memory, a more demanding task that is typically more lateralized to the RH. The activation patterns younger adults (aged 20-35) older high-performing and older low-performing adults (aged 63-78) were examined. Outcomes revealed similar RH bias during source memory tasks in both young and low-performing older adults. In contrast, high-performing older adults exhibited greater bilateral activity. These results revealed two significant findings. First, similar activation patterns in low-performing older adults and young adults indicated less efficient RH engagement, but did not reflect a general loss of hemispheric specialization (i.e., hemispheric asymmetry reduction) due to aging. Second, the neuroplastic changes observed in high-performing adults (i.e., bilateral activation), mirrored effective compensatory recruitment of LH to offset age-related performance declines in demanding tasks.

In a preliminary study of changes associated with normal aging and features of executive functioning, Amieva and colleagues (2003) investigated symptomatic behaviors experienced in daily life. Healthy participants aged 66-74 completed a battery of neuropsychological tests measuring executive functions, which included verbal memory, inhibition, selective, alternating, and divided attention, task and self-monitoring. Performance accuracy and reaction time were compared to the self-reported Dysexecutive Questionnaire (DEX) (Burgess, Alderman, Evans, Emslie, & Wilson, 1998). The DEX is a 20-item survey rating the occurrence of executive functioning deficits in typical daily life situations. Principal Component Analysis (PCA) revealed five factors of executive dysfunction accounting for 75.9% of the total variance associated with normal aging: intentionality, interference management, inhibition, planning, and social regulation. None of the neuropsychological tests correlated with the planning component. A significant correlation between the inhibition factor and test performance were consistent with previous research. The authors proposed that significant correlations between verbal memory performance and intentionality and interference management factors might indicate strategy allocation and regulation of distractions during memory tasks. They also suggested a relationship between processing speed and social regulation consequent to timed tasks significantly correlating with the component.

Indeed, older adults frequently exhibit performance changes across several executive functions and cognitive control domains. Age-related differences may present as specific or joint deficits in, for example, working memory and attentional control, (Babcock & Salthouse, 1990; Fristoe et al., 1997; Salthouse, Fristoe, Lineweaver, & Coon, 1995), or behavioral regulation and speed of processing (Rush et al., 2006; Salthouse, 1996b). Moreover, the processing speed theory of cognitive aging (Salthouse, 1996b) offers empirical evidence that a primary reduction in processing speed is responsible for observations of the aforementioned performance decrements, and that such observations are further mediated by a wide variety of cognitive variables, including factors related to simple and complex processing demands (Babcock & Salthouse, 1990; Fristoe et al., 1997; Rush et al., 2006; Salthouse, 1996a; Salthouse et al., 2006).

The preceding glimpse into concepts relating language and cognition barely scratches the surface of human cognitive-linguistic processing abilities and limitations; to assume that all variants could be accounted for would be undeniably naïve. Existing knowledge of interactions between cognitive resources, environmental demands, and behavioral performance has prompted overlapping models of cognitive processing capacity. While recognizing conceptual distinctions between specified views of processing capacity, functional parallels contributing to unique behavioral performance are also illustrated. The following theoretical frameworks are presented in support of the current study's paradigm for exploring individual differences in cognitive capacity and everyday discourse processing performance.

Models of Cognitive Processing Capacity

Explanations for cognitive processing capacity have long linked limited yet flexible executive functioning resources to variations in performance. However, methodologies interpreting the roles of WM, attentional control, and metacognitive factors remain topics of debate. General descriptive mechanisms approximate processing capacity via dual-task performance measures, which denote the supply of cognitive resources under increased cognitive load. Simultaneously completing two or more tasks obviously increases load, thus depleting available WM and attentional resources. The seminal models of WM (Baddeley & Hitch, 1974) and attentional control (Kahneman, 1973) illustrate distinct but related concepts of processing capacity that underlie existing frameworks for variability in multiple-task performance. Consistent with Baddeley's model of WM (Baddeley, 2000; Baddeley & Wilson, 1988; Baddeley & Hitch, 1974), information processing and storage is regulated by the multi-component "central executive system", which acts as a control center, and consists of subordinate domain-specific systems. Broadly, these components interact to inhibit, sequence, shift, manipulate, and assimilate information into the bigger picture or overall gist. Performance costs of limited-capacity WM resources are influenced by the cognitive load associated with modality of and interference between multiple task stimuli, as well as motivation, experience, and mental effort (Cocchini, Logie, Della Sala, MacPherson, & Baddeley, 2002). In the theory asserted by Kahneman (1973), attentional control, which is analogous to mental effort, dictates efficient information processing. An undifferentiated central "pool" allocates available resources. When tasks compete for a limited shared resource or the cognitive load requires more mental effort to process, performance declines. By extension, attention is considered the single undifferentiated resource responsible for limitations in WM processes influencing linguistic or non-linguistic task performance (Kahneman, 1973; Norman & Shallice, 1986).

Specific models of limited capacity processing expand on functional divergence in behavior by accounting for intrinsic and extrinsic qualities that contribute to performance costs. The underlying philosophies of such rival frameworks are comparable—incongruous descriptive terminology and methodologies aside. Resource allocation theory and cognitive load theory are two prominent models of cognitive processing capacity contrasted herein. The availability of cognitive resources, task demands, and related interactive effects on processing abilities and behavioral performance are emphasized.

Resource Allocation Theory. In accordance with a bottleneck theory of attention, first proposed by Broadbent in 1958, resource allocation theory (RAT) corresponds with Kahneman's (1973) model of attention and effort, and which suggests a domain-general, amodal source of attention that is shared between one or more tasks (Kahneman, 1973). RAT asserts that performance constraints in concurrent tasks result from inadequate or inefficient distribution of amodal attentional resources. Three stages of task processing include: 1) a *precentral stage* involving stimulus perception and encoding; 2) a *central stage* affecting response selection; and 3) a *postcentral stage* concerning response initiation and completion (Hula & McNeil, 2008; Kahneman, 1973; McNeil et al., 2004). Because the central stage can only process one task at a time, cognitive processing capacity is dependent on the task to which attentional resources are allocated. Thus, when two tasks overlap, the sharing of limited resources can result in longer response latencies and greater performance deficits (Hula & McNeil, 2008; McNeil et al., 2004; Murray, Holland, & Beeson, 1997; Norman & Shallice, 1986; Wickens, 1991).

Resource allocation to a specific task is not directly biased by cognitive, perceptual, or motor conditions, but is contingent upon interdependent factors including load/task demands, motivation, experience, and mental effort. Moreover, allocation of attention is influenced by under- or over-arousal, enduring dispositions (automatic processing), momentary intentions (conscious processing), and judgment of task demands (Kahneman, 1973; Norman & Shallice, 1986). A model of limited capacity processing aligned with attentional resource allocation is shown in figure 1 (illustration from Kahneman, 1973). Many researchers have examined the theoretical and functional importance of cognitive load on performance within the context of RAT. For example, McNeil et al. (2004) described two advantages of investigating resource allocation using a dual-task paradigm: 1) to measure the expended mental effort resulting from the combination of performing a task under specific environmental conditions; and 2) the ability to respond to such workload demands (Hart & Wickens, 1990; Hula & McNeil, 2008; McNeil, Matthews, Hula, Doyle, & Fossett, 2006; Murray et al., 1997). Thus, the more concurrent task demands compete for shared attentional resources, the greater the performance decrements in one or both tasks.

Cognitive Load Theory. Cognitive load theory (CLT) offers an alternate processing model to RAT. In contrast to the RAT, dual-task performance varies by the cognitive architecture of a multi-sourced central executive system, with interrelated yet separate components for visual and auditory information (Paas, Renkl, & Sweller, 2004; Van Merrienboer & Sweller, 2005; Wickens, 2008). CLT describes processing capacity in terms of available WM resources, as posited by Baddeley & Hitch (1974), rather than shared attentional resources. CLT is commonly used to investigate methods that reduce load or task demands and facilitate knowledge acquisition and functional problem solving. Within CLT, mechanisms of schema acquisition and habituation, which are vital to efficient information processing and performance, are dependent upon the associated cognitive load. Three types of cognitive load are highlighted: intrinsic- load imposed by actual task content/context; extraneous- load imposed by ineffective, unrelated, or distracting stimuli; and germane- load devoted to processing information, creating and internalizing schemas (Paas & Van Merriënboer, 1994; Sweller, 1994). An additional contrast to the allocation of attention, available WM resources can be differentially affected by modality, specifically if the dual-task condition adds to the extraneous load. Recent valuations of CLT have shown significant interactive effects on load: "causal" elements such as task format, complexity, environment, and learner characteristics; and "assessment" factors such as the mental effort allotted to accurately complete the demands of a given task and consequent performance accuracy (Choi, Van Merriënboer, & Paas, 2014; Kirschner, 2002; Leahy & Sweller, 2011; Paas et al., 2003; Van Merriënboer, Kester, & Paas, 2006; Van Merrienboer & Sweller, 2005). Figure 2 (from Kirschner, 2002) depicts factors influencing WM resources and limited capacity processing resources according to CLT. Representative schematics CLT (from (Kirschner, 2002) is shown in figure 2.

Cognitive Load and Performance Variability

A vast range of latent variates including experience, cognitive style, and metacognitive strategies contribute to capacity limits and individual differences in performance (Engle & Kane, 2003; Humphreys & Revelle, 1984; Kozhevnikov, 2007; Kraemer, Hamilton, Messing, DeSantis, & Thompson-Schill, 2014). The cognitive load imposed by dual-task measures has demonstrated deleterious effects on sensorimotor tasks, executive functioning, and linguistic processing. Increasing the cognitive load (e.g., via multitasking or competition of intrusive stimuli) requires more mental effort to process and may compromise self-regulation, judgement, and adaptive behaviors (Hofmann, Schmeichel, & Baddeley, 2012; Lavie, 2005; Logan & Cowan, 1984; Pashler, 1994; Wickens, 2008). Additionally, one's perception and/or expression of these attributes fluctuates under varying environmental conditions.

As discussed with regard to HAROLD, literature on life-span development indicates frontal lobe and executive function degeneration with advancing age (Amieva et al., 2003; Cannizzaro & Coelho, 2013; Craik, 2006; Salthouse et al., 2003; Zacks, 1989). Processing capacity is constrained by the associated increase in mental effort and can be exacerbated by external competition from added sensory, perceptual, or kinesthetic stimuli. Lindenberger, Marsiske, and Baltes (2000) examined concurrent sensorimotor and cognitive dual-task costs (DTCs) among three age groups- young, middle-aged, and older adults. Due to typical age-related declines in both memory and motoric function, they suggested that older adults needed to recruit additional cognitive resources and exert more effort to successfully perform tasks; thus, greater DTC would result from an increase in demands. Findings confirmed a negative correlation between aging and performance on an episodic memory task and a tricky 'balance-beam' style-walking task. Experimental analyses showed greater DTCs- in both speed and accuracy of concurrent tasks- with increasing age. While the authors acknowledged drawbacks regarding chosen tasks and methodologies, these results were consistent with previous research on the effect of aging on sensorimotor and cognitive performance. If a surge in environmental demands exceeds an already engaged cognitive system, performance decrements proliferate.

Capacity Limits and Linguistic Behaviors. Processing linguistic stimuli involves the dynamic interplay of factors beyond understanding the meaning of words. Capacity limits manifested by linguistic behaviors encompass deficits in WM, attention, and metacognitive skills. Apparent symptoms can reflect linguistic-specific comprehension and expression impairments, cognitive processing deficits, or concomitant weaknesses (Angeleri et al., 2008; Carlomagno, Giannotti, Vorano, & Marini, 2011; Hula & McNeil, 2008; Just & Carpenter, 1992; Keidser, Best, Freeston, & Boyce, 2015; Keil & Kaszniak, 2002; Kimelman, 1999; Murray et al., 1997; Vas, 2015). Disentangling the complex relations concerning observed performance, executive function domains, and linguistic conditions is a thorny matter. In any case, overall cognitive-linguistic performance is characterized by longer response latency and increased errors-- in both type and frequency of occurrence

To illustrate, an individual with poor naming abilities may struggle to retrieve stored information from semantic memory or encode novel information. Responses that are irrelevant or tangential may suggest poor inhibition associated with reduced attentional control and mental effort. Inadequate metacognitive skills may present as lacking awareness, inflexibility, inappropriate or absent behavior modification. The array of pathologies, preexisting variations, linguistic tasks, and environmental load conditions is even more staggering when considering the multiple combinations possible. Detecting the precise nature of cognitive-linguistic breakdown is confounding. A mystery akin to “which came first, the chicken or the egg?” prevails.

Specialized lines of research often approach cognitive-linguistic processing from bottom-up or top-down paradigms (Cosentino, Adornetti, & Ferretti, 2013; Crossley, Allen, Kyle, & McNamara, 2014). The bottom-up approach contends that stimuli is processed gradually and systematically, building upward from the smallest linguistic units to develop a complete concept (Gibson, 1960). For example, when a stimulus is presented, phonemes are first perceived, combined to create words, words are combined to form sentences, and finally attached to meaning. Bottom-up processing relies on stimulus to drive the flow of information, which is dependent upon the accessibility of explicit facts offered and discounts the impact of contextual elements. In contrast, a top-down approach can be described as a more spontaneous means of processing driven by conceptual or abstract knowledge (Gregory, 1970; Reyna & Brainerd, 1995). Top-down processing has been described as a strategic, goal-driven approach in which context cues allow interpretation of ‘the bigger picture’ rather than a piecemeal development of meaning (Chapman & Mudar, 2014; Vas, Chapman, & Cook, 2015). Clearly, bottom-up and top-down processes are mutually important to efficient linguistic performance. However, a review of recent literature found a tendency toward bottom-up analyses of linguistic behaviors. This evidence is largely focused on decontextualized tasks and disorders of language development and acquired neurogenic impairments of acute or more apparent severity (Bayliss, Jarrold, Gunn, & Baddeley, 2003; Cocchini et al., 2002; Fougnie & Marois, 2006; Kintsch, 2005; Martin, Kohen, Kalinyak-Fliszar, Soveri, & Laine, 2012; Raymer, 2001). While it is acknowledged that modality-specific, stimulus-driven language processing has significant multidisciplinary value, the basic assumption of a unidirectional flow of information poses certain disadvantages.

Various accounts of linguistic processing and underlying cognitive mechanisms have emerged from specific language disorders such as aphasia (Caramazza et al., 2005; Hillis, 2001;

Murray & Chapey, 2001). Evidence based on such performance is constrained by stimulus type and level of processing. For example, processing single words, objects, and actions subsumes a modular framework of modality-specific representations, which is divided into functionally distinct units for phonological and semantic memory (Caramazza & Hillis; 1990; Raymer & Rothi, 2001). The analysis of aphasic language within the described cognitive-linguistic processing models has demonstrated exceptional knowledge of moderate to severe communication disorders. However, it also leaves a sizeable gap through which individuals with mild deficits may fall—specifically in relation to higher-order cognitive processes and practical application to discourse behaviors.

Research from the life-span development, neuroscience, and communication sciences and disorders fields point to the importance of broadening allied studies of higher-order cognitive processes and more complex linguistic performance(Alexander & Stuss, 2006; Constantinidou et al., 2012; Cosentino et al., 2013). Thus, advancing our knowledge of functional discourse processing is an area of interest. The current study was motivated, in part, by limited evidence regarding naturalistic discourse and the impact of individual variability in cognitive processes on real-world functioning(Coelho, Liles, & Duffy, 1991; Cosentino et al., 2013; Crossley et al., 2014). Indeed, myriad cognitive, physical, and social factors that may trigger real-world performance costs are conceivable. Characteristics relevant to individual variation in discourse processing and everyday behaviors is considered below.

Naturalistic Discourse Processing. The ability to communicate through discourse is a uniquely human trait that distinguishes us from other members of the animal kingdom. We derive factual and subjective meaning for life through communication across cultural, social, and educational contexts. Ultimately, discourse customs are central to forming meaningful connections, developing awareness, and navigating interactions that might resemble a sort of 'linguistics in practice'. Nearly all forms of discourse involve nuanced aspects of narrative macrostructure—proper content, sequencing and relating main ideas to specific details. Communiqués are typically reorganized and exchanged with others via storytelling or narrative discourse (Hagstrom & Wertsch, 2004; Shadden, Hagstrom, & Koski, 2008). Recounts of individual anecdotes encompass diverse manners of representation, perception, emotion, and reasoning (Adolphs, 2003; Anand et al., 2011; Cannizzaro & Coelho, 2013; Chapman, Levin, Matejka, Harward, & Kufera, 1995; Juncos-Rabadán, Pereiro, & Rodríguez, 2005; Sparks & Rapp, 2010; Vas, 2015). As such, discourse processing is a complex concept that is difficult to quantify.

Discourse studies incorporate numerous cognitive and linguistic views and apply to perspectives of both typical and disordered behaviors across the life-span. This creates an intriguing yet equally complicated topic of study, which lies, in part, in the level of description adopted. En masse, top-down processing justifies the extent to which particular cognitive and ancillary contexts affect complex linguistic performance in real-life. Likewise, this investigation adopts a top-down perspective to estimate age-related changes in oral discourse processing and corollaries on social engagement and quality of life.

Herein, we also suggest that efficient discourse processing is governed by the capacity to abstract meaning from a variety of contexts and environments. Abstracting meaning or extracting the gist of a message actively uses one's prior experience to interpret novel or ambiguous information rather than habitually decoding, encoding, and updating concrete details (Anand et al., 2011; Brainerd & Reyna, 2002; Chapman & Mudar, 2014; Vas, Spence, & Chapman, 2015; Vas, 2015). Although the gist is unlikely to convey exhaustive details from a stimulus, associating personally relevant facts may support a more effective exchange of information. In fact, recent evidence in discourse analysis suggests that complex or lengthy information is processed more efficiently, holds more meaning, and is more enduring when it is related to personal experience (Cannizzaro & Coelho, 2013; Carlomagno et al., 2011; Coelho et al., 2005; Coelho et al., 1991; Keidser et al., 2015; Mufwene, 2014; Rush et al., 2006; Ska et al., 2009; Sparks & Rapp, 2010; Vas et al., 2015; Vas, 2015). One reason for this may be that synthesizing and abstracting information based on experience is richer in content, thereby requiring less mental effort than attempting to store and retrieve verbatim details. Additionally, verbatim recall can be cognitively overwhelming. The resulting exchange of information may involve inaccurate, irrelevant, and/or false interpretation and retrieval of actual details contained in the materials.

Ska and colleagues (2009) reviewed recent evidence of the impact of load and individual differences in executive function on routine communication tasks. The utility of studying discourse processing in relation to maintaining abilities, improving impairments, and preventing functional declines was demonstrated from behavioral, cognitive, and neuroscientific perspectives. In fact, related studies of healthy populations with age-related changes suggest that varying the type of manipulation and complexity of dual-task demands is suggested as a possible line of research that may deepen understanding of other cognitive-linguistic performance deficits; furthermore, behavioral and neuroimaging studies have emphasized the relevance of discourse comprehension and production in both brain injured and healthy older adults (Cannizzaro & Coelho, 2013; Ferstl et al., 2005; Ska et al., 2009).

Ecologically Valid Cognitive-Linguistic Assessment

Determining the impact of cognitive control processes on complex linguistic performance, which is directly related to psychosocial communication behaviors and real-world functions, is a

critical challenge in predictive assessment (e.g., Constantinidou et al., 2012; Jurado & Rosselli, 2007). Research investigating the ecological validity of established neuropsychological tests of executive functioning have suggested confounding outcomes between scores on standardized measures and real-life behavioural performance—inconsistently significant relationships with weak-to-moderate magnitude (e.g., Chaytor et al., 2006; Cicerone et al., 2006; Coelho et al., 2005; Constantinidou et al., 2012; Ferstl et al., 2005; McNeil et al., 2004). It stands to reason that several factors, including aforementioned task and environmental demands and individual differences, would play a substantial role in such performance variation. In an effort to improve the ecological validity of neuropsychological assessment, Chaytor et al. (2006) investigated the relationship between performance on a battery of well-known tests and informant-report surveys of everyday executive functioning skills in adults with ABI. The authors also incorporated the contribution of environmental demands into their study. Results showed that the battery of tests alone (Trail Making Test, Wisconsin Card Sorting Test, Stroop, and Controlled Oral Word Association Test) accounted for only 18-20% of the variance in everyday executive functioning, as measured by informant report on the DEX and Brock Adaptive Functioning Questionnaires), and that the variance accounted for increased to 47%
with the addition of variables representing environmental demands. These findings support the value of holistic methods to advance ecologically valid assessments.

Although a growing body of literature advises a comprehensive evaluation of executive functioning behaviors in everyday life, empirical evidence reveals a paucity of holistic cognitive-linguistic assessments (Cannizzaro & Coelho, 2013; Chaytor, Schmitter-Edgecombe, & Burr, 2006; Coelho et al., 2005; Ferstl et al., 2005; Vas et al., 2015). Conventional linguistic assessments are typically substantiated by evaluations of aphasic language disorders, which are diagnostic tools meant to categorize aphasia subtypes and guide appropriate intervention goals. Decontextualized tasks are presented systematically, in a highly controlled, distraction-free environment (Coelho et al., 2005; Constantinidou et al., 2012; Vas, 2015). Certainly, these tests are reliable means of evaluating fundamental communication abilities. However, aphasia batteries measure core language skills that are largely recovered beyond acute stages of ABI and/or in less severe cases. Individuals with executive functioning deficits also tend to perform better in structured environments, which could mask disparate language processing limitations that appear in more demanding environmental and social conditions (Angeleri et al., 2008; Brookshire & Nicholas, 1997; Coelho et al., 1991; Ferstl et al., 2005; Vas et al., 2015). Accordingly, assessment of complex linguistic processing should incorporate a collection of ecologically valid tasks estimating everyday communication behaviors such as discourse processing.

As described above, traditional evaluations of linguistic skills and neuropsychological tests of executive functioning are similarly decontextualized in nature—thus, lack sufficient detail to adequately measure real-life performance. This is especially true concerning complex goal-directed behaviours, such as discourse processing, and for individuals with mild deficits, such as those associated with healthy aging. Cannizzaro and Coelho (2013) examined narrative discourse structure as an ecologically valid measure of age-related changes in executive functioning. General findings revealed significant relationships between aging, narrative macrostructure, and both linguistic and non-linguistic aspects of executive functioning. They concluded that executive functioning and narrative structure represent ecologically valid measures of age-related changes in goal-related behaviours. Furthermore, the authors emphasized that discourse processing is essential to social participation and echoed sentiments that studies on social interaction and discourse processing are "among the most scarcely explored cognitive functions in the world" (e.g., Ska et al., 2009).

Summary of the Present Study

The overarching goal of this study sought to develop an ecologically valid approach to cognitive-linguistic assessment by examining the effect of individual differences in cognitive capacity on naturalistic oral discourse processing. In general, effective discourse processing is regulated by cognitive control processes incorporating WM, attention, and self-monitoring mechanisms. Theoretical and empirical studies have established the impact of individual differences, task demands, task modality, and cognitive load on limited capacity processing and behavioural performance. Extensive research using dual-task methodologies have demonstrated that simultaneously completing two tasks increases the cognitive load, thus requiring more cognitive resources and greater mental effort to process, and results in performance decrements. Increased dual-task costs (DTCs) associated with healthy aging have been well-documented in the literature, yet links between cognitive capacity and age-related changes in everyday performance remain somewhat uncertain. To date, no known study has investigated age-related differences in cognitive capacity and oral discourse processing via dual-task performance.

Explorations into discourse processing, particularly functional performance in aging populations, essentially yields an 'oral discourse desert'. A range of environmental demands can add to the cognitive load during real-life contexts. Aligned with models of cognitive processing capacity, presuming an increased load on WM, attentional, and metacognitive resources, the dual-task paradigm was intended not only to estimate DTCs, but also to simulate the extraneous load imposed by demands encountered in everyday life.

The complexity of interrelated psycholinguistic components makes oral discourse processing a difficult construct to quantity; however, developing this line of research was of interest for several reasons—in no particular order. Current literature offers a solid foundation for examining relations between the effect of load, capacity limits, and complex cognitive-linguistic processing. There is a significant absence of behavioural studies investigating differences in cognitive capacity and oral discourse processing. Effective discourse processing is vital to social engagement, participation, and quality of life across the lifespan; by extension, enhancing ecologically valid methods of assessing discourse performance may be valuable in understanding the nature of everyday behaviours.

Research Questions and Hypotheses. In pursuit of the overarching goal, the current study examined age-related performance in three parts: first, dual-task costs under varying cognitive load; then, the relationship between cognitive capacity and oral discourse processing under varying degrees of load; finally, the nature of capacity limits influencing oral discourse processing (ODP) under varying degrees of cognitive load. The following research questions and hypotheses were addressed.

1. **How does cognitive load influence age-related processing differences during dual-task performance?**

Hypotheses 1.1 - 1.4. In alignment with models of limited capacity processing, the availability of cognitive resources is expected to decrease as cognitive load increases. When compared to the performance of younger adults, hypothesis 1.1 predicts greater DTCs in oral discourse processing for older adults under both simple and complex loads. Since the complex secondary task involves visual-motor coordination, it is expected to impose a greater extraneous load than the simple repetitive motor task; thus, hypothesis 1.2 predicts that older adults will exhibit more significant DTCs in oral discourse processing during the complex dual-task condition as compared to performance costs during the simple dual-task condition. When comparing DTCs in each secondary task under the load of ODP (i.e., reciprocal dual-task performance), hypothesis 1.3 predicts no significant differences in simple secondary task performance between younger and older adults. In contrast, slower reaction times (i.e., fewer items completed) in the complex secondary task are expected for older adults (hypothesis 1.4). Significant results for hypotheses 1.1 and 1.4, indicating DTCs in both primary and secondary task performance under complex load, would suggest that greater demands on cognitive resources differentially affect overall processing capacity of younger and older adults.

2. **What is the relationship between cognitive capacity and oral discourse processing under varying cognitive load in younger and older adults?**

Hypotheses 2.1 and 2.2. Overall executive functioning, as described by the GEC (global executive composite) from the BRIEF-A (Roth, Isquith, & Gioia, 2005), serves as an estimate of cognitive capacity that summarizes the relationship between an individual's self-report of everyday behaviors and cognitive resources. Everyday psychosocial communication behaviors are influenced by an individual's cognitive processing capacity, which is further dependent on the magnitude of extraneous load involved. Hypothesis 2.1 states that higher GEC scores, which indicate greater difficulty in everyday behaviors related to executive functioning, will correspond to poorer ODP performance under complex load. Hypothesis 2.2 predicts a significant correlation between GEC scores and ODP performance under complex load for older adults, when compared to younger adults.

3. What is the nature of capacity limits influencing oral discourse processing under varying cognitive load?

Hypothesis 3. As defined by the BRIEF-A, everyday executive functioning inferred from the GEC is composed of two distinct but highly correlated indices: the BRI (Behavioral Regulation Index) and the MI (Metacognitive Index), which are subdivided by overlapping cognitive control mechanisms. Scales representing an individual's ability to maintain sufficient attention and WM to plan, organize, sequence, and manage single and multiple tasks fall within the MI, whereas the BRI implicates self-monitoring skills that guide behavioral performance, such as thought flexibility, perspective taking, and emotional control. Although exploratory, it is hypothesized that both indices will correlate to simple and complex dual-task ODP performance, while the relationship between MI scores and dual-task costs under complex extraneous load are predicted to be stronger, particularly for older adults. The rationale behind this hypothesis relates to evidence suggesting age-related compensatory hemispheric recruitment (e.g., see review of HAROLD; Cabeza et al., 2002), constraints in capacity for encoding, manipulating, and retrieving linguistic information under demanding cognitive loads requiring greater mental effort (e.g., see review of CLT; Sweller, 1994; Choi et al., 2014), and differential processing of verbatim representations and abstracted meaning (e.g., see review/materials for discourse processing; Brainerd & Reyna, 2002; Vas et al., 2015).

CHAPTER 3 METHODS

Participants

Eighty participants were recruited from the Metro Detroit area via direct person-to-person solicitation, word of mouth, advertisements, and/or flyers. Recruitment efforts were further supported by the Healthier Black Elders Center (HBEC) participant resource pool (PRP), a joint collaboration between Wayne State University's Institute of Gerontology and University of Michigan's Institute of Social Research (Chadiha et al., 2011; Participant Resource Pool for Minority Health and Aging Research, IRB#: 119102B3E). The total sample consisted of 35 older adults, ranging in age from 65-75 years (Mean age = 69.5 years, *SD* = 3.2 years) and 45 younger adults, ranging from 19-29 years of age (Mean age = 24.1 years, *SD* = 2.2 years). All participants were native English speakers with at least some college education, with no known history of learning disabilities, major psychiatric or neurological disorders, and with no substantial hearing or vision loss. Neither ethnicity nor race were considered as demographic variables. The distribution of gender (male or female) and handedness did not differ across the two groups. Demographic information of the sample is summarized in Table 2.

The purpose of the study and all experimental procedures were explained thoroughly, and all participants gave their written informed consent. Administration of the entire protocol took approximately 60-90 minutes; participants were compensated upon completion of the study (see Appendix A for approximate timeframe).

Screening. Previous medical history and personal information were obtained via clinical interview using the questionnaire in Appendix B. Vision and hearing were screened using a near card screener and word recognition via a list of 50 words from the Northwestern University Auditory Test Number Six (NU-6), respectively. The Mini-Mental State Examination (MMSE) was used to screen for the presence of cognitive impairment (Folstein, Folstein, & McHugh, 1975). Lastly, the Center for Epidemiologic Studies Depression Scale (CES-D) self-report screened participants for depressive disorder (Radloff, 1977). Per self-reported medical history and cutoff scores associated with each of the above screening devices, all participants were determined to be in good health and presented with adequate hearing and vision and no signs of cognitive or depressive disorders confounding involvement in the study.

Materials and Measures

Oral Discourse Processing Stimuli. Linguistic structure of narrative stimuli and story transcripts used to measure ODP are reported in Table 1 and Appendix C, respectively. Narratives were drawn from the Logical Memory stories in *Wechsler Memory Scales* (Wechsler, 2008), stories validated as alternates to the WMS-IV (Morris et al., 2014), and the recall stories in *Rivermead Behavioural Memory Test* (Wilson, 2010). Each composition is lexically/linguistically comparable, based on specifications used by Morris and colleagues (2014) to develop re-test stories equivalent to those in WMS-IV. Pre-recorded 30-second stimuli were fashioned as 'human-interest story' commentaries intended to prompt an abstracted emotional response via relatable characters, feats, trials and tribulations.

Cognitive Load. Processing demands were manipulated using a dual-task paradigm with two levels of extraneous load. Variance in DTCs was elicited by incorporating tasks of different modality and complexity with ODP—a simple finger-tapping task and a complex grooved pegboard task. The finger-tapping test (FT) is an assessment of motor speed originally (and still) a feature of the Halstead–Reitan Neuropsychological Test Battery (Reitan & Wolfson, 1985). Via a small board with a lever and a counting device, as the test name indicates, the number of finger taps completed in a set time-interval is measured. The grooved-pegboard task (GP; (Kløve, 1963)) involves a higher level of processing and is a measure of visual-motor coordination. The task entails manipulating key-like pegs to fit into a board, which has 25 holes with randomly positioned slots.

Cognitive Capacity. A computerized version of the BRIEF-A self-report (Roth et al., 2005) was used to assess individuals' perceived executive functioning in everyday life, and served as an estimate of cognitive capacity. Respondents read statements describing specific behaviors and rated, using a standardized 3-point scale, whether they felt the behaviour was a 'problem' during the last month (never, sometimes, often). The BRIEF-A is composed of 75 items takes approximately 10 minutes to complete. The online version automatically calculates *T* scores and percentiles for each of nine overlapping scales (inhibit, shift, emotional control, self-monitor, initiate, WM, plan/organize, task monitor, organization of materials), which compose the Behavioral Regulation Index (BRI—the first four scales), the Metacognitive Index (MI—the last five scales) and the Global Executive Composite (GEC—the combined index scores). Figure 3 illustrates behavioural tasks, measures, and how the components were combined to determine individual differences within subjects and between groups.

Procedures and Experimental Conditions

All participants completed the online version of the BRIEF-A self-report, per published administration guidelines, followed by two trials of each single- or dual-task condition, which were presented in a counterbalanced manner to offset potential order effects. The purpose of the three experimental conditions and individual task directions were introduced per the counterbalancing order as follows. FT: participants were instructed to tap the lever as rhythmically and quickly as possible, using the finger of their dominant hand, for 30-seconds; GP: participants were instructed to rotate each peg to match the shape of the hole and insert it into the board, left-to-right from the top row to the bottom, using only their dominant hand, for 30-seconds; ODP: elements of a gist-based retell—including reduction, integration, and perspective—with regard to essential details in an example story were demonstrated and understanding was confirmed. General performance guidelines [i.e., maintain consistent performance on each task (single and/or dual), regardless of perceived complexity] were introduced before each trial/condition.

Administration of each counterbalanced narrative stimulus was presented as follows. Participants listened to a recorded story and immediately retold the story in their own words, which was audio-recorded and later transcribed for scoring. Following the retell, participants engaged in a serial 7s distractor task, alternating origin number and completing five calculations, to incorporate a delay and prevent further rehearsal. The examiner then asked eight Yes/No questions consisting of paired true positive and false positive probes for inferred and explicit detail recognition. Recognition probes were presented in random order and are listed in Appendix C.

Condition 1: Single-Task Performance (ODP1—Baseline). Baseline performance measures consisted of two trials of each task in isolation (i.e., ODP, FT, and GP, separately). One trial was implemented before and one trial after all experimental dual-task conditions. Individual task instructions were given as outlined above and presented in counterbalanced order.

Condition 2: Simple Dual-Task Performance (ODP2—Simple Extraneous Load). In the simple extraneous load condition, participants completed two consecutive dual-task trials of oral discourse processing with concurrent finger-tapping (ODP + FT). Participants were instructed to listen carefully to the story while simultaneously tapping as rhythmically and quickly as possible during the 30-second sample. Retell and recognition probe procedures were followed as above, with five serial 7s calculations performed between trials.

Condition 3: Complex Dual-Task Performance (ODP3—Complex Extraneous Load). In the complex extraneous load condition, participants completed two consecutive trials of oral discourse processing with the concurrent grooved-pegboard task (ODP + GP). Participants were instructed to listen carefully to the story while simultaneously fitting the pegs into the board as quickly as possible during the 30-second narrative. Retell and recognition probe procedures were followed as above, with five serial 7s calculations performed between trials.

Scoring Procedures

Objective scoring procedures for ODP were synthesized from a number of sources reflecting basic linguistic content (Brookshire & Nicholas, 1997; Juncos-Rabadán et al., 2005; McNeil, Doyle, Fossett, Park, & Goda, 2001; Morris et al., 2014), top-down models of discourse processing (Cosentino et al., 2013; Sparks & Rapp, 2010), analyses of narrative structure and executive function in naturalistic settings (Cannizzaro & Coelho, 2013; Whitney et al., 2009), and gist-reasoning (Gamino, Chapman, & Cook, 2009; Stein & Kirby, 1992; Vas et al., 2015; Vas, 2015). Performance accuracy for free recall of story details, narrative macrostructure, and gist-reasoning and cued recognition of explicitly stated (verbatim representations) and inferred details (suggested interpretations), were based on the narrative stimuli in Appendix C and scoring criteria in Appendix D.

Each participants' narrative retells were orthographically transcribed by the examiner and scored by three independent raters, who were all graduate students trained to score retells for information units (IUs) and gist reasoning per the criteria outlined in Appendix D. During rater training sessions, six (one per trial) different 'faux' retells considered to be of high, mid, and low performance were scored. The raters reached sufficient reliability after the third training. Orthographic transcripts of the data were notated in the same order (not counterbalanced) and coded so that raters were not biased by perceived age group or experimental condition/task complexity. After initial independent scoring by each rater, the examiner reviewed all IU and gist reasoning scores for agreement between 2/3 of raters. In the case of disagreement among raters, a consensus procedure (see Shriberg et al., 1984) was adopted to determine a valid score. Reliability analyses on 50% of the scored data yielded a Chronbach's alpha of .883 and an average intraclass correlation coefficient of .883, with a 95% confidence interval from .859 to .905 $F(239, 1195) = 8.551$, $p<.001$ (see Shrout & Fleiss, 1979).

Raw scores on individual measures of IU recall, gist-reasoning, and recognition, for each trial in each condition were averaged and transformed to a standardized score, reflecting overall oral discourse processing. Two ratio scores were computed to assess DTC in ODP under simple extraneous load (ODP_SL) and complex extraneous load (ODP_CL): simple dual-task-to-baseline performance (ODP_SL = ODP2/ODP1) and complex dual-task-to-baseline performance (ODP_CL = ODP3/ODP1). The resultant ratio scores, shown in Table 3, were used in the repeated measures ANOVA examining age-related differences in dual-task ODP performance under varying cognitive load.

Behavioral reaction times for simple FT and complex GP secondary task performance were measured by counting the total number of taps completed and the total number of pegs placed, respectively, within each 30-second interval of each trial in each condition. The two trials of each secondary task in each condition were averaged, and two ratio scores were computed to assess reciprocal DTCs in simple secondary task (DT_FT) and complex secondary task (DT_GP) under load: dual-task-to-baseline performance for simple secondary task (reciprocal DT_FT = FT + ODP/FT) and complex secondary task (reciprocal DT_GP = GP + ODP/GP). The resultant ratio scores, shown in Table 3, were used in the repeated measures ANOVA examining age-related differences in reciprocal dual-task performance under the cognitive load of ODP.

CHAPTER 4 RESULTS

This study examined age-related differences in cognitive capacity, oral discourse processing, and the impact of cognitive load on behavioural performance. In an effort to advance holistic assessment methods that approximate communication demands encountered in real-life, variance in ODP performance was investigated in three parts. Results of the mixed-model repeated measures and correlation analyses used to address specific research aims are presented below.

The Effect of Cognitive Load and Age-Related Differences in Dual-Task Processing

Two 2x2 mixed ANOVAs were conducted to determine the effect of cognitive load and age on dual-task processing performance, with age group as a between-subjects factor and cognitive load with two levels (simple and complex) as a within-subjects factor. The first repeated measures ANOVA examined dual-task costs in ODP performance under simple and complex cognitive loads for older and younger adults. The second repeated measures ANOVA examined reciprocal dual-task costs in the performance of simple and complex secondary tasks under load. Descriptive statistics and group comparisons of mean dual-task costs are displayed in Table 3.

The Effect of Load and Age on Dual-Task ODP Performance. As expected, older adults demonstrated greater ODP performance costs under both the complex (M = .803, SD = .136) and simple (M = .861, SD = .130) cognitive loads when compared to ODP performance costs in younger adults under the complex (M = .910, SD = .138) and simple (M = .911, SD = .113) cognitive loads. The main effects of load ($F(1, 78) = 4.46$, $p = .04$, partial $\eta_2 = .550$) and age ($F(1, 78) = 9.67$, $p = .003$, partial $\eta_2 = .866$) on dual-task ODP performance were both significant. A significant interaction was observed between age and cognitive load on ODP, $F(1, 78) = 4.20$, $p = .04$, partial $\eta_2 = .525$. This interaction of power is shown in figure 3. The simple main effect of load on dual-task ODP performance was significant for older adults ($F(1, 34) = 5.52$, $p = .025$, partial η^2 = .140), but did not significantly impact ODP performance in younger adults (F(1, 44) = .003, p = .956, partial η^2 < .001). Simple effects tests revealed significant age-related decrements in ODP performance under complex cognitive load, F(1, 78) = 12.320, p = .001, partial η^2 = .136. In contrast, age-related decrements in ODP under simple cognitive load were not statistically significant F(1, 78) = 3.34, p = .071, partial η^2 = .041.

The Effect of Load and Age on Reciprocal Dual-Task Performance. Assumptions of normal distribution, homogeneity of variances and covariances were not met. Data screening revealed a highly negatively skewed distribution for the complex secondary task (value of skewness compared to twice *SE* of skew < -1); additionally, there were two outliers with z-score values < -3.29 (one in each of the simple and complex reciprocal dual-task data) for older adults, as well as two outliers in the simple reciprocal dual-task data for younger adults (one z-score value < -3.29 and one value > 3.29). Correction methods, including transformation of the variables, removal of the outliers, and re-running the ANOVA, were unsuccessful and did not impact statistical significance of the results. Given the robustness of mixed ANOVAs to normality violations coupled with the unequal and relatively small sample size, the outliers were kept in the analysis.

In contrast to the expected age-related differences, reciprocal dual-task performance for the complex secondary task was similar for older adults (M = .90, *SD* = .21) and younger adults (M = .92, *SD* = .08), and greater reciprocal dual-task costs were demonstrated in the performance of the simple secondary task for older adults (M = .76, *SD* = .26) and younger adults (M = .87, *SD* = .16). The main effect of load (F(1, 78) = 11.25, p = .001, partial η^2 =.126) on reciprocal dual-task performance of the simple and complex secondary tasks was significant. The main effect of age on reciprocal dual-task performance of simple and complex secondary tasks was significant with a relatively small effect size $F(1, 78) = 4.05$, $p = .048$, partial $\eta_2 = .049$. There was no statistically significant interaction between load and age on reciprocal dual-task performance of either secondary task (figure 4), $F(1, 78) = 2.83$, $p = .097$, partial $\eta_2 = .035$.

The Relationship Between Cognitive Capacity and ODP Under Varying Cognitive Load

To assess the relationship between overall cognitive capacity—as estimated by self-report GEC scores, and ODP performance under varying load, Pearson's correlations were examined. Three correlation coefficients were computed for each condition of ODP and each age group. Descriptive statistics and correlations are presented in Tables 5 and 6, respectively. Higher GEC scores, indicating greater difficulty in everyday behaviors related to executive functioning, thus limited cognitive capacity, were expected to correlate to poorer performance ODP under complex extraneous load (ODP3). We predicted a negative correlation between GEC and ODP3, which would be greater for older adults when compared to younger adults.

In direct contrast to the hypothesized relationship, the correlation between GEC and ODP3 was weak and not statistically significant for older adults, $r(33) = -.115$, $p = .509$; for younger adults, the correlation was not only weak and not statistically significant, but it was also positive in direction, $r(43) = .050$, $p = .744$. Surprisingly, a statistically significant, moderate negative correlation between GEC and the baseline single-task measure of ODP (ODP1) was found for older adults, $r(33) = -.344$, $p = .043$, with cognitive capacity accounting for 11% of performance variability in ODP1. No other meaningful correlations between GEC and ODP performance were indicated in this sample of older and younger adults.

The Nature of Capacity Limits and ODP Performance Under Varying Cognitive Load

To understand the nature of cognitive capacity limits affecting everyday ODP performance, the relationships between GEC indices of BRI and MI and ODP under varying load were explored via Pearson partial correlations. While both the BRI and MI indices were expected to correlate with dual-task ODP performance, the relationship between MI scores and ODP performance under complex extraneous load was predicted to be stronger, particularly for older adults. Descriptive statistics and partial correlations are presented in Tables 5 and 7, respectively.

No meaningful relationships were observed between BRI and ODP at baseline (ODP1), under simple dual-task load (ODP2), nor under complex dual-task load (ODP3) for either older adults ($r(33)$ values ranged from -.181 to .063) or younger adults ($r(43)$ values ranged from -.047 to .055). After controlling for MI, no significant differences in these relationships were observed for younger adults; however, there was a slightly stronger relationship between BRI and ODP2 ($r_{partial}(42) = -.129$). Similarly, no significant differences in the partial correlations were observed for older adults; yet, considerably stronger and positive relationships were noted between BRI and ODP2, $r_{partial}(32) = .248$, and BRI and ODP3 $r_{partial}(32) = .297$.

No meaningful relationships between MI and ODP under varying load were observed for younger adults ($r(43)$ values ranged from -.104 to .009; $r_{partial}(42)$ values ranged from -.165 to .016). For older adults, the moderate significant correlation between MI and ODP1 (r(33 = -.389, $p = .021$) was relatively unchanged after controlling for BRI ($r_{partial}(32) = -.386$, $p = .024$), while the moderate significant relationship between MI and ODP2 (r(33 = -.340, $p = .046$) was somewhat stronger when BRI was controlled for, $r_{partial}(32) = -.403$, $p = .018$. A weak non-significant relationship between MI and ODP3 was observed (r(33 = -.180, $p = .302$); as expected, that relationship was stronger when BRI was controlled for, $r_{partial}(32) = -.337$, but the correlation was only marginally significant ($p = .051$).

CHAPTER 5 DISCUSSION

The primary aim of this study was to enhance the ecological validity of cognitive-linguistic assessments in adults. To accomplish this, individual differences in cognitive capacity and naturalistic oral discourse processing (ODP) were examined—specifically, age-related differences, limited capacity processing, cognitive load, and ODP performance. In further support of that aim, we sought to reveal links between underlying executive functioning resources and ODP under varying load in younger and older adults, respectively. Three research goals and consequent hypotheses were extended. Support for hypotheses, or lack thereof, are specifically addressed for each research goal, followed by a discussion of integrated findings and study limitations. Finally, general merit, implications and future directions of the current study are proposed.

The Effect of Cognitive Load and Age-Related Differences in Dual-task Performance

Results supported the hypotheses that the effect of cognitive load on ODP performance would be greater for older adults when compared to younger adults, and that age-related ODP performance costs would be greater under the complex dual-task condition. Older adults exhibited dual-task costs (DTCs) in ODP performance that were greater under complex cognitive load, whereas there were no differences between the DTCs in ODP performance under simple or complex loads for younger adults. These findings revealed an interaction between load and age that accounted for an additional 5.1% of variance in ODP performance. In other words, age-related differences in ODP performance costs increased as the complexity of the dual-task condition increased. The observed age-related differences in dual-task ODP contribute to theoretical and empirical research, which has established the significance of task demands and cognitive aging on limited capacity processing and performance outcomes of dual-task measures (e.g., Babcock & Salthouse, 1990; Rush et al., 2006; Fristoe, Salthouse, & Woodard, 1997; Verhaeghen et al., 2003).

Conversely, results of reciprocal DTCs in secondary task performance (i.e., simple FT and complex GP secondary tasks under extraneous load of ODP) must be interpreted with caution. Overall, results of reciprocal dual-task measures were insufficient to suggest that greater demands on cognitive resources differentially affected processing performance of younger and older adults. Although no significant age-related differences were expected for reciprocal dual-task performance in the simple secondary task (FT + ODP), we predicted that when compared to younger adults, older adults would demonstrate significantly slower reaction times (i.e., fewer items completed) for reciprocal dual-task performance in the complex secondary task (GP + ODP). Mean differences in DTCs for simple and complex secondary tasks showed a significant effect of load on performance; age-related differences in secondary task measures were significant but DTCs for the complex secondary task were less than expected; finally, there was no interaction between load and age. Potential constraints in the context of methodological issues and limitations are discussed in more detail below.

The Relationship Between Cognitive Capacity and ODP Under Varying Cognitive Load

Results did not support the hypotheses—that higher Global Executive Composite (GEC) scores on the BRIEF-A self-report scores would correspond to poorer performance in ODP under complex extraneous load (ODP + GP; ODP3), and that this relationship would be significantly stronger for older adults. First, let us consider the GEC, which provides a summary of overall executive functioning; higher scores indicate less awareness of cognitive abilities and greater difficulty in everyday situations. Asserting that cognitive capacity can be defined as the availability of limited executive function (EF) resources (e.g., Baddeley and Hitch, 1974), the GEC score was deemed a reasonable approximation of cognitive capacity. While mean GEC scores were slightly higher for older adults, both age groups scored well under the ‘elevated’ threshold of a *T*-score of 65 (Roth et al., 2005). Concerning mean ODP scores in each condition, as the extraneous load was increased, ODP performance decreased, and mean differences were greater for older adults. These results align with studies establishing the consequence of aging, task demands, and cognitive load on limited capacity processing and optimal performance (e.g., Chapman & Mudar, 2014; Salthouse, & Woodard, 1997; Sweller, 1994). Correlations between capacity limits, as estimated by GEC, and ODP under load revealed an opposing trend, even with notable differences in mean performance. In fact, the relationship between GEC and ODP decreased as the extraneous load increased. Despite being underpowered to detect significant correlations, the strongest relationship—between GEC and baseline ODP in older adults—was also statistically significant. Potential issues and limitations regarding interpretation are discussed in more detail below. Overall, correlation coefficients revealed stronger relationships between GEC scores and ODP for older adults compared to younger adults. These findings suggest that older adults needed to recruit additional EF resources to successfully manage goal-directed behaviours such as everyday oral discourse processing.

The Nature of Capacity Limits Influencing ODP Under Varying Cognitive Load

The final analysis did not provide sufficient evidence to disentangle the nature of individual differences in capacity limits on everyday oral discourse processing performance. It was predicted that the relationship between the Metacognitive Index (MI) and ODP under complex extraneous cognitive load (ODP3) would be strongest, specifically for older adults, after controlling for the Behavioural Regulation Index (BRI), as the two indices are highly correlated. To recap, the GEC measure used to estimate cognitive capacity is comprised of the two overlapping indices: the BRI assesses the ability to inhibit, shift, emotional control, and self-monitor; the MI assesses WM and the ability to initiate, plan/organize, task monitor, and organize materials. Mean MI scores were considerably higher than BRI scores in older adults, but both index scores were still well below the 'elevated' threshold. Higher MI scores indicate deficits in WM, initiation, planning/organization, task monitoring, and organization of materials, which can be interpreted as reduced ability to actively manage task demands (Roth et al., 2005). In older adults, the correlation between MI and ODP3 was considerably stronger after partialling out the BRI; however, the relationships between MI and ODP at baseline (ODP1) and ODP under simple extraneous load (ODP2) were both not only stronger, but also statistically significant. These findings corroborate previous research suggesting performance decrements associated with age-related declines in WM, attentional control, and processing speed (e.g., Babcock & Salthouse, 1990; Fristoe et al., 1997; Salthouse et al., 2006) may influence the online encoding, manipulation, and retrieval of complex linguistic information such as oral discourse processing.

Integration and Summary of Findings

The overarching goal this study was to advance ecologically valid cognitive-linguistic assessment measures by capturing the effect of individual differences in cognitive capacity and approximating oral discourse processing (ODP) in everyday life. Specific methods were designed with the prospect of obtaining meaningful patterns that quantify variance in ODP performance. To accomplish this goal, a self-assessment of everyday executive functioning was combined with a dual-task ODP performance measure to provide a more holistic estimate of limited capacity processing and simulate increased cognitive loads associated with environmental demands. Although significant results of this study were mixed, the observed trends in higher-order cognitive-linguistic processing and the contribution of executive functions were substantiated by previous research on the impact of cognitive aging, task demands, & capacity limits on behavioural performance. Furthermore, the proposed methodology advances ecologically valid cognitive-linguistic assessment measures and has the potential to improve holistic neurorehabilitation efforts and quality of life outcomes.

With regard to dual-task performance methods, many cognitive-linguistic deficits only manifest under demanding environmental loads. Conventional assessments typically evaluate core skills in decontextualized conditions. Such parameters seldom predict the complexity of behaviors elicited by naturalistic demands. Processing everyday discourse requires extensive cognitive resources; competition from environmental stimuli increases the load on an already engaged cognitive system and can hinder behavioral performance. Consequently, persons with mild impairments may score within functional limits when, in reality, performance may suffer given the demands of naturalistic contexts. Considerable research investigating age-related behavioral change in a variety of task modalities has been comparable to populations with mild acquired brain injury and neurodegenerative decline (Bherer et al., 2005; Chapman & Mudar, 2014; Cicerone, 1996; Hula & McNeil, 2008; Just & Carpenter, 1992; Lavie, 2005; Lindenberger et al., 2000; McNeil et al., 2004; Paas & Van Merriënboer, 1994; Pashler, 1994; Salthouse et al., 1995; Van Gerven, Paas, Van Merriënboer, & Schmidt, 2004; Van Merriënboer et al., 2006; Vas, 2015; Verhaeghen, Steitz, Sliwinski, & Cerella, 2003). Under demanding loads, age-related reductions in the synchronization of cognitive mechanisms affect performance abilities similar to the functional deficits observed in mild ABI (Cabeza et al., 2002; Cannizzaro & Coelho, 2013; Constantinidou et al., 2012; Ferstl, Walther, Guthke, & von Cramon, 2005; Salthouse et al., 1995; Wickens, 1991). While precise relationships between available cognitive resources and the capacity to process complex linguistic information remain uncertain, dual-task paradigms have demonstrated fundamental limitations in processing capacity. To date, no known study has considered the role of individual differences in cognitive capacity and environmental demands on oral discourse via dual-task performance measures.

In addition to the performance costs imposed via the increased load of dual-task paradigms, online processing of complex stimuli such as discourse is cognitively demanding and tends to require greater mental effort and executive functioning resources for aging populations. The expected inverse relationship between task complexity and performance was upheld by mean ODP scores in the three conditions, that is age-related performance decrements increased with each level of complexity and differences between each level were greater for older adults. A qualitative observation related to ODP performance costs in older adults involved perceived task difficulty. Although not formally measured, older adults spontaneously reported that it was harder to "pay attention and remember the story" after the dual-task conditions. Another noteworthy observation was that participants across both groups tried to exceed FT and GP scores in previous trials, oftentimes asking if they "beat the last one", despite instructions to maintain attention to the primary, ODP task.

The consequences of undesirable changes in executive functioning (EF) logically affect psychosocial communication behaviors to varying degrees. Deteriorating intrinsic characteristics such as processing speed, encoding new and retrieving stored information from WM, attentional control, and flexibility adapting behaviors to fit environmental demands may impact meaningful conversational exchanges, thereby reducing motivation, social engagement, and overall quality of life. Despite being underpowered, links between cognitive capacity limits (i.e., EF resources measured by self-report scores on the BRIEF-A) and ODP performance under varying load were detected in healthy older adults; furthermore, the contributions of WM, initiation, planning/organization, task monitoring, and organization on ODP were significant or approaching significance. This suggests adopting a similarly holistic paradigm could be beneficial in the assessment and treatment of clinical populations including, but not limited to, early detection and identification of mild cognitive impairments affecting everyday discourse behaviours.

It has been acknowledged that while traditional evaluations of cognitive-linguistic skills are vital in determining the type and/or severity of particular disorders, the influence of everyday demands on limited capacity processing and communicative performance are often overlooked. Ecologically valid metrics could help disentangle the nature of capacity limits impacting goal-directed behaviors such as naturalistic discourse. Ideally, this would aid in developing therapeutic targets and compensatory strategies that are tailored to the individual, and, by extension, promote generalizability to real-life situations.

Study Limitations

A number of limitations were noted in the current study. Despite the robustness of the repeated-measures approach to violations of assumptions of normality, linearity, and homogeneity of variance/covariance, the final sample size was smaller than originally anticipated and resulted in unequal *n* between groups. As some results were marginally significant and/or approaching significance, this likely contributed to the mixed findings. Another possible factor was the similarity in participants' education level. All participants in the younger group were either current undergraduate or graduate students. All participants in the older group had at minimum completed an associate degree or 'some college', with most reporting graduate degrees; furthermore, the researcher did not ask for the highest level of education in years, but in nominal categories (see Appendix B). As a result, differences in ODP performance by level of education was not reliably assessed and this sample may not have sufficiently represented a random sampling of the population. It should be noted that had the sample included participants with only a high school education, similar outcomes would be anticipated. One measure of compatible linguistic structure across narrative stimuli was the FOG index, which estimates the of years education necessary for comprehension (e.g., Morris et al., 2014); as shown in Table 1, the stimuli ranged from 9.24 – 10.51 years of education.

Conceptual discrepancies and methodological issues were consistent with related research employing similar dual-task paradigms and not necessarily unique to this study. As previously discussed, contemporary understanding of executive functioning and brain-behaviour relationships is largely based on lesion-deficit characteristics; terminology regarding executive functions, how they interact, and the contribution of specific mechanisms to behavioural performance has given rise to overlapping models of cognitive processing capacity. The current paper adopted a model of limited capacity processing presuming that adding extraneous load to an already cognitively demanding task, such as everyday oral discourse processing, would further deplete available WM, attentional, and metacognitive resources—cognitive load was manipulated using two levels of dual-task complexity. However, much like the "chicken or the egg?" conundrum, individual differences in behaviours that emerge via dual-task performance may be shaped by the behavioural measures themselves.

Concerning secondary tasks, it was assumed that the finger tapping (FT) task, requiring simple motor function, and the more complex visuomotor coordination required to complete the grooved-pegboard (GP) task, would adequately represent two distinct levels of demand. There were several limitations concerning the FT task—in no particular order. During dual-task trials, many participants had difficulty initiating the counter on the apparatus. Because the narrative stimuli began at the same time, this resulted in fewer taps being counted during one or both of the simple dual-task trials. Another problem was the noise produced by the FT device during dual-task trials. Some participants commented that it was difficult to hear the story and others tapped louder in an effort to tap faster, the latter case happened more frequently as for some reason, the majority of participants were overly concerned with ‘beating’ their previous number. Either way, this added to the interference of the simple extraneous load, which may have added unnecessary complexity and/or contributed to the skewed results. A number of participants in both age groups had difficulty grasping pegs for the GP task. Long nails, arthritis, and “chubby fingers” were all given as reasons for slowed performance. For the most part, the GP, which requires more mental effort and is a sensitive measure of psychomotor speed, lateralized brain impairment, and executive dysfunction (Mitrushina, Boone, Razani, & D'Elia, 2005), was tackled with far less effort than FT. Taken together, issues with FT and GP likely added to error variance in dual-task performance estimates of cognitive capacity.

Another limitation involved the narrative stimuli used in the dual-task design. The narrative style chosen was assumed to embrace fundamental components of representation, perception, and reasoning, and was thought to be compatible with naturalistic discourse qualities. As part of their retells, many participants included that they thought the story was “boring” or “uninteresting” and “so, I didn’t really pay attention”. It is possible that the human-interest story style was in fact too boring, or that the 30-second stimuli was too short to engage and maintain participants’ attention. Different stories should be adopted in future studies.

Finally, use of the BRIEF-A self-report as an additional estimate of cognitive capacity may have limited findings. Respondents were asked to rate how often a listed behaviour was a problem. Although they were instructed to answer as honestly as possible, responses were restricted to three options: often, sometimes, never; and depended on their definition/perception of a problem. As the population in this study consisted of healthy volunteers, it is entirely possible that problematic behaviours were either under-or over-estimated. On the positive side, if the same assessment was used in a clinical population, the self-report can be compared to caregiver responses and may be more indicative of limited executive functioning resources.

Conclusions

The findings presented herein are considered a springboard to strengthening holistic assessments of cognitive functioning and the effects on everyday discourse performance. Current research also indicates a need for ecologically valid assessments of executive functioning mechanisms underlying goal-directed behaviours. The extant literature offers a solid foundation for examining the relations between limited capacity processing, load, and complex cognitive-linguistic behaviors. Alas, the majority of studies have observed combinations of simpler tasks such as word list learning or verbal association. While no single explanation can satisfy human performance dynamics at play, modifying our approach to evaluating such interactions may help to illuminate hazy links between cognitive functions and everyday communication behaviors. To date, no known studies have investigated the role of individual differences in capacity limits on oral discourse processing via dual-task performance. From a research perspective, substantiating assessment methods that integrate behavioural performance, environmental demands, and self-report instruments, advances ecological validity and may encourage other researchers to explore the complex natures of limited capacity processing and everyday discourse. Findings could also be expanded in the context of current neuroscientific evidence of brain-behavior relationships and cognitive aging. From a clinical perspective, a comprehensive battery of cognitive-linguistic metrics has the potential to improve many neurorehabilitation efforts, including early detection and identification of mild cognitive-linguistic deficits associated with aging. Exploring the contribution of individual differences in cognitive capacity (i.e., the extent and allocation of executive functioning resources) to the unique variance in complex, goal-directed behaviours may help identify core limitations, predict their impact on psychosocial communication behaviors, and optimize therapeutic interventions. Ultimately, substantiating holistic approaches that enhance ecologically valid and predictive assessments of cognitive-linguistic function is an important line of research for improving social engagement, participation, quality of life for a diverse range of needs in many adult populations.

APPENDIX A

Protocol Administration and Approximate Timeframe

Informed Consent……………………………………………………………………...5 minutes

Questionnaire and Screenings………………………………………………………20-30 minutes
Medical History: 5min
Hearing and Vision: 5min
CESD: 5-10min
MMSE: 5-10min

Data Collection……………………………………………………………………...30-35 minutes
BRIEF-A: 10-15min
Baseline and Experimental Conditions (including directions and all trials)
Narrative and Retell: 7-8min
Single-task finger tapping and grooved pegboard: 3-4min
Distractor Serial 7s: 3-4min
Recognition Probes: 4-5min
Condition Interval Serial 7s: 3-4min

Total Participant Time Commitment………………………………..approximately 60-75 minutes

APPENDIX B

ID Code:
Date of Visit:

MEDICAL HISTORY & PERSONAL INFORMATION QUESTIONNAIRE

All questions contained in this questionnaire are strictly confidential

Name:		**DOB:**	**Age:**		▭ M	▭ F
Marital status:	▭ Single	▭ Partnered	▭ Married	▭ Separated	▭ Divorced	▭ Widowed
Handedness:	▭ Right	▭ Left				
Primary Language:	▭ English	▭ Other				
Highest Level of Education:	▭ High school	▭ Some College	▭ Bachelor's	▭ Graduate		

Previous Medical History

Check if you have ever been diagnosed with any of the following:		
▭ Stroke/CVA	▭ Brain Aneurysm	▭ Psychiatric Disorder (e.g., Major Depressive, Bipolar, or Personality Disorder)
▭ TIA	▭ Seizure Disorder	▭ Drug or Alcohol Addiction
▭ Head Injury	▭ Abnormal CAT scan/MRI of Brain	▭ Uncorrected Hearing or Visual Impairment
▭ Coma/Loss of Consciousness	▭ Neurological Disorder (e.g., Parkinson's Disease, MS)	▭ Learning Disability

Personal Information

Work Status	Are you currently employed?	▭ Yes	▭ No
	What is your employment status?	▭ Full time	▭ Part time
	Are you retired?	▭ Yes	▭ No
	Do you volunteer?	▭ Yes	▭ No

Personal & Social Status	Do you live with or near family/friends?	▭ Yes	▭ No
	Do you live alone?	▭ Yes	▭ No
	Do you participate in any organized social groups/hobbies?	▭ Yes	▭ No
	Do you watch TV, movies and/or read for entertainment?	▭ Yes	▭ No
	Do you ever have difficulty following TV, movies, or reading materials?	▭ Yes	▭ No

Additional Information:

APPENDIX C

Narrative Stimuli and Recognition Probes

N1: Anna Thompson

Anna Thompson of South Boston, employed as a cook in a school cafeteria, reported at the police station that she had been held up on State Street the night before and robbed of fifty-six dollars. She had four small children, the rent was due, and they had not eaten for two days. The police, touched by the woman's story, took up a collection for her.

Recognition Probes

- Was the woman's name Anna Thompson? **Y** N
- Was the woman's name Annie Thomas? Y **N**
- Was the woman robbed of her rent money? Y **N**
- Was the family hungry? **Y** N
- Was the mother looking for restaurant work? Y **N**
- Did the woman have a job? **Y** N
- Did the police arrest the thief? Y **N**
- Did the woman have four kids? **Y** N

N2: Joe Garcia

At six on Monday evening, Joe Garcia of San Francisco was watching television as he dressed to go out. A weather bulletin interrupted the program to warn that thunderstorms would move into the area within the next two to three hours and remain until morning. The announcer said the storm could bring hail and up to four inches of rain and cause the temperature to drop by fifteen degrees. Joe decided to stay home. He took off his coat and sat down to watch old movies.

Recognition Probes

- Did the man like old movies? **Y** N
- Was the man's name John? Y **N**
- Did the news tell people they should stay home? Y **N**
- Does San Francisco get erratic weather? **Y** N
- Was the rain predicted to freeze? Y **N**
- Was the storm going to last overnight? **Y** N
- Was Joe afraid of thunder? Y **N**
- Did Joe break his plans to go out? **Y** N

N3: Greg Fortune

The Savannah Wolves football captain and quarterback, Greg Fortune, was injured on a fishing trip last week. After bringing a large bluefish aboard his cabin cruiser, the ferocious fish jumped up and bit off the tip of his left ring finger. Even though it took 17 stitches to close up the wound, he was still able to play in Sunday's game against the Sharks.

Recognition Probes

- Was Greg the captain of a soccer team? Y **N**
- Did Greg play for the Savannah Wolves? **Y** N
- Are fish expected to bite humans? Y **N**
- Did doctors fix his finger? **Y** N
- Did Greg let the fish go? Y **N**
- Was the fish aggressive? **Y** N
- Did Greg get to play in Saturday's game? Y **N**
- Did Greg get 17 stitches? **Y** N

Rick Ventura

On a laid-back Sunday morning around ten o'clock, Rick Ventura was making brunch in his Chicago apartment when he heard a knock. A red-headed woman came to his door and said a tow truck would arrive in a few minutes to take away his automobile unless he moved it. The neighbor warned that he would get a ticket and an expensive fine for parking across her driveway an hour ago. Rick looked at his watch. He jumped to grab his windbreaker and quickly ran out of the apartment.

Recognition Probes

- Was the man cooking food? **Y** N
- Was the man's name Rich? Y **N**
- Is it easy to find legal parking in Chicago? Y **N**
- Was Rick's neighbor upset? **Y** N
- Was the neighbor hotheaded? Y **N**
- Did Rick lose track of time? **Y** N
- Did Rick live in a house? Y **N**
- Was Rick's car blocking a driveway? Y N

The Black Twins

After twenty years, identical twins Jennifer and Diane Black have been reunited. They had both been adopted at birth by different families in Manhattan, but neither one knew the other existed. Diane discovered she had a twin when she requested a copy of her birth certificate. She then began to search for her, a task that took two years. The sisters said it was like looking into a mirror when they met.

Recognition Probes

- Were the twins born in New York? **Y** N
- Were the twins fraternal? Y **N**
- Did the twins remember their birth mother? Y **N**
- Did it take a long time for the sisters to meet? **Y** N
- Did Jennifer need a copy of her passport? Y **N**
- Did Diane search for her sister? **Y** N
- Was the adoption done in secret? Y **N**
- Were the twins happy to finally meet? **Y** N

Willie Carter

Willie Carter was rescued late Tuesday night after his boat capsized in Lake Michigan. A ferry operator discovered the wreckage and notified the coast guard. The local patrol boat found him shortly after and transported him to the closest hospital where he was met by his wife and three children. Doctors report that he is being treated for exposure, having spent four hours in the ice-cold water. He is expected to make a full recovery.

Recognition Probes

- Was a man found in Lake Michigan? **Y** N
- Was the coast guard's name Willie? Y **N**
- Was the man in a rowboat? Y **N**
- Did the man know how to swim? **Y** N
- Was Willie in critical condition? Y **N**
- Is Lake Michigan cold? **Y** N
- Did Willie's wife take him to the hospital? Y **N**
- Was the boat wrecked? **Y** N

APPENDIX D

Scoring Criteria for Oral Discourse Processing

Oral discourse processing (ODP) performance quantified by a composite score of detail-level (information units) and abstract-level (gist reasoning) content in narrative retells, and recognition of explicitly stated and implied information in the stimuli. ODP performance scores for each narrative stimulus range from 0-43 points. Breakdown of scoring criteria follows.

Information Units (IUs): measure of detail-level processing in narrative retell (0-25pts)

- IUs identify logical, accurate, and informative content
- Stimuli divided into 25 IUs corresponding to words and/or phrases
    - 1pt for each verbatim detail or closely related synonym recalled
    - 1/2pt for each partially correct detail or loosely related synonym recalled
    - 0pt for incorrect/irrelevant details, or inaccurate synonyms recalled

Gist Reasoning Scale: measure of abstract-level processing in narrative retell (0-10pts)

- Reduction and generalization of stimuli preserving narrative macrostructure
    - 5- complete and coherent synopsis
    - 4- partially complete and coherent synopsis[a]
    - 3- adequate and coherent, but incomplete synopsis[b]
    - 2- inadequate and vague synopsis
    - 1- incoherent and confusing synopsis
    - 0- no thematic generalization or relationship to overall story meaning
- Interpretation of story meaning via global perspective/personal opinion statement
    - 5- valid and relevant interpretative statement
    - 4- valid but ambiguous relationship to story meaning
    - 3- valid but completely literal interpretation
    - 2- distorted or unrelated interpretative statement
    - 1- irrelevant opinion stated
    - 0- no interpretation/perspective offered

Recognition: identification of inferred or explicitly stated details in the stimuli (0-8pts)

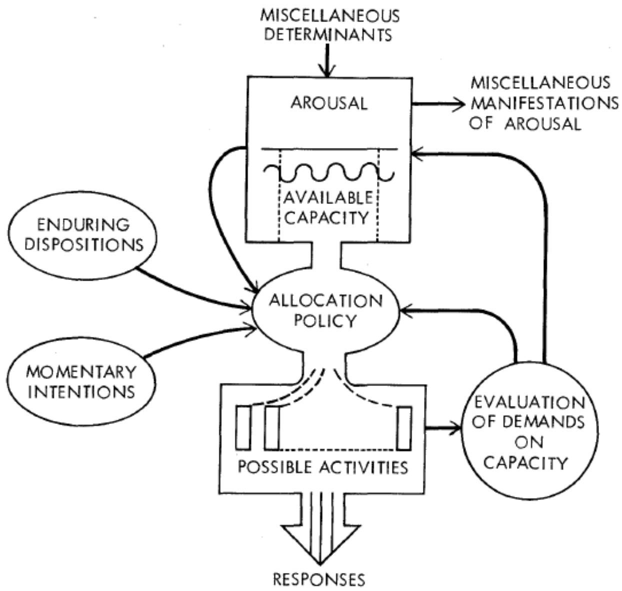
- Yes/No probes recounting true positive and false positive information
    - 1pt for each correct response to eight (8) yes/no questions

[a] A synopsis was rated as partially complete and coherent if only trivial details, those which would not alter the overall story premise or listener understanding, were omitted.

[b] A synopsis was rated as adequate and coherent, but incomplete if crucial details, those which would alter the overall story premise or affect listener understanding, were omitted.

Figure 1

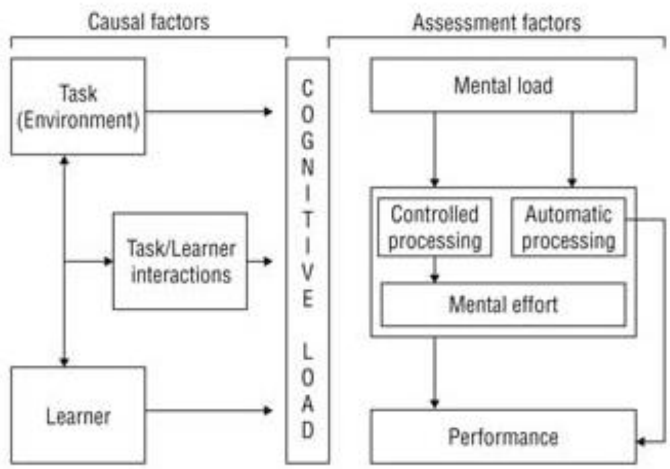
Attentional Resource Allocation Model of Cognitive Processing Capacity (RAT)



Note: Reproduced from image titled, "A capacity model for attention", by Kahneman, D, 1973, *Attention and effort*: Englewood Cliffs, NJ: Prentice-Hall.

Figure 2

Influences on WM Resources and Limited Processing Capacity (CLT)



Note: Reproduced from Kirschner, P. A. (2002). Cognitive load theory: Implications of cognitive load theory on the design of learning: Elsevier.

Figure 3

Behavioural Tasks and Performance Measures

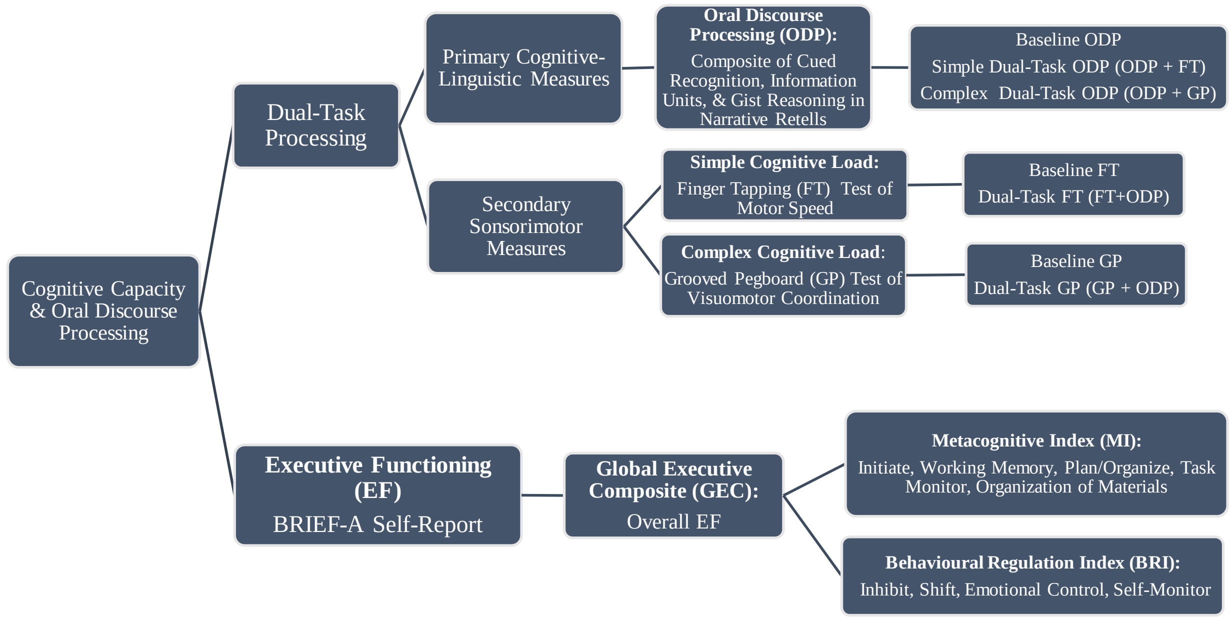


Figure 4

Dual-Task Costs in ODP by Load & Age

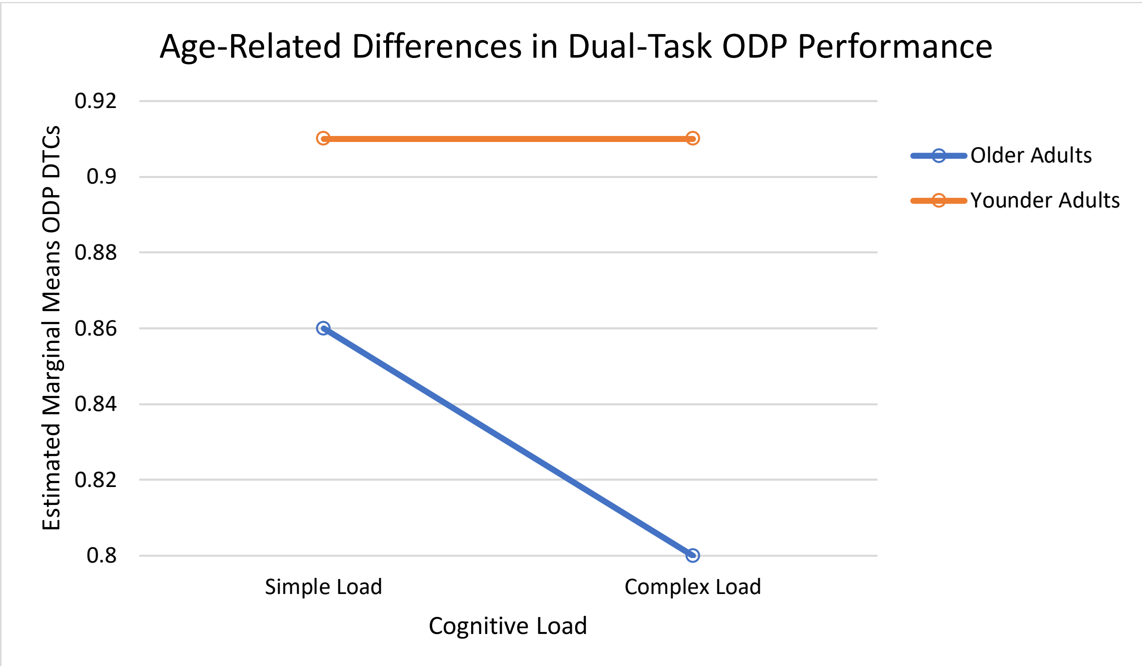


Figure 5

Reciprocal Dual-Task Costs by Load & Age

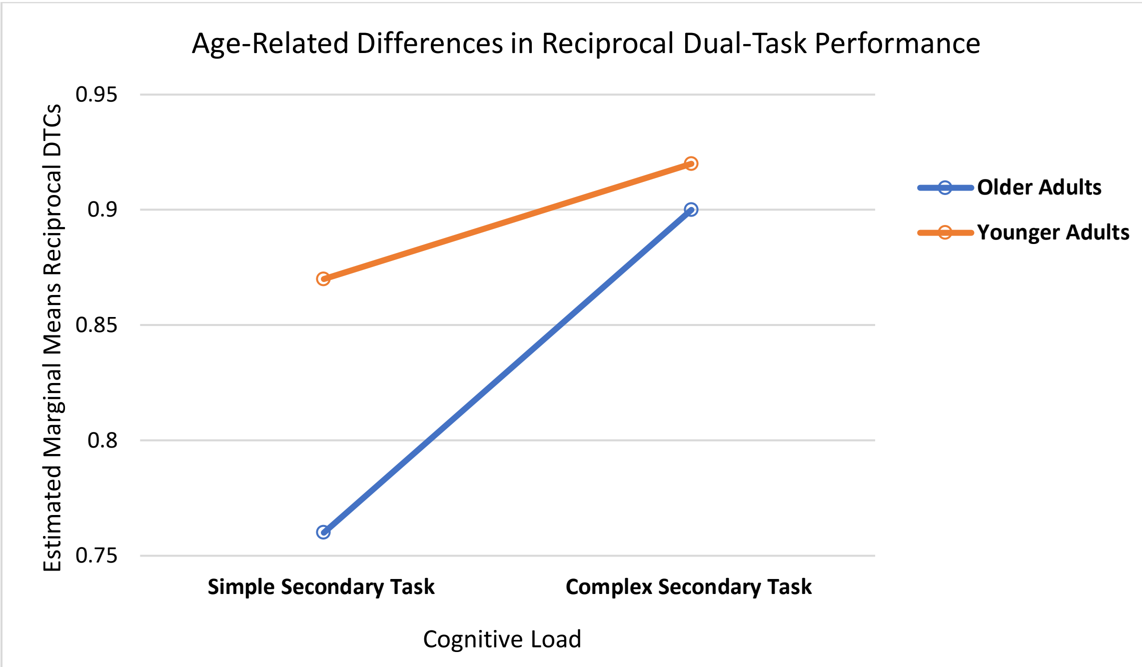


Table 1

Linguistic Structure of Narrative Stimuli

Stimulus	Index							
	Total words	Total sentences	Total syllables	Mean syllables/word	% Complex syllables	Mean sentence length	% Lexical density	FOG index
N1	65	3	86	1.32	4.61	21.67	50.77	10.51
N2	86	5	119	1.38	9.30	17.20	56.98	10.60
N3	65	3	88	1.35	4.62	21.67	56.92	10.51
N4	88	5	123	1.4	9.09	17.60	54.41	10.68
N5	72	5	103	1.43	9.72	14.40	51.39	9.65
N6	76	5	110	1.45	7.89	15.20	56.58	9.24

Complex syllables ≥ 3syllables; *Lexical density* = # different words/total words (100%); *FOG index* (estimate of years education for comprehension; e.g., Morris et al., 2014) = .4($\bar{x}$ sentence length + % complex syllables)

Table 2

Participant Demographics

Age Group	N	Mean Age	*SD*	Gender	Handedness	Minimum Education
Older Adults	35	69.54	3.16	31 Female, 4 Male	30 Right, 5 Left	Some College
Younger Adults	45	24.11	2.17	41 Female, 4 Male	41 Right, 4 Left	Some College

Table 3

Dual-Task Performance Costs

Older Adults	Minimum	Maximum	Mean (*SD)*	*SE*
ODP_SL	.65	1.25	.86 (.13)	.02
ODP_CL	.53	1.13	.80 (.13)	.02
Reciprocal DT_FT	.08	1.36	.76 (.26)	.04
Reciprocal DT_GP	.00	1.24	.90 (.21)	.03
Younger Adults	Minimum	Maximum	Mean	*SE*
ODP_SL	.63	1.19	.91 (.11)	.02
ODP_CL	.54	1.19	.91 (.14)	.02
Reciprocal DT_FT	.53	1.25	.87 (.16)	.03
Reciprocal DT_GP	.77	1.06	.92 (.08)	.02

Note: ODP_SL = simple load (ODP + FT); ODP_CL = complex load (ODP +GP); Reciprocal DT_FT = simple secondary task under load (FT + ODP); DT_GP = complex secondary task under load (GP + ODP)

Table 4

Cognitive Capacity and ODP Measures

Older Adults	Minimum	Maximum	Mean	*SD*
ODP1	14.75	31.25	21.17	3.72
ODP2	11.75	24.75	18.11	3.57
ODP3	10.75	22.75	16.83	3.30
GEC	37	79	52.14	9.80
BRI	37	65	48.66	7.94
MI	37	86	54.54	11.18
Younger Adults	Minimum	Maximum	Mean	*SD*
ODP1	14.75	32.25	23.07	4.49
ODP2	14	32	20.87	4.25
ODP3	13.75	27.5	20.71	3.76
GEC	36	77	50.20	9.50
BRI	36	78	49.42	10.52
MI	38	77	50.84	8.79

Note: ODP1 = ODP in isolation (baseline); ODP2 = ODP + FT (simple extraneous load); ODP3 = ODP + GP (complex extraneous load); GEC = Global Executive Composite: measure of overall executive functioning, comprised of overlapping scales that compose two indices: BRI= Behavioural Regulation Index: inhibit, shift, emotional control, self-monitor; MI = Metacognitive Index: initiate, WM, plan/organize, task monitor, organization of materials.

Table 5

Correlations for Cognitive Capacity and ODP Measures

Older Adults	GEC	ODP1	ODP2	ODP3
GEC	1			
ODP1	-.344*	1		
p-value	.043			
ODP2	-.279	.666**	1	
p-value	.105			
ODP3	-.115	.585**	.617**	1
p-value	.509			
Younger Adults	**GEC**	**ODP1**	**ODP2**	**ODP3**
GEC	1			
ODP1	-.028	1		
p-value	.857			
ODP2	-.045	.778**	1	
p-value	.771			
ODP3	.050	.668**	.830	1
p-value	.744			

Note: GEC = Global Executive Composite: measure of overall executive functioning; ODP1 = ODP in isolation (baseline); ODP2 = ODP + simple extraneous load; ODP3 = ODP + complex extraneous load; * Correlation significant at α = .05 level; ** Correlation significant at α = .01 level

Table 6

Partial Correlations BRI and ODP Measures Controlling for MI

Older Adults	Control Variable	BRI	ODP1	ODP2	ODP3	MI
BRI	none	1				
ODP1		-.181	1			
p-value		.299				
ODP2		-.095	.666**	1		
p-value		.588				
ODP3		.063	.585**	.617**	1	
p-value		.718				
MI		.740**	-.389*	-.340*	-.180	1
	MI					
BRI		1				
ODP1		.173	1			
p-value		.327				
ODP2		.248	.616**	1		
p-value		.157				
ODP3		.297	.568**	.601**	1	
p-value		.088				
Younger Adults	**Control Variable**	**BRI**	**ODP1**	**ODP2**	**ODP3**	**MI**
BRI	none	1				
ODP1		-.047	1			
p-value		.761				
ODP2		.012	.778**	1		
p-value		.940				
ODP3		.055	.668**	.830**	1	
p-value		.720				
MI		.732**	-.023	-.104	.953	1
	MI					
BRI		1				
ODP1		-.044	1			
p-value		.778				
ODP2		.129	.780**	1		
p-value		.404				
ODP3		.071	.669**	.836**	1	
p-value		.647				

Note: : BRI= Behavioural Regulation Index: inhibit, shift, emotional control, self-monitor; MI = Metacognitive Index: initiate, WM, plan/organize, task monitor, organization of materials; ODP1 = ODP in isolation (baseline); ODP2 = ODP + simple extraneous load; ODP3 = ODP + complex extraneous load;* Correlation significant at α = .05 level; ** Correlation significant at α = .01 level.

Table 7

Partial Correlations MI and ODP Measures Controlling for BRI

Older Adults	Control Variable	MI	ODP1	ODP2	ODP3	BRI
MI	none	1				
ODP1		-.389*	1			
p-value		.021				
ODP2		-.340*	.666**	1		
p-value		.046				
ODP3		-.180	.585**	.617**	1	
p-value		.302				
BRI		.740**	-.181	-.095	.063	1
	BRI					
MI		1				
ODP1		-.386*	1			
p-value		.024				
ODP2		-.403*	.663**	1		
p-value		.018				
ODP3		-.337	.607**	.627**	1	
p-value		.051				
Younger Adults	**Control Variable**	**MI**	**ODP1**	**ODP2**	**ODP3**	**BRI**
MI	none	1				
ODP1		-.023	1			
p-value		.881				
ODP2		-.104	.778**	1		
p-value		.499				
ODP3		.009	.668**	.830**	1	
p-value		.953				
BRI		.732**	-.047	.012	.055	1
	BRI					
MI		1				
ODP1		.016	1			
p-value		.916				
ODP2		-.165	.779**	1		
p-value		.286				
ODP3		-.046	.673**	.831**	1	
p-value		.768				

Note: : MI = Metacognitive Index: initiate, WM, plan/organize, task monitor, organization of materials; BRI= Behavioural Regulation Index: inhibit, shift, emotional control, self-monitor; ODP1 = ODP in isolation (baseline); ODP2 = ODP + simple extraneous load; ODP3 = ODP + complex extraneous load;* Correlation significant at α = .05 level; ** Correlation significant at α = .01 level

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ABSTRACT

TOWARD ENHANCING ECOLOGICAL VALIDITY OF COGNITIVE-LINGUISTIC ASSESSMENT: THE ROLE OF INDIVIDUAL DIFFERENCES IN COGNITIVE CAPACITY ON ORAL DISCOURSE PROCESSING

by

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A growing body of multidisciplinary research indicates the need for more holistic tests of executive cognitive functioning and complex language metrics that predict real-life performance. However, empirical studies investigating cognitive aging, limited capacity processing and everyday discourse behaviours are still lacking. The present research focused on ecologically valid methods for capturing individual differences in cognitive capacity and the effects of cognitive load on oral discourse processing (ODP) in healthy adult participants. This methodology sought to tease apart the nature of capacity limits and provide a better estimate of age-related differences in everyday discourse behaviors in three parts. First, the effects of simple and complex cognitive load and age-related differences in ODP performance were investigated using a dual-task paradigm. Second we examined, links between overall cognitive capacity—estimated via scores on a standardized self-report survey of everyday executive functioning—and dual-task ODP under varying load in younger and older adults. Finally, we explored the nature of capacity limits (i.e., scores on the self-report survey measuring particular executive functions) influencing age-related differences in ODP under varying load.

Results yielded evidence that age-related differences in ODP performance costs increased as the complexity of the dual-task condition increased. Results of our second inquiry did not support the prediction that overall cognitive capacity and ODP under complex load would be negatively correlated, and that this relationship would be greater for older adults. However, older adults' mean scores indicated slightly reduced cognitive capacity and poorer ODP performance as the cognitive load increased. Results of the final analysis, while revealing weak-to-moderate and non-significant relationships, suggested that capacity limits in working memory, initiation, planning/organization, task monitoring, and organization of materials, influenced age-related declines in ODP performance.

Overall, findings add to literature advocating for ecologically valid cognitive-linguistic assessments. Combining dual-task performance measures with tests of executive functioning has the ability to tap individual differences in cognitive capacity and their relation to everyday discourse processing. Further, such methodologies promote a more holistic approach to assessing performance, which could strengthen the ability to predict meaningful behavioural patterns, and optimize intervention efforts for a diverse range of needs across adult populations.

AUTOBIOGRAPHICAL STATEMENT

Nancy Naperala, M.A., CCC-SLP, is completing her doctoral degree in the Department of Communication Sciences and Disorders with a minor in Psychology at Wayne State University. She received her Master of Arts in Speech-Language Pathology from Wayne State University and earned a bachelor's degree in Biology, with minors in English and Theatre, from Purdue University. Her research interests emphasize a biopsychosocial perspective to understanding cognitive-linguistic behaviours and advancing holistic practices that optimize quality of life in adults. Throughout her Ph.D. studies, she has worked as a clinical supervisor for graduate student clinicians in Wayne State University's Speech Therapy and Education for Program for Stroke Survivors (STEPSS) clinical practicum; she also teaches phonetics to classes including undergraduate, post-bachelor, and graduate students.