Research Statement
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The aim of my program of research is to understand the cognitive and neural mechanisms underlying language and memory systems across the adult lifespan. I adopt an interdisciplinary approach to this work, drawing on theories and methods in cognitive science, neuroscience, gerontology, linguistics, and quantitative and experimental psychology. I also adopt a multi-method approach, including the non-invasive study of human brain activity (e.g., event-related brain potentials [ERPs], transcranial magnetic stimulation [TMS]), eye movements and pupil dilation via eye tracking technology, and behavioral performance (e.g., reaction time, memory). Below, I provide a snapshot of three inter-related lines of research within this program.

Cognitive Aging and Individual Differences in Language and Memory Functioning

Language comprehension is complex, involving the recruitment of a highly distributed set of neural systems supporting perceptual, motor, and higher-order cognitive processing. Aging can begin to compromise these systems, negatively impacting the ability to comprehend language and learn from text and speech. One line of my research investigates how aging and individual differences impact comprehension and verbal memory, and how sensitive measures of moment-to-moment language processing (e.g., ERPs, eye tracking, and reaction time) reveal mechanisms of these differences. For example, we have shown that age-related changes in working memory and language experience are dissociable across the adult lifespan (e.g., Payne et al., 2012, 2014), and have differential impacts on lexical, semantic, and syntactic processing (see e.g., Payne & Silcox, 2017; Stine-Morrow & Payne, 2015 for reviews). Notably, we have shown evidence for a compensatory role of literacy experience for language and memory outcomes in middle age and older adulthood, such that adults with greater literacy skills show better language performance outcomes in the face of cognitive decline (Chin et al., 2015; Ng et al., 2020, 2018; Payne et al., 2012, 2020; Steen-Baker et al., 2017), including in the face of age-related neurocognitive disorders (e.g., Mild Cognitive Impairment; Payne & Stine-Morrow, 2016). Related to this work. we recently published the first large-scale study to our knowledge using eye tracking technology to characterize literacy differences in reading processes among community-dwelling middle aged and older adults (Payne et al., 2020). We believe this work has the potential to improve adult literacy assessments and interventions by focusing on real-time language-related cognitive processes during reading.

In a recent applied direction, my lab has begun examining the cognitive and neural correlates of *listening effort* among younger and older adults during challenging speech processing (e.g., speech in background noise; Silcox & Payne, 2021; Payne & Silcox, 2019), and exploring ways to offset the negative effects of effortful listening. As part of an extramurally funded project (***CaptionCall, LLC****; PI: Payne*) we have recently shown that assistive text captioning technology can offset the negative effects of background noise on speech processing and memory in both younger and older adults with and without sensorineural hearing loss (Payne et al., 2021), and recent student-led work (Crandell et al., 2022) has begun to explore the mechanisms and boundary conditions of the text captioning benefit to speech (e.g., diminished benefits in the presence of captioning errors), revealing important principles of multi-sensory language processing across the adult lifespan.

Bridging the Gap Between the Behavioral and Neural Study of Comprehension

One major theme of my work is the adoption of multi-method approaches and paradigms to “bridge the gap” between the behavioral and neural study of language comprehension. For example, in one line of work, I have examined the neural mechanisms underlying the allocation of covert attention across the visual field in reading. This work has combined behavioral, eye tracking, and electrophysiological measures to probe (a) lexical semantic processing in parafoveal vision (e.g., Lopes et al., in preparation; Payne et al., 2019, Stites et al., 2017), (b) the relationship between foveal word processing and parafoveal attention allocation (Payne & Federmeier, 2017; Payne et al., 2016), and (c) how age-related cognitive and sensory changes modulate visual attention and the perceptual span in reading (Payne & Federmeier, 2017; Payne & Stine-Morrow, 2012). Findings have highlighted cognitive and neurophysiological constraints on models of reading. For example, in an invited letter in *Trends in Cognitive Science*, my colleague and I drew on findings from this work to argue for constraints on recent computational models of reading (Schotter & Payne, 2019).

One emerging line of this work involves developing best practices for simultaneously recording and co-registering event-related brain potentials with eye movement behavior (e.g., fixation onsets and saccades) during natural reading. This work will allow us to examine neural mechanisms of naturalistic reading behavior in ecologically valid environments. To achieve these aims, I recently co-organized and co-lead an international workshop bringing together experts in attention, eye tracking, and ERP research to develop best practices for ERP and eye-tracking co-registration in applied vision science (https://coregworkshop.com). This workshop was possible due to generous grant support from the ***National Science Foundation*** (*PI: Schotter, Co-PI: Payne*) and the ***Psychonomic Society*** *(PI: Schotter, Co-PI: Payne).* Related to this work, two of my PhD students are currently conducting our first eye-tracking and ERP co-registration studies in the lab. Moreover, in an upcoming NSF grant submission, my colleague Liz Schotter (USF) and I are proposing a large-scale (*N* = 200) multi-site co-registration study to systematically examine individual differences in fixation-related brain potential measures of fundamental reading processes (e.g., lexical, semantic, and syntactic processing) across the adult lifespan during natural reading. If successful, this will be the largest co-registration study to date.

Related to this work, I have a growing line of work simultaneously recording and co-registering measures of pupil dilation with ERPs to better understand the neural mechanisms underlying the cognitive pupil dilation response (PDR) – the observed increase in pupil dilation under cognitive demand— in the domains of language, memory, and attention. One recent student-led project published in *Psychophysiology* used a novel co-registration and analysis approach to examine trial-to-trial variation between the P300 ERP component and the PDR in a sustained attention task (LoTemplio et al., 2021). We showed that both physiological responses were unique and independent predictors of behavioral performance. In another student-led project recently published in *Cortex*, we used the PDR as a measure of listening effort in speech processing and showed that PDR-mediated increases in effort predicted the N400 ERP component (a neural correlate of semantic memory retrieval) and subsesquent speech memory (Silcox & Payne, 2021). These findings have implications for understanding the oft-“hidden” cognitive effects of age-related hearing loss on speech comprehension. Towards this aim, I have recently been awarded a 3 year grant from the ***National Institute of Deafness and Other Communication Disorders*** *(**R21 Early Career Award**; PI: Payne)* to use simultaneous ERP and pupillometry measures to characterize the effects of listening effort on high-level language and memory processes in older adults with sensorineural hearing loss. We believe this project will help lead to the identification of objective and reliable neural markers of comprehension and memory processes impaired by hearing loss, leading to better future clinical assessment and design of evidence-based interventions to improve speech comprehension and memory in aging.

In other ongoing work in this area, I have studied sustained attention in language processing by examining intra-individual trial-to-trial variability in behavioral and neural measures of language processing (Jongman et al., under review; Payne et al., 2020; Payne & Federmeier, 2015, 2017, 2018, 2019). This work has begun to reveal the mechanisms underlying why it is that we can sometimes process language efficiently, and other times we seem to ‘zone out’. By combining the single-item level measurement, visualization, and analysis of ERPs (Payne et al., 2015, Payne & Federmeier, 2017, 2019) with single-trial behavior (e.g., reading time) we have revealed previously ‘hidden’ neural responses coupled to reading behavior that are obscured by traditional ERP averaging methods. For example, we used these methods to show direct electrophysiological evidence for the role of cognitive control functions in the volitional control of reading (Payne & Federmeier, 2017). We have extended these findings into the assessment of comprehension processes in special populations, including adults with low literacy (Ng, Payne, et al., 2018; Payne & Silcox, 2017), and, as part of a grant funded by ***Google, LLC*** *(PI: Payne),* we’ve additionally used these methods to investigate age-related changes in the functional organization of semantic memory during reading (Silcox et al., in preparation).

Finally, in collaboration with the Utah Non-Invasive Neurostimulation Program and funded by the ***Office of the Vice President for Research*** (PI: Payne), I have been conducting a series of experiments using non-invasive brain imaging (TMS) to directly examine the role of the language production system in predictive language comprehension. To do this work, we have developed a novel methodology combining event-related TMS with functional speech mapping and recording of high-density electroencephalography (EEG) during comprehension tasks. Our first study from this project has revealed that event-related TMS to the left inferior frontal cortex (LIFC) attenuates prediction-related neural activity during a silent reading. These findings provide the first causal evidence to our knowledge of the role of the speech production network in predictive processing. Moreover, we have shown that LIFC-TMS leads to attenuation of the beneficial effects of predictability on verbal memory, suggesting downstream and enduring effects on prediction due to disruption of the speech production system (Silcox, Mickey, & Payne, under review). We believe these findings have the potential to advance causal models of the neurobiology of language and memory with implications for improving communicative competence and language remediation in aging and in certain clinical populations. Towards this translational goal, I am currently working with Dr. Julie Wambaugh (Communication Sciences and Disorders) and Lydia Kalhoff, a speech language pathology student on a project that will examine differences in predictive processing via ERPs in people with non-fluent aphasia who have LIFC lesions.

Cognitive Resilience in Adulthood

There exist considerable individual differences in cognitive and brain functioning in older adulthood, such that some adults in late life can outperform their younger counterparts in complex cognitive domains, while others show substantial deficits. What are the mechanisms that underlie this variability in aging? My line of research that addresses this question relies on the collaborative analysis of large-scale cognitive interventions such as the Senior Odyssey Study (Stine-Morrow, Payne et al., 2014), and the ACTIVE (Advanced Cognitive Training in Independent and Vital Elderly) trial (Payne et al., 2017; Gross, Payne, et al., 2018), as well as longitudinal studies including the MIDUS (Midlife In the United States, Hill et al., 2020; Dewitte et al., 2020) study. My primary goal of this work has been to highlight the role that individual differences in dispositional and personality characteristics play in understanding trajectories of healthy cognitive aging and responsiveness to interventions to promote cognitive health in aging (see reviews in Payne & Lohani, 2020; Hill & Payne, 2017). For example, my work in this domain has focused on topics such as (a) characterizing individual differences in longitudinal trajectories of change in verbal memory with aging (Payne et al., 2014), (b) examining relationships between cognitive functioning and self-referent memory beliefs (Payne et al., 2012, 2017; DeWitte et al., 2020), and (c) exploring factors that relate personality characteristics (e.g., openness) to cognitive functioning in older adulthood (Jackson et al., 2019; Hill et al., 2020). Currently, my colleagues and I are continuing this line of work by conducting intensive micro-longitudinal ambulatory assessments via home-based computerized cognitive assessments and interventions (e.g., Payne & Stine-Morrow, 2017). Towards this goal, I have recently applied for funding from the ***National Science Foundation*** (PI: *Hill, Co-PI:* Payne) to continue this collaborative work with colleagues at Washington University in St. Louis, with the goal of better understanding relationships between between daily variation in cognition, personality, and self-referent memory beliefs across the adult lifespan.