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Does posture impact affective word processing? Examining the role of posture across adulthood in an incidental encoding task

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DOES POSTURE IMPACT AFFECTIVE WORD PROCESSING? EXAMINING THE ROLE OF POSTURE ACROSS ADULTHOOD IN AN INCIDENTAL ENCODING TASK

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DOES POSTURE IMPACT AFFECTIVE WORD PROCESSING?

EXAMINING THE ROLE OF POSTURE ACROSS ADULTHOOD IN AN

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ABSTRACT

Research in emotional aging has primarily investigated mechanisms that could explain the age-related increase in positive emotionality despite various age-related losses. Of particular note is the increasing importance of age-related positivity effects and underlying biological influences on affective processes. Despite evidence of weakened mind-body connectivity in older adulthood presented in the maturation dualism framework, research shows age-similarities in subjective and objective reactivity for certain negative emotional states across adulthood. Thus, robust physiological-experiential associations may still exist in later life. Investigations of integrated mind-body connectivity have lead researchers to examine the influence of posture on cognitive outcomes. Prior evidence has observed that specific postural manipulations (i.e., stooped posture) is linked to negative affective biases in memory and emotional experiences. To interrogate potential posture effects on word recognition, an incidental encoding task was utilized. Although no age differences emerged for concrete words, younger adults outperformed older adults on both negative and neutral abstract words, and older adults remembered more positive relative to neutral abstract words. These results provide partial support for age-related positivity, perhaps in line with older adults' motivated positive affective goals. Although posture effects were absent in both age groups, there remains considerable room for other integrative research assessing mind-body connectivity within emotion-cognition links across adulthood.

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INTRODUCTION

Older adulthood is stereotypically assumed to be a time of loss. Cognitive decline is commonly discussed in the aging literature, although the impact on daily life is still debated (Salthouse, 2012). Physical age-related losses may include declines in mobility (Salzman, 2010) or trouble with vision and hearing (Schieber, 2006; Fozard & Gordon-Salant, 2001); however, “age-related” pathologies (e.g., Alzheimer’s disease, Parkinson’s disease) are sometimes incorrectly thought to be an inevitable part of aging (Morris, 1999). In contrast to this loss-dominated narrative, older individuals report living rather positive affective lives in the face of potential declines (Scheibe & Carstensen, 2010). Emotional aging research provides insight into potential age-related differences and trajectories in positive emotional functioning across the adult lifespan. Emotional functioning in old age appears to be quite positive (e.g., Carstensen et al., 2011) with research suggesting age-related decreases in experienced negative affect (Charles, Reynolds, & Gatz, 2001) combined with age-related maintenance (or increases) in positive affect (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000). Many studies have attempted to explain how older adults may utilize specific age-related mechanisms that modulate emotional experiences to favor positive affective states.

Socioemotional Selectivity & Age-Related Positivity

One explanation for positive affect trajectories in old age comes from socioemotional selectivity theory (SST; Carstensen, Isaacowitz, & Charles, 1999). This theory suggests that as individuals age, goal pursuits shift as a function of a changing time perspective—viewing time as time remaining rather than time lived (Charles & Carstensen, 1999). SST posits that, instead of seeking novel information and expanding relational networks, older adults are motivated to seek out emotionally rewarding and familiar information and relationships in order to minimize potential for negative experiences and maximize potential for positive experiences (Carstensen, 1992). In other words, older adults desire to avoid negative and pursue positive affective states.

SST predicts that as an individual ages and realizes the finitude of life, they should engage with the world in a way that helps facilitate positive affective experiences in the here-and-now. These positive affect motivations may also be reflected in how individuals process emotional information from their environment. Older adults have been observed to preferentially process (i.e., within attention and memory domains) positive relative to negative emotional stimuli in comparison to younger adults, referred to as a *positivity effect* (Mather & Carstensen, 2005; Reed, Chan, & Mikels, 2014).

Several studies have observed age-related positivity effects using memory (Carstensen & Mikels, 2005; Charles, Mather, & Carstensen, 2003; Kensinger, 2008) and attention paradigms (Isaacowitz, Toner, Goren, & Wilson, 2008; Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Noh & Isaacowitz, 2013), with the assumption that older adults' preferences for the positive over negative are in the service of hedonic well-being goals. For example, in one study, younger adults showed a recall and recognition bias for negative images whereas older adults showed no such bias (Charles, Mather, & Carstensen, 2003). When viewing faces, older adults visually engaged significantly less with anger and fear stimuli when compared with younger adults (Isaacowitz, Wadlinger, Goren, & Wilson, 2006). Furthermore, after undergoing a negative mood induction, older adults showed a gaze preference for positive faces and allocated visual attention away from negative faces while younger adults displayed a mood-congruent gaze preference for negative faces (Isaacowitz, Toner, Goren, & Wilson, 2008). These studies provide reliable evidence of age-related positivity in memory and attention such that older adults appear to engage and process positive over negative information.

While age-related positivity is observable in various empirical tasks, the strength of the positivity effect may not be consistent across all contexts. Notably, one factor that may impact emotional processing is the degree to which a stimulus arouses an individual. The prevailing assumption here is that highly arousing emotional information may be remembered easier, regardless of age, due to the enhanced bottom-up saliency of arousing information (see Mather & Carstensen, 2005). On the other hand, non-arousing information may be more amenable to top-down control processes (e.g., pro-hedonic motivation) for guiding older adults' information processing. Thus, arousal level of the stimulus may act as a moderator for when, and under what circumstances, age-related positivity occurs.

Illustrating the importance of arousal, Kensinger (2008) examined affective word processing in an incidental encoding task to examine age-related information processing biases for arousing (e.g., ecstacy v. hatred) vs. non-arousing (e.g., nature v. gloom) words. In line with the expected pattern, no age x valence interaction emerged for arousing words (i.e., within-group recognition performance was comparable for high arousing positive and negative words). Conversely, age-related positivity effects were observed for non-arousing words, with older adults remembering more positive words relative to negative words and younger adults showing the opposite pattern. Thus, distinguishing stimuli by valence and arousal reveals one potential boundary condition for age-related positivity, suggesting that older adults positive preferences are amenable to certain stimulus and situational demands.

These studies illustrate how emotion-cognition in older adulthood may be shaped by age-related positivity, arguing that (according to SST) older adults' default information processing style is to attend to positive information, which is then translated into a heightened memory for positive relative to negative stimuli. When considering what influences the extent to which these age-related information processing biases occur, much work has been devoted to exploring social and cognitive factors. For example, some work has emphasized older adults' reliance on contextual factors in emotion recognition (Ngo & Isaacowitz, 2015; Noh & Isaacowitz, 2013), showing the importance of relational stimulus features for guiding emotion perception. Additionally, cognitive control/executive functioning resources, necessary for motivated emotion regulation (Optiz, Lee, Gross, & Urry, 2014), are thought to decrease with age and demonstrate how effortful processes are used to confront and modify affective states.

Emotional aging research has also endeavored to uncover biological substrates of affective processing through various methodologies, including neuroimaging and autonomic nervous system recordings (e.g., cardiorespiratory, Uchino, Birmingham, & Berg, 2010; neuroendocrine, Piazza, Almeida, Dmitrieva, & Klein, 2010). In this way, physiological assessments complement subjective responses by allowing a more comprehensive understanding of an emotive experience by providing near real-time analysis of unfolding responses.

While these areas provide insight into fine details of information processing within the body, little attention has been given to how whole-body states may modulate psychological outcomes. Viewing cognition as a whole-body experience, researchers have attempted to address how physical states may impact cognition. Some of the earliest work regarding whole-body physical states influencing emotion-related cognitions revealed that a hunched-forward, or stooped, posture interferes with one's ability to recall pleasant memories (Riskind, 1983). This dynamic interplay between mind and body appears to inform, to some degree, how information is processed. Whole-body posture has been at the center of several recent studies investigating how whole-body states impact cognition (e.g., Michalak, Rohde, Troje, 2015). Aging undoubtedly impacts posture, but the question remains as to how this may influence mind-body connectivity. This is the focus of the current work. The present study aims to interrogate the recent research that suggests that posture is a potential modulator of cognitive and emotive processes; however, this must first be understood in the context of mind-body integration across the human adult lifespan.

Mind-Body Integration in Later Life: The Case of Sadness

In the context of the aging body, older adults' default posture is significantly more stooped when compared to younger adults (Milne & Lauder, 1974). These differences occur due to changes in spinal curvature stemming from the thoracic spine (Milne & Williamson, 1983). This stooping-forward condition, called thoracic kyphosis, is particularly prevalent in older women (Drzal-Grabiec, Snela, Rykala, Podgórska, & Banas, 2013; Hinman, 2004). Overall, aging is related to an increased prevalence in kyphotic posture, although the thresholds between "normal" and pathological kyphosis are difficult to operationalize (Ailon, Shaffrey, Lenke, Harrop, & Smith, 2015; Bartynski, Heller, Grahovac, Rothfus, & Kurs-Lasky, 2005). Spending more time in a kyphotic posture could impact both general cognitive outcomes as well as affective experiences.

Paradoxically, older adulthood is marked by general positive affect despite stooped posture being significantly more prevalent than in younger adulthood. Berry Mendes (2010) addresses this paradox by arguing that the robust body-mind connection evident in early life (e.g., adolescence and young adulthood) may potentially lose some of its integrity with advancing age. This perspective, referred to as *maturational dualism* (MD), asserts that lessened integrated reactivity to evocative stimuli in older adulthood happens as a function of three factors: (1) weakened aptitude to sense external bodily states, known as *proprioception* (Goble, Coxon, Wenderoth, Van Impe, & Swinnen, 2009; Riva, et al., 2013; Shaffer & Harrison, 2007), (2) difficulty discerning internal physical states, frequently referred to as *interoception* (Khalsa, Rudrauf, & Tranel, 2009; Pollatos, Gramann, & Schandry, 2007), and (3) lessened initial physiological reactivity to stimuli (Charles, 2010; Uchino, Birmingham, & Berg, 2010). Thus, psychological experiences become more cognitive than visceral.

Essentially, MD argues that the physiological inputs received from the body that are integrated into psychological states deteriorate over time and, thus, the body and mind become less codependent, operating as two distinct mechanisms. For example, negative affective experiences may be "felt" less by the body such that stimuli elicit less physiological reactivity. Prior research has illustrated how older adults may experience a lack of cardiovascular reactivity to certain stressors (Levenson, Carstensen, Friesen, & Ekman, 1991). Within the maturational dualism framework, weakened physiological reactivity limits the effect of the body on mental processes, namely affective experiences.

If the body impacts emotion-cognition connectivity less in older adulthood, this may help explain why older adults report high levels of positivity. Older adults may experience more robust positivity due to the body's inability to signal high arousal states. Thus, age-related positivity may result from a diminished visceral experience of high arousal (namely negative) states. Importantly, both high arousal negative and positive states may not be preferred by older adults, as they are both imbued with uncomfortable psychophysiological arousal that could jeopardize hedonic regulatory goals (see Charles, 2010 for a review). With these physiological signals reduced (and less preferred), older adults may focus on maintaining and promoting low arousing, hedonic states. As such, MD proposes that high arousal states would likely be the first to be disintegrated, as they are highly contingent upon physiological reactivity (e.g., higher sympathetic nervous system activation).

Consider anger-inducing stimuli/scenarios. Anger is largely viewed as a high arousal state. MD would predict that anger experiences become less integrated as a function of its association with high arousal negative affectivity. In line with this prediction, older adults report greater control over and fewer expressive and subjective feelings of anger when compared with younger adults (Phillips, Henry, Hosie, & Milne, 2006). Furthermore, older adults have been reported to show less physiological reactivity to anger elicitors when compared with younger adults (Charles & Carstensen, 2008).

Thus, anger states may be experienced/acknowledged less frequently, given the high arousing nature of those affective experiences.

In contrast to anger, there is evidence that sadness maintains its mind-body connection in older adulthood. Several studies report increases in self-reported sadness, as well as intact physiological reactions to sadness elicitors throughout adulthood and old age (Kunzmann, Richter, & Schmukle, 2013; Seider, Shiota, Whalen, & Levenson, 2011). A study by Kunzmann and Gruhn (2005) illustrated that subjective sadness responses to three sad film clips (e.g., *21 Grams* clip of a mother mourning the loss of her children) were significantly higher for older adults when compared to younger adults. Similar effects have been seen in other studies (Lohani & Isaacowitz, 2013; Shiota & Levenson, 2009). Older adults show more cardiorespiratory reactivity than younger adults while viewing sad film clips (Kunzmann & Grühn, 2005; Seider, Shiota, Whalen, & Levenson, 2011; Shiota & Levenson, 2009), and well as increased or comparable reactivity to sadness-eliciting autobiographical events (Kunzmann & Thomas, 2014; Kunzmann, Richter, & Schmukle, 2013; Kunzmann, Rohr, Wieck, Kappes, & Wrosch, 2017).

Although sadness has been theoretically viewed as a low arousal emotion, this is not always the case in practice. The aforementioned studies highlight how sadness elicits robust physiological reactivity in older adult samples. Furthermore, sadness-specific stimuli utilized in prior studies (e.g., film clips, autobiographical memories) illustrate the stressful nature of sadness. For instance, watching someone mourn for the loss of a loved one has been shown to provoke stress-related physiological responses highly negative subjective appraisals (Kunzmann & Grühn, 2005; Seider, Shiota, Whalen, & Levenson, 2011; Shiota & Levenson, 2009). Furthermore, mentally reliving and ruminating upon one's own past experiences of sadness promotes reliable, stress-related responses (e.g., Kunzmann et al., 2017). Thus, sadness, due to its presumed mind-body connectivity across adulthood, may serve as a prototype for understanding maintained whole-body information processing in old age.

With this in mind, the proposed research aims to interrogate broad negative information processing biases that may result from bodily states, namely posture. In prior research, posture has been related to increased negative affective experiences (e.g., Veenstra, Schneider, & Koole, 2016). Thus, adopting specific postures may elicit corresponding mental states (e.g., stooped posture elicits sad affect). As an example, individuals with depression have revealed distinct postural profiles when walking, displaying more stooping and sluggish movements compared to their never-depressed counterparts (e.g., Michalak, Troje, Fischer, Vollmar, Heidenreich, & Schulte, 2009). Thus, assessing mind-body integration in the present study may refine aspects of the current MD framework, providing potential boundary conditions for predicting the extent to which mind and body impact emotion and cognition links across adulthood.

The Effect of Posture on Emotion-Cognition Links

Evidence of maintained physiological reactivity (Kunzmann & Grühn, 2005; Seider, Shiota, Whalen, & Levenson, 2011; Shiota & Levenson, 2009) to sadness elicitors supports its visceral relevance in old age. Counter to MD, underlying physiological connections may retain their robustness in the case of sadness. More generally, these intact biopsychological connections may be modulated by whole-body states, which could then be reflected in biased information processing. In fact, one recent study indicated that posture might influence some aspects of cognition in older adulthood. For instance, more upright neck angles predicted higher verbal episodic memory scores (Cohen, Vasavada, Wiest, & Schmitter-Edgecombe, 2016), indicating that a more alert and upright posture positively impacted cognitive performance in an older adult sample. Thus, if posture can impact performance on basic cognitive tasks with non-emotional stimuli, effects could perhaps be observed when processing affective information.

Recent evidence shows that upright postures may allow individuals with mild-to-moderate depression to experience enhanced positive emotions and heightened energy levels (Wilkes, Kydd, Sagar, & Broadbent, 2017). In contrast, stooped postures have been associated with lower energy levels (Peper & Lin, 2012), more negative affect (Veenstra, Schneider, & Koole, 2017), and difficulty recalling positive memories (Tsai, Peper, & Lin, 2016; Wilson & Peper, 2004). This evidence supports the notion that upright posture may allow people to "look on the bright side," whereas stooped posture is associated with a more negative affective profile.

Recent work has associated major depressive disorder (MDD) with specific body postures. Michalak and colleagues (2009) illustrated how cognition and emotion may be linked in the posture and gait patterns of individuals with MDD. People who were currently depressed displayed significantly slower walking rates, shorter stride length, and more stooped postures compared to non-depressed individuals (Michalak, et al., 2009). Furthermore, when non-depressed individuals adopted this "depressed" walking pattern, they exhibited significant self-referential negative information processing biases (Michalak, Rohde, & Troje, 2015). Here, participants were asked to remember words by constructing a self-referential mental scene that encompassed the presented word. The finding of negative biases in the context of this self-referential task supports the claim that adopting a more stooped posture, congruent with that of a depressed individual, influences emotional stimulus processing.

A similar study indicated that by manipulating sitting posture, individuals with MDD no longer demonstrated negative episodic memory biases if placed in an upright posture (Michalak, Mischnat, & Teismann, 2014). This dynamic interplay between posture and emotion-related cognitions indicates that manipulating posture may produce downstream effects on information processing. This literature particularly implicates stooped posture as producing negativity biases, driven either by more easily engaging with negative material or difficulties working with positive material (Tsai, Peper, & Lin, 2016; Wilson & Peper, 2004).

Deciphering what is known about older adults' default posture, how can the finding of age-related positivity coexist with evidence of increased kyphosis in older adulthood and an apparent link between stooped, kyphotic posture and negativity biases? If aging has such a deleterious effect on posture, MD would argue that posture effects on emotive processing may be less pronounced or non-existent. However, evidence of heightened/maintained sadness reactivity in older relative to younger adulthood (e.g., Kunzmann & Grühn, 2005; Seider, Shiota, Whalen, & Levenson, 2011; Shiota & Levenson, 2009) may indicate that adopting a more stooped posture may modulate responsivity to negative stimuli, irrespective of age.

The proposed research will help elucidate how emotive processing across age groups may be affected by postural states. Understanding how posture may impact emotional information processing in older adulthood may provide a new perspective on our understanding of the apparent paradox of higher general positive affect in spite of age-related declines. This study aims to address potential boundary conditions of the maturational dualism framework by assessing how posture may interact with emotional word processing. For instance, age-related positivity could be embedded in whole-body physiology and modulated by adopting various postural states; thus, theoretical notions of age-related emotional processing and well-being trajectories throughout the adult lifespan would need to incorporate this information.

The Present Study

The primary goal of the proposed research is to uncover potential interactions between age and posture during affective information processing, with the purpose of expanding upon theoretical notions of emotional aging, particularly in the context of age-related positivity. When discussing the disconnect between bodily states and mental processes in older adulthood, MD would argue that integration between underlying physiological arousal and bodily states (e.g., posture) will exert little to no effect on emotion-related cognitions and affective experiences among older adults. However, counter to these theoretical predictions, sadness appears to retain its physiological robustness in older adulthood (Haase, Seider, Shiota, & Levenson, 2012; Kunzmann et al., 2017; Kunzmann & Grühn, 2005; Kunzmann, Kappes, & Wrosch, 2014; Seider, Shiota, Whalen, & Levenson, 2011; Shiota & Levenson, 2009). We contend that evidence regarding intact psychophysiological sadness reactivity in later life provides reason to believe that mind-body connectivity may yet remain to some degree with advancing age.

If pronounced biases in memory (Michalak, Mischnat, & Teismann, 2014; Michalak, Rohde, & Troje, 2015; Tsai, Peper, & Lin, 2016; Wilson & Peper, 2004) and affective responses (Nair, Sagar, Sollers, III, Consedine, & Broadbent, 2014; Veenstra, Schneider, & Koole, 2017; Wilkes, Kydd, Sagar, & Broadbent, 2017) can be elicited by adopting a stooped posture, what then could be expected for older adults who may spend more time in that stooped, kyphotic posture? This literature needs to be expanded into an exploration of how posture may impact the degree to which age-related positivity effects will be observed.

Aiming to examine posture effects on general information processing, this research will make use of an incidental encoding task from Kensinger (2008) to uncover potential surreptitious effects of posture on information processing. This task will provide insight into how age and posture interact to influence affective-based cognitive information processing biases (e.g., Michalak, Mischnat, & Teismann, 2014). Given the existing evidence outlining negativity biases that co-occur with stooped posture (Michalak, Mischnat, & Teismann, 2014; Tsai, Peper, & Lin, 2016; Wilson & Peper, 2004), posture is expected to directly influence participants' word recognition performance. Hence, two specific hypotheses are proposed:

Hypothesis 1:

> Word valence and posture will interact such that stooped posture, regardless of age group, will lead to a negativity bias in word recognition. This prediction is intended to test whether the results from this study are in line with prior literature reporting posture-related negativity biases (e.g., Michalak, Rohde, & Troje, 2015).

Hypothesis 2:

Age, word valence, and posture are expected to interact to produce differential patterns of affective word recognition. We predict that both younger and older adults will display negativity biases while in a stooped posture; however, in an upright posture, older adults will display positivity biases based on SST predictions (Reed, Chan, & Mikels, 2014).

CHAPTER II

METHOD

Participants

60 undergraduate students from Cleveland State University (ages 18-30) and 53 community-dwelling older adults (60+) were recruited for this study. An online research participation database (SONA Systems) was used to recruit younger adults who received partial college credit for their participation. Older adult participants were recruited from the Project 60 initiative at CSU and an extant database of past participants in studies conducted by the Aging, Cognition, and Emotion (ACE) laboratory. Older adults were compensated at the rate of $10/hr.

All participants were screened for severe back problems (e.g., scoliosis, osteoporosis, spinal disc herniation) or recent back surgeries (e.g., spinal fusion), ensuring comfortability with the postural manipulation. Older adults were pre-screened for these issues; however, two younger adults were excluded due to spinal issues. Fifty-eight younger and 53 older adults completed the study; however, one younger adult was excluded due to lost data. See Table 1 for information on all demographic, affect, cognitive, and experiment-related variables. This study was approved by the Institutional Review Board at CSU under the criterion put forth by the Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research.

Materials

All stimuli (e.g., videos, instructions, memory words) were presented using SensoriMotoric Instruments (SMI) Experiment Center 2.0 (Berlin, Germany). All participants provided information regarding their gender, race, ethnicity, marital status, and subjective physical health. Additional personality and affect questionnaires (see below) were completed using Qualtrics Online Survey Software.

Cognitive assessment. Participants completed an executive functioning battery (Glisky, Polster, & Routhieaux, 1995) to gain a snapshot of cognitive functioning and determine whether any potential performance differences on the emotional word memory task could be accounted for by age differences in basic cognitive faculties. This battery assessed cognition via 4 tasks: word fluency, backwards digit span, mental arithmetic, mental control, and Shipley's vocabulary test. A single, composite executive/frontal lobe functioning score was created using preexisting factor loading values for z-score transformations such that standardized performance on each individual task was weighted across each task. There were no group differences in overall cognitive scores based on age or posture (see Table 1).

Posture assessment. The Lumo Lift (designed by Lumo Bodytech) was used to monitor and manipulate posture. Each participant was asked to assume either the upright or slouched posture prior to having the Lumo Lift affixed. Configuration of the Lumo Lift allowed for adjustments based on height, weight, sex, and age in addition to setting a three-second delay for posture correction. When a deviation from the target posture was detected, it vibrated as a corrective measure to maintain adherence to the manipulated posture and minimize human error. Participants often verbally reported to the experimenter when the device vibrated although not explicitly told to do so.

Due to age-differences in baseline posture, it is important to note the baseline differences in the same way one would approach physiological reactivity assessments. Spinal curvature was assessed using the protocol for clinical assessment of kyphosis (Prost, 2015) and a flexicurve ruler (Staedtler Mars Inc, Nurnberg, Germany). The flexicurve ruler is a malleable band of metal covered with plastic that retains the shape in which it is bent. Participants were told: *"Stand in your usual best posture, resting your hands on the table in front of you. Look straight ahead."* After molding the flexicurve to the contour of the spine, the spinal process curvature was transposed onto graph paper. This methodology has been validated in studies on older adults (Yanagawa, Maitland, Burgess, Young, & Hanley, 2000) in addition to being a valid assessment tool when compared with X-ray measures of spinal curvature (Scheeren de Oliveira, et al., 2012).

Affect and well-being. The Positive Affect and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) and the 5-item Satisfaction with Life Scale (SWLS; Diener et al., 1985) were used to index subjective well-being, independently and as a composite. The Center for Epidemiological Studies – Depression Scale (CES-D; Radloff, 1977) assessed subclinical depressive symptoms. Momentary affect was assessed six times throughout the experiment via on-screen prompts asking participants to rate the present emotionality on a 10-point Likert scale from 1 (*negative*) to 10 (*positive*).

Table 1.

Group Differences in Demographic, Cognitive, Affective, & Experiment-Related Variables

Variable		YA (n = 57)		OA (n = 53)				
		Upright	Stooped	Upright	Stooped	F	p	η_p^2
Gender	M/F	7 / 21	6 / 23	13 / 14	15 / 11	-	-	-
Age	*M* (*SD*)	19.1 (1.57)	19.2 (1.66)	70.1 (7.30)	71.0 (6.79)	$.23^{YA}$ $.46^{OA}$	.82 .65	- -
Education*	*M* (*SE*)	13.4^{a} (.42)	13.1^{a} (.42)	16.8^{b} (.43)	17.7^{b} (.44)	86.72^{A}	< .001	.45
Subjective Health	*M* (*SE*)	4.21 (.11)	4.35 (.11)	4.22 (.11)	4.23 (.11)	$.41^{P}$	.53	.00
BAQ	*M* (*SE*)	87.6 (2.52)	85.0 (2.48)	86.5 (2.57)	82.6 (2.62)	1.69^{P}	.20	.02
Cognitive Composite	*M* (*SE*)	-.04 (.30)	-.42 (.30)	.29 (.31)	.27 (.31)	2.78^{A}	.098	.03
Positive Affect*	*M* (*SE*)	35.0^{a} (1.15)	34.1^{a} (1.13)	39.1^{b} (1.17)	37.4^{b} (1.20)	10.27^{A}	.002	.09
Negative Affect*$^{+}$	*M* (*SE*)	16.3^{a} (1.01)	18.8^{b} (1.00)	$14.9^{a,c}$ (1.03)	13.5^{c} (1.05)	10.46^{A} 5.47^{X}	.002 .056	.09 .03
SWLS^{+}	*M* (*SE*)	24.6^{a} (1.07)	23.6^{a} (1.05)	$25.3^{a,b}$ (1.09)	27.0^{b} (1.11)	3.54^{A}	.06	.03
CES-D*	*M* (*SE*)	9.79^{a} (1.40)	12.9^{b} (1.37)	7.00^{c} (1.42)	6.42^{c} (1.45)	10.89^{A}	< .001	.09
Posture Comfort*	*M* (*SE*)	6.29^{a} (.23)	$5.86^{a,b}$ (.23)	$5.70^{a,b}$ (.24)	5.42^{b} (.24)	4.65^{A}	.033	.04
Posture Adherence*	*M* (*SE*)	4.68^{a} (.21)	$4.93^{a,b}$ (.21)	5.44^{c} (.22)	$5.20^{b,c}$ (.22)	5.62^{A}	.02	.05
% of Time in Posture*	*M* (*SE*)	88.8^{b} (2.20)	93.0^{a} (2.16)	93.7^{a} (2.24)	88.5^{b} (2.29)	4.48^{X}	.04	.04
Curvature Change*	*M* (*SE*)	$.17^{a}$ (.17)	$-.97^{b}$ (.16)	$.58^{c}$ (.16)	$-.45^{d}$ (.17)	8.09^{A} 43.20^{P}	.005 < .001	.07 .30

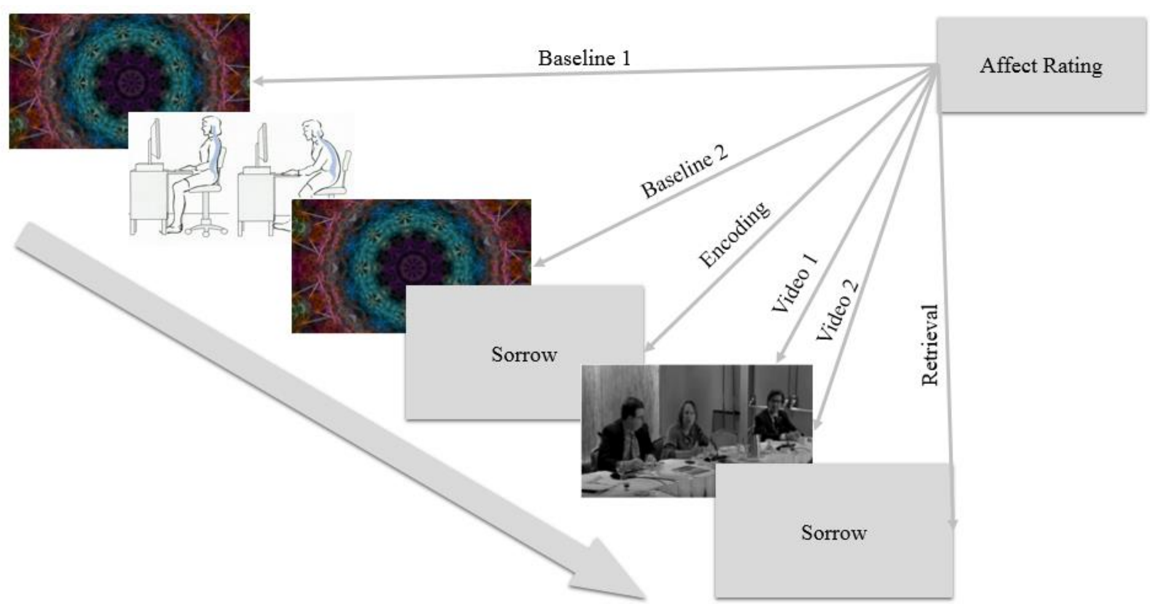
Note. 2 (Age; Younger, Older) X 2 (Posture; Upright, Stooped) ANOVAs were conducted except for chronological age where an independent samples t-tests was used. Values in a row with the same letters are not significantly different. ^{A} = Age Main Effect. ^{P} = Posture Main Effect. ^{X} = Interaction.

Procedure

See Figure 1 for a visual representation of the experimental protocol. Upon completion of an initial health screening and informed consent, participants received the battery of well-being, affect, and cognitive tests. Participants were then affixed with electrodes for electrocardiogram (ECG) recordings to mask the primary purpose of the study. To mask the role of posture, the recording of the normal spinal curvature was recorded prior to affixing the ECG equipment. Participants were told that spinal curvature needed to be assessed to better locate where the electrodes need to be placed. After the ECG configuration, baseline assessments of heart rate and respiration were conducted prior to participants assuming their assigned posture. This baseline assessment included participants watching a kaleidoscope screen-saver video for roughly 3 minutes.

Once initial baseline recording was completed, an initial affect rating was obtained. Then, participants were told, *"the ECG signal appears to be getting disrupted by electrical interference. We have an extra piece of equipment to help sort this issue out.*

Figure 1. *Experimental protocol.*



It is safe and should cause no discomfort to you. This will simply clean up the ECG signal and vibrate when the signal begins to get disrupted." This acted as a cover story for the inclusion of the Lumo Lift. Once the randomly assigned posture is assumed, the participant underwent a second baseline assessment under the guise of a re-run; however, this functioned to assess resting physiological activity in the manipulated posture. This second baseline recording, again roughly 3 minutes, served as an intermediate period where participants acclimated to the assigned postural state.

Incidental encoding task. Adapted from Kensinger (2008), a recognition paradigm was used to assess incidentally encoded word stimuli. 300 words (100 non-arousing positive, 100 non-arousing negative, 100 neutral) were presented from the Affective Norms for English Words (ANEW; Bradley and Lang, 1999) database. See Table 2 for valence, arousal, and frequency data for selected words. Participants underwent a brief practice period (5 words) to acclimate to the speed of word presentation and making button press selections. During the encoding phase, 50 of each word type were presented in a randomized order with a three-second display time.

Table 2. *Descriptive Statistics of Selected ANEW Words*

Emotion	Valence	Arousal	Frequency
Positive	6.85[a]	4.37[a]	17.5[a]
	(.53)	(.54)	(15.2)
Neutral	5.07[b]	4.01[b]	18.4[a]
	(.50)	(.46)	(12.2)
Negative	2.95[c]	4.39[a]	16.7[a]
	(.69)	(.51)	(29.2)

Note. Values in the same column with the same letters are not significantly different. Values with different letters in the same column are significantly different.

After categorizing the first 150 words as concrete or abstract with a key press, participants watched two neutral film clips for a total of 10 minutes to provide a consolidation delay period (see Kensinger, 2008, for a similar retention interval timecourse). During the retrieval phase, participants were presented with all 300 words and asked to identify the 150 old words presented during encoding from a list of 150 new words introduced at retrieval. For both encoding and retrieval, words were pseudo-randomized with no more than four words of the same valence repeated. Corrected recognition scores were then calculated by subtracting the false alarm rate – indicating a word as old when new – from the hit rate – indicating a word as old when old. This methodology is in line with prior research (Kensinger, 2008).

Debriefing. Prior to the removal of the Lumo Lift, participants responded to several questions to ensure that potential effects of posture were not jeopardized due to expectancy effects and awareness of the manipulation. Participants reported if they had any ideas regarding the goal of the study or the manipulations. No participant reported an awareness of the postural manipulations. No differences in memory performance for positive, negative, or neutral words emerged for participants who did (15 YA, 12 OA) and did not (42 YA, 41 OA) expect their memory to be tested (YA: $t(55) = .17$, $p = .87$, $t(55) = .22$, $p = .83$, $t(55) = .55$, $p = .59$; OA: $t(51) = .16$, $p = .87$, $t(51) = .01$, $p = .99$, $t(51) = .30$, $p = .76$). Once informed of the posture manipulation, participants rated how comfortable they were and how well they thought they adhered to their assigned posture on a 7-point Likert scale from 1 (*not at all*) to 7 (*very much so*). Spinal curvature was assessed a second time to account for changes from baseline. Participants were then compensated, given contact information, and thanked.

CHAPTER III

RESULTS

To begin, groups were compared on demographic, cognitive, affective, and experiment-related variables via 2 (Age; Younger, Older) × 2 (Posture; Upright, Stooped) factorial ANOVAs with age and posture condition as between-subjects factors. These results are noted in the far right column of Table 1. No significant differences emerged in subjective health ratings or BAQ scores; however, older adults were more educated. No age differences on the cognitive functioning composite were obtained. The affective battery yielded results similar to past studies with older adults reporting more positive affect, less negative affect, more satisfaction with life, and fewer depression symptoms. However, although these assessments were done prior to posture manipulations, an interaction between age and posture emerged for negative affect such that younger adults in a stooped posture reported more negative affect than those in an upright posture. There were no differences between the older adult groups as a function of posture

Regarding experiment-related variables, older adults rated their assigned postures as less comfortable. This was slightly corroborated by percentages of time spent in the posture; there was a significant interaction such that older adults in a stooped posture spent less time in their assigned posture. The older adults in a stooped posture also reported their posture as the least comfortable in comparison to all other groups. Regarding self-rated adherence, older adults reported higher levels of adherence to the postural manipulation.

Differences between pre-test and post-test spinal curvature assessments illustrate an age effect as well as a posture effect. The posture effect is in the expected direction with more negative values in the stooped condition, indicating more kyphotic posture (i.e. more stooping). The age effect highlights the well-documented effect of age on posture such that older adults are more stooped, which translates into more room to revert to an upright posture but less room to accentuate stooping. On average, younger adults deviated from baseline very little in the upright condition, while there was a 30% deviation in the stooped condition. Older adults had an average deviation of 13% in the upright condition and 18% in the stooped condition. These apparent age differences in deviations were not statistically significant when tested via independent samples *t*-tests ($t(46) = 1.70$, $p = .09$ for upright; $t(41) = 1.39$, $p = .17$ for stooped).

To determine which of these variables identified in Table 1 related to memory performance, correlation coefficients were calculated. After correcting for multiple comparisons using Bonferroni corrections, only the cognitive composite significantly correlated with corrected recognition scores ($r = .25$ for positive; $r = .27$ for negative; $r = .25$ for neutral; ps $< .01$). As a result, the cognitive functioning composite was identified as an important covariate; however, the affect and posture comfort/adherence ratings were also used as covariates in the omnibus analyses given our a priori assumption that these individual difference factors could impact either a.) valenced-based memory performance and/or b.) affect ratings throughout the memory task. .

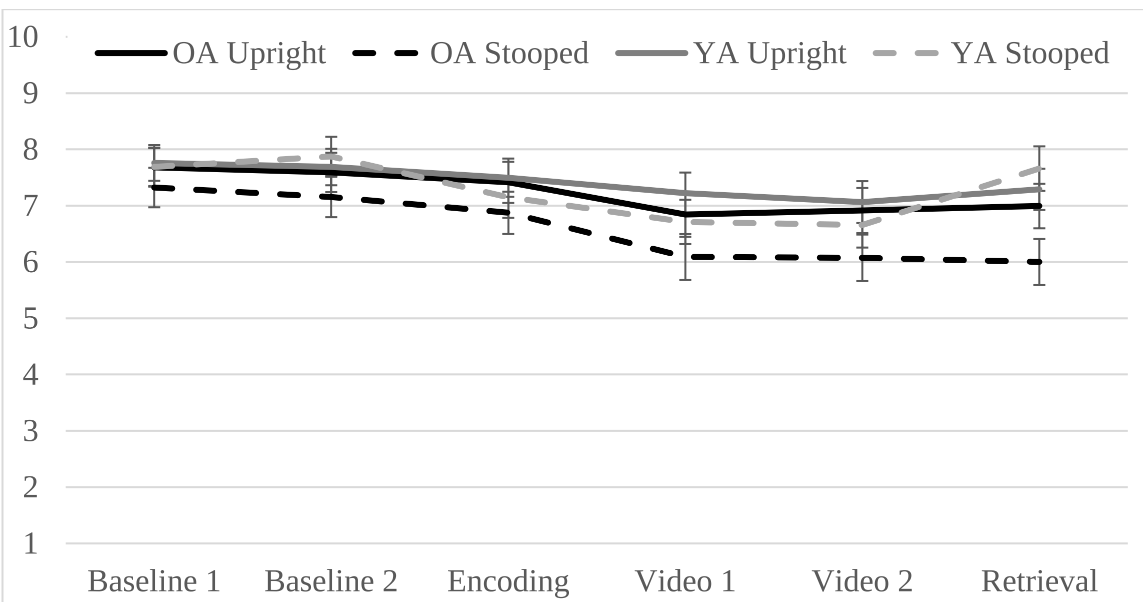
Outlier analyses were then conducted to ensure participants were adhering to their assigned posture, with time spent in posture being above 75% for YA and above 78% for OA. Adequate performance on the memory task was also tested with cutoff values of -.20 for positive, -.06 for negative, .00 for neutral for (YA) and -.08 for positive, -.04 for negative, -.06 for neutral for OA. Cutoffs were determined using 1.5 times the interquartile range as determined from Tukey boxplots (Brillinger, 2011), and these were calculated separately for younger and older adults. Four younger adults and 7 older adults were identified as outliers due to low percent time spent in their assigned posture. Additionally, 4 younger adults and 2 older adults were excluded based on low memory performance. These participants were excluded from all subsequent analyses. As a result, there were 49 younger adults (25 upright, 24 stooped) and 44 older adults (23 upright, 21 stooped) included in the full analyses.

First, mood changes across the experiment were examined to assess whether posture was impacting current affect during the memory task. Each mood rating was uncorrelated with memory performance (*p*s > .70). Next, a 2 (Age; Younger, Older) × 2 (Posture; Upright, Stooped) × 6 (Time; Baseline 1, Baseline 2, Encoding, Video 1, Video 2, Retrieval) mixed ANOVA was conducted using the Greenhouse-Geisser correction due to a violation of the sphericity assumption. There was a main effect of time, $F(2.64, 234.9) = 23.51$, $p < .001$, $\eta_p^2 = .21$, but no interactions emerged (*p*s > .10 after correction). Interestingly, the main effect of posture was trending towards significance,

$F(1,89) = 3.41$, $p = .068$, $\eta_p^2 = .04$, with stooped posture being associated with lower mood scores.

When examining simple main effects to determine if only one age group was illustrating a posture effect, a marginal interaction between posture and mood emerged for younger adults, $F(2.89,124.7) = 2.68$, $p = .057$, $\eta_p^2 = .05$. However, when individual differences in pre-experimental well-being (as assessed via the CES-D, PANAS, and SWLS) were accounted for, the main effect of time and marginal effect of posture were no longer significant. Higher well-being (i.e. lower CES-D scores, higher SWLS, more positive affect) was associated with better mood and vice versa. Figure 2 illustrates how mood decreased over time for all groups, irrespective of age and posture condition when accounting for pre-experiment well-being.

Figure 2. *Instantaneous mood changes during the experiment.*



Note. Error bars represent standard errors for estimated marginal means when controlling for individual differences in global affect measures. *N* sizes after outlier exclusion are 24 OA Upright, 21 OA Stooped, 25 YA Upright, and 24 YA Stooped.

To test the proposed hypotheses, a 2 (Age; Younger, Older) × 2 (Posture; Upright, Stooped) × 3 (Word Valence; Positive, Negative, Neutral) repeated-measures ANOVA was conducted with age and posture as between-subjects factors and word valence as the repeated within-subjects factor. There were no significant main effects of age or posture (*p*s > .50); however, there was a significant main effect of word valence, $F(2,178) = 25.21$, $p < .001$, $\eta_p^2 = .22$. Counterintuitively, neutral words ($M = .61$, $SE = .02$) were remembered better (*p*s < .001) than positive ($M = .55$, $SD = .02$) and negative words ($M = .52$, $SE = .02$). Positive words were remembered better than negative words ($p = .013$).

Contrary to Hypothesis 1, the interaction between word valence and age was non-significant, $F(2,178) = 1.53$, $p =.22$, as well as the other two-way interactions (word valence × posture: $F(2,178) = .52$, $p = .59$; age × posture: $F(1,89) = 1.95$, $p = .17$). Contrary to Hypothesis 2, the 3-way interaction between age, posture, and word valence was non-significant, $F(2,178) = 1.50$, $p = .23$. These effects remained non-significant when covariates (i.e. cognitive, affective, and posture comfort/adherence) were included, indicating that suppressor effects were likely not at play. In the absence of any significant posture effects, the simple interaction between posture and word valence was tested in the younger adult group in light of previous studies documenting posture effects. Failing to replicate past findings, the simple interaction between posture and word valence did not emerge within the younger adult group when tested in isolation, $F(2,94) = 1.51$, $p = .23$.

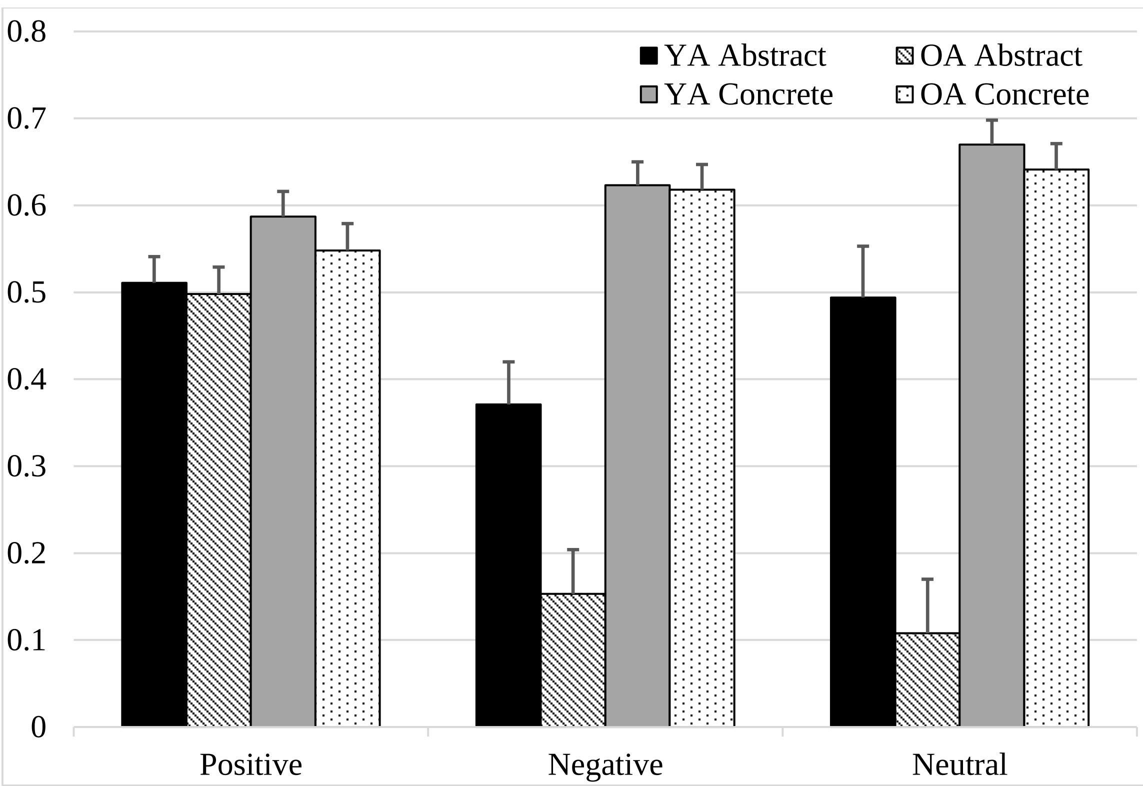
These null findings, the lack of main effects in particular, were quite unexpected; thus, further exploration was deemed necessary. First, performance on the initial word sorting task may have impacted performance on the subsequent recognition task. To test this, partial correlation coefficients between corrected recognition scores and accuracy scores during the word sorting task for positive, negative, and neutral words were calculated (adjusting for cognitive composite scores). No significant correlations emerged between any corrected recognition scores and accuracy scores (*p*s > .20).

Next, additional aspects of the word stimuli were investigated. Since participants were asked to sort each word as either abstract or concrete during the encoding task, we assessed whether this semantic feature could have influenced recognition performance. There were unequal distributions of abstract and concrete words within the emotion categories, as noted by a Chi-square analysis, χ^2 (2, N = 300) = 21.24, $p < .001$. There were significantly more concrete neutral words (n = 80) than abstract neutral words (n = 20), whereas positive and negative words were relatively equal across categories (n = 48 abstract, n = 52 concrete; n = 47 abstract, n = 53 concrete; respectively). Corrected recognition scores were then calculated for the 6 groups: abstract positive, abstract negative, abstract neutral, concrete positive, concrete negative, and concrete neutral.

Word type (2; abstract, concrete) was added as a within-subjects factor in the 2 (Age; Younger, Older) × 2 (Posture; Upright, Stooped) × 3 (Word Valence; Positive, Negative, Neutral) repeated-measures ANOVA with cognitive composite scores as a primary covariate. This yielded a significant main effect of word type, $F(1,88) = 95.05$, $p < .001$, $\eta_p^2 = .52$, word valence, $F(2,176) = 12.07$, $p < .001$, $\eta_p^2 = .12$, and age, $F(1,88) = 9.89$, $p = .002$, $\eta_p^2 = .10$. The main effect of posture and all interactions including posture were non-significant (*p*s > .09). Age interacted with word type and word valence, $F(1,88) = 10.60$, $p = .002$, $\eta_p^2 = .11$; $F(2,176) = 9.50$, $p < .001$, $\eta_p^2 = .10$, respectively. The interaction between word type and word valence was also significant, $F(2,176) = 35.53$, $p < .001$, $\eta_p^2 = .29$. However, these effects were qualified by a 3-way interaction between age, word type, and word valence, $F(2,176) = 10.44$, $p < .001$, $\eta_p^2 = .11$. Importantly, accounting for all additional covariates (i.e., well-being and posture comfort/adherence), the 3-way interaction remained. See Figure 3 for a visual representation.

Age differences within each category were tested via independent samples *t*-tests. Older and younger adults did not differ in their recognition of concrete words across all emotion categories (*p*s > .60). However, for abstract words, younger adults outperformed older adults on negative, $t(91) = 2.27$, $p = .03$, $r^2 = .05$, and neutral words, $t(91) = 3.49$, $p = .001$, $r^2 = .12$. No age differences emerged for abstract positive words, $t(91) = .19$, $p = .85$. Both age groups more accurately remembered concrete words, regardless of emotion, whereas older adults' performance declined for abstract words except for positive words.

Figure 3. *Illustrating the 3-way interaction between age, word type, and word valence.*



Note. Error bars represent standard errors for estimated marginal means in the omnibus test with cognitive composite scores as a covariate. *N* sizes after outlier exclusion are 24 OA Upright, 21 OA Stooped, 25 YA Upright, and 24 YA Stooped.

Irrespective of valence, younger adults performed significantly worse on all abstract words when compared concrete words, *t*s(48) > 2.95, *p*s < .01. Older adults displayed a similar pattern for negative and neutral words, *t*s(43) > 6.50 , *p*s < .001; however, this difference was only marginal for positive words, *t*(43) = 1.97, *p* = .055. Comparing abstract words within age groups, older adults more accurately remembered positive relative to negative, *t*(43) = 5.80, *p* < .001, r^2 = .44, and neutral words, *t*(43) = 5.11, *p* < .001, r^2 = .38. Younger adults displayed a similar pattern, with positive words more accurately remembered than negative, *t*(48) = 3.32, *p* = .002, r^2 = .19, although there was no significant difference between positive and neutral, *t*(48) = .791, *p* = .43.

Although corrected recognition scores take into account response biases, total accuracy was also assessed. This was done by creating a percentage score (total correct divided total possible) for each of the 6 categories. Thus, another 2 (Age; Younger, Older) × 2 (Posture; Upright, Stooped) × 2 (Word Type; abstract, concrete) × 3 (Word Valence; Positive, Negative, Neutral) repeated-measures ANOVA with cognitive composite as a covariate was conducted on these percentage scores. The 3-way interaction between age, word valence, and word type remained significant, *F*(2,176) = 3.90, *p* = .022, η_p^2 = .04. When other covariates were added into the analysis, the 3-way interaction often dropped to a marginal level; however, this likely reflects the lower sensitivity of this metric making group differences less distinct. For example, if a participant correctly identified 35 old and 35 new words out of the 80 neutral concrete words presented, they would have a percentage score of .875 (70 divided by 80) as opposed to a corrected recognition score of .75. For abstract words, older adults remembered more positive words than negative, *t*(43) = 4.31, *p* < .001, r^2 = .30, and neutral words, $t(43) = 4.73$, $p < .001$, $r^2 = .34$. Younger adults showed the same pattern, $t(48) = 2.69$, $p = .01$, $r^2 = .13$; $t(48) = 2.21$, $p = .032$, $r^2 = .09$, respectively, although to a lesser degree. This pattern follows results obtained with corrected recognition scores.

CHAPTER IV

DISCUSSION

The current study intended to illuminate how age, posture, and emotion may interact to produce biased word processing. Previous research has routinely illustrated age-related positivity effects (e.g., Kensinger, 2008), age differences in physiological reactivity to emotional stimuli (e.g., Kunzmann, et al., 2017), and postural influences on the processing of emotionally laden information (e.g., Michalak, Mischnat, & Teismann, 2014). However, integrating this research into a single study has not been done, particularly in the context of aging. As a result, several predictions were made integrating prevailing evidence across these areas.

First, it was predicted that age and word valence would interact such that older adults would correctly recognize more positive relative to negative words in comparison to younger adults, reflective of an age-related positivity effect predicated on tenets of SST (e.g., Charles & Carstensen, 1999). Second, age, posture, and word valence were expected to interact given evidence of negativity biases among younger adults when displaying a stooped posture. This 3-way interaction was expected to produce negativity biases in stooped postures for both age groups and an age-related positivity bias when individuals displayed an upright posture. Ultimately, after incorporating word type, positivity effects emerged; however, posture appeared unrelated to memory performance.

Semantic and Emotional Content for Low Arousal Words

Past research suggests that age-related positivity effects may emerge as a function of deliberative, top-down processing in an effort to maximize positive emotional experiences (Reed & Carstensen, 2012). Although positive preferences were observed in the present study, an important boundary condition of word type emerged. There were no age differences within any emotional category for concrete words; however, for abstract words, age differences emerged only for negative and neutral words, not for positive words. Furthermore, older adults remembered significantly more positive relative to negative words, and younger adults displayed a similar pattern, although to a lesser degree. These results provide some support for positivity in emotional information processing (e.g., Kensinger, 2008; Reed, Chan, & Mikels, 2014) while also illuminating another potential stimulus feature for when such effects manifest.

Utilizing a prior incidental encoding procedure from Kensinger (2008), only low arousal words were selected (see Table 2). This was because, in that study, age-related positivity effects emerged only within low arousal word stimuli while no valence-based recognition differences were observed for high arousal words. The lack of valence differences among high arousal words was thought to reflect automatic, bottom-up salience of high-intensity information. Low arousal words were thought to require more controlled, top-down processing, which might have facilitated older adults' positive preferences (i.e., akin to research suggesting that top-down control is necessary for effective implementation of positive affective preferences; Kryla-Lighthall & Mather, 2008). However, within concrete words, the emotional recognition benefit was not observed. Conversely, for abstract words, positive preferences were observed.

One potential methodological explanation for heightened memory performance on concrete words could be the greater number of words presented within this category. There were 80 neutral, 52 positive, and 53 negative concrete words used in the present study. Thus, recognition scores could have potentially been inflated due to more trials. However, the use of corrected recognition scores as the dependent variable utilizes hit and false alarm rates rather than raw scores. Theoretically, this should reflect a more undistorted view of performance, as response biases are controlled for within such an analysis. Furthermore, the 3-way interaction remained when using percentage scores.

Yet, there still may be insidious effects of the unequal groups of abstract and concrete words within each emotion category. If these discrepancies did make a difference, they would be within the smallest group: the neutral abstract words. With only 20 words, one mistake would result in a 5% reduction in performance. Due to the remarkably low levels of accuracy for older adults, this could have played a role. However, older adults remembered negative and neutral abstract words to a similar degree. Furthermore, older adults remembered positive abstract words to the same degree as younger adults. This leads to the conclusion that there may have been preferential processing at play.

One possibility for the concrete/abstract discrepancy could be related to how these words were processed, as prior studies provide evidence that abstract and concrete words are differentially processed. Using a word recognition task with non-emotional abstract and concrete words, Peters and Daum (2008) studied a lifespan sample of younger, middle, and older adults. All age groups more accurately remembered concrete words relative to abstract words, and the authors argue that this 'concreteness' effect illustrates how image-based associations are more readily available for concrete words. Sensory experiences, namely visual, may be more readily available for concrete words whereas abstract words may require more intensive cognitive processing (e.g., conjuring up a scene). For example, upon viewing "lightbulb," few people would experience difficulty creating a mental image of that word whereas "easygoing" is probably a bit more difficult to visualize. With only 3 seconds of exposure to each word during the initial word sorting task, this could have allowed concrete words to be more fully processed, resulting in fewer recognition errors.

Beyond this robust 'concreteness' effect, past research investigating emotional words (as opposed to non-emotional words) is equivocal. Using a lexical decision-making task, Yao and colleagues (2018) examined emotional memory for concrete and abstract words. They found that emotional words were recognized faster than neutral words; however, this effect was significantly greater for abstract words. Kousta and colleagues (2011) also used lexical decision-making tasks to highlight this affective benefit of abstract words, both in overall ratings of affectivity within the words and subsequent memory performance. Thus, past research suggests that abstract words are more emotionally tinged, and this translates to heightened performance.

Within the present study, the lack of age differences among concrete words, regardless of emotional content, follows the 'concreteness' effect illustrated in Peters and Daum (2008). Although concrete words may possess image-based associates that are more easily processed, abstract words are thought to benefit from their affective nature (e.g., Kousta et al., 2011). Here, a significant age by valence interaction emerged. Younger adults outperformed older adults when recognizing negative and neutral words, but positive word recognition was comparable between age groups. In the absence of image-based, semantic associates, word valence influenced word recognition for abstract words. Thus, although to differing degrees, both semantic (abstract/concrete) and emotional (positive/negative/neutral) content appear to have contributed to how individuals remembered words within this experiment.

As noted earlier, SST argues that as a function of a pro-hedonic motivational shift in later life, meta-cognitive mechanisms, namely age-related positivity, underscore how older adults engage with information. However, these cognitive mechanisms are contingent upon the availability of resources and the ability to successfully and selectively deploy attention toward positive and away from negative stimuli. Thus, the current study was able to address task performance motivation and general cognitive functioning as potential alternative explanations.

In terms of performance motivation, in a recent meta-analysis, Reed, Chan, and Mikels (2014) suggested that task demands might play a significant role in whether or not age-related positivity emerges. Specifically, if participants are explicitly told that their memory will be tested, positivity biases tend not to manifest. Thus, an incidental encoding paradigm should provide more optimal conditions for detecting effects. In the present study, among those who suspected that their memory would be tested, no performance differences were observed, suggesting that the incidental encoding procedure did not introduce performance-oriented demand characteristics. Furthermore, if participants were motivated to perform well on the abstract/concrete word sorting task, this could have lead to subsequent differences in recognition. If this were the case, word sorting performance and corrected recognition scores should have been related; however, this was not the case, suggesting that motivation to perform well on the initial word sorting task did not appear to bias word recognition.

Cognitive ability has been frequently discussed as important for age-related positivity (e.g., Reed & Carstensen, 2012). Reed, Chan, and Mikels (2014) also identified the importance of cognitive ability, such that age-related positivity effects manifest when older adults' cognitive control resources are unencumbered or among older adults who display intact cognitive resource capacities. Our composite frontal lobe functioning score was the only significant correlate with corrected recognition performance. As a result, this score was included as a covariate in our omnibus analyses. In the final analysis (including word type as a within-subjects factor), cognitive ability was a significant covariate; however, the significant 3-way interaction between word valence, word type, and age remained. Although (presumably) performance-oriented motivations did not appear to exert any effect within the current study, general cognitive abilities did. However, beyond being associated with overall performance, cognitive ability did not specifically contribute to the observed positivity among our older adult sample. Thus, age differences in affective word recognition may have been due to age-related positivity effects in line with SST postulates regarding motivated affective preferences in later life.

Ultimately, both semantic and emotional content appeared to influence performance. Semantic distinctions played a significant role in how well words were correctly recognized. Specifically, concrete words were more accurately remembered across all word valence categories. Emotional content influenced performance evident in the interaction between age, word type, and emotion. Although no age differences emerged for concrete words across all emotion categories, positive abstract words were more accurately remembered than negative and neutral abstract words. Younger adults did not differ from older adults in recognizing positive abstract words; however, they outperformed older adults on both negative and neutral abstract words. This provides partial evidence for preferential processing in line with age-related positivity (at least in terms diminished negativity in older adults' recognition). In other words, older adults were more accurate with positive relative to negative and neutral information, perhaps in line with motivated positive affective goals (however, such a link was not explicitly addressed in the present study).

Addressing Maturational Dualism

Maturational dualism (Berry Mendes, 2010) posits that later life is accompanied by a greater disconnect between mind and body. Contrary to this proposition, older adults have been documented as being sufficiently reactive, both subjectively and physiologically, to certain negative affect elicitors (e.g., sadness; Kunzmann & Grühn, 2005; Seider, Shiota, Whalen, & Levenson, 2011; Shiota & Levenson, 2009). Although it was predicted that mind-body connectivity would be evident in both age groups, posture had no effect on affective word processing. Even when isolating the posture effect to the younger adult group, no significant effects emerged, which directly contradicts past work. Key methodological differences (i.e. type of task, posture assessments) between previous studies and the current study may explain why these effects did not manifest. Additionally, discrepancies exist in how researchers have addressed the links between memory, mood, and posture that weigh heavily on the current research.

Type of memory task. Past research, exclusively using younger samples, has implemented memory tasks aimed at assessing recall rather than recognition. For example, Michalak, Rohde, and Troje (2015) employed a self-referential encoding paradigm and examined word recall. Another study had individuals recall autobiographical memories (Tsai, Peper, & Lin, 2016). Recall and recognition tasks differ in how information is retrieved. The present study utilized an incidental encoding paradigm where participants were asked to discriminate previously seen words from a list of new words, which has not been used in conjunction with a postural manipulation. Due to the relative ease of recognition in comparison to recall, group differences between upright and stooped postures may have been more difficult to detect within the current study. Both recall and recognition tasks may utilize similar encoding techniques (e.g., incidental, deliberate); however, recall tasks do not provide additional information at the point of retrieval. For recognition tasks, to-be-remembered target stimuli are presented along with never-before-seen stimuli, and individuals are asked to distinguish between new and old. Thus, recognition paradigms tend to lead to enhanced memory performance, as research suggests that older adults perform better on recognition tasks than recall tasks (e.g., Danckert & Craik, 2013). The existing literature implicates stooped posture as producing negativity biases; however, these effects may be an artifact of the experimental paradigm used (e.g., recall tasks).

Recall tasks, which likely require greater cognitive resource demands relative to recognition tasks, may be more negatively impacted by stooped posture. Although no direct comparison of recall versus recognition performance has been conducted, current evidence suggests that stooped posture has a detrimental effect on recall. For example, when asked to recall autobiographical memories in both stooped and upright postures, younger adults report greater ease recalling events in upright postures and do so much quicker when compared to a stooped posture (Tsai, Peper, & Lin, 2016). Thus, variations between recall and recognition tasks could be a key reason for why posture effects did not emerge. Past studies reporting significant posture effects have observed relatively small effect sizes, on the order of .04 (e.g., Veenstra, Schneider, & Koole, 2017) to .12 (e.g., Michalak, Mishcnat, & Teismann, 2014), with samples ranging from 40 to 120 participants (20-30 participants within each group). These sample sizes are quite similar to what was used in the current study, and our a priori power analysis justified our sample size (G*Power 3.1). Hence, due to the small effect sizes seen in previous studies, any characteristics of the memory task that provide even subtle influences on performance (e.g., the use of retrieval cues when recognizing versus recalling) could eliminate the influence of a postural manipulation.

Differences in posture assessments. Within the current study, several methodological decisions were made to ensure comfort and feasibility of the posture manipulation for all participants. Due to the integrative nature of this research, no clear precedent exists for assessing and manipulating posture in different age groups. As a result, no restraints (e.g., kinesthetic tape) were used, and the postural manipulation was somewhat relaxed (e.g., not adherent to a percentage of posture change). Several methodological issues need to be addressed: posture assessment, manipulation method, length/point of intervention, and participant awareness.

In the current body of research, there is little specification as to what metrics should be used to assess posture. Complicating matters further, there is no standard metric available to compare across studies. For example, utilization of motion capture technologies (e.g., Michalak, Rohde, & Troje, 2015; Nair et al., 2014; Wilkes et al., 2017) allows for an analysis of joint changes, which is useful for pinpointing specific postural alterations; however, these metrics are largely incompatible with our pre-post spinal curvature assessments. In other research, only self-reported ratings from the participant and experimenter are given (e.g., Veenstra, Schneider, & Koole, 2017). This disconnect in measurement standards may contribute to disparate findings across studies and may partially explain why our posture manipulation did not appear to influence memory performance.

Posture manipulations also differ between studies. In the present study, spinal curvature assessments and simple verbal instructions appeared not to be sufficient for eliciting posture effects on valenced-based memory. In other studies, verbal instructions were sufficient (e.g., Michalak, Mischnat, & Teismann, 2014; Veenstra, Schneider, & Koole, 2017). This leads us to question the amount one's posture must change in order to see significant memory effects. In the present study, we calculated the amount of change via pre and post spinal curvature. However, when a percentage of change was calculated, we observed that younger adults increased their stooping by 30%, whereas older adults did so by 18%. Alternatively, older adults in the upright condition became 15% more upright, whereas younger adults were nearly identical to their baseline in the upright condition. These age differences were not significant. Unfortunately, past research does not indicate a point at which posture effects should begin to emerge (e.g., a percentage of deviation), and we can only speculate that these percent changes may not have been enough to elicit posture effects on our recognition task.

However, even though these percentages are not mappable to any past studies, we argue that standardized manipulation methods may illuminate what magnitude of change is necessary for potential effects to manifest. This study used a non-invasive approach via the Lumo Lift so as to eliminate expectancy effects; conversely, other studies have utilized motion capture suits (e.g., Michalak, Rohde, & Troje, 2015) and kinesthetic tape (e.g., Nair et al., 2014; Wilkes et al., 2017) to produce more robust posture manipulations, which could facilitate more significant associations with biased memory performance.

Further complicating the implementation of our posture manipulation was determining the time at which a change in posture should begin to elicit psychological effects. Again, there is no clear standard for the time course of postural manipulations. For the current study, we reasoned that participants would need a brief period of time to acclimate to the different posture, and a 3-minute time interval was given to participants prior to starting the encoding portion of the incidental memory task. While several studies have utilized a similar strategy of having participants acclimate to their assigned posture (Michalak Rohde, & Troje, 2015; Nair et al., 2014), such acclimation procedures are equivocal across studies. For instance, some studies have participants in their assigned postures only during the task of interest, with no time to acclimate to the posture (e.g., Veenstra, Schneider, & Koole, 2017).

A more discrepant aspect between studies is the length of time participants spend in their assigned posture. Past research ranges from one minute (e.g., Tsai, Peper, & Lin, 2016) to 30 (e.g., Michalak, Rohde, & Troje, 2015) minutes in an assigned postural state whereas our participants were in their assigned posture for approximately 35-40 minutes.

These methodological differences allow for very different interpretations. With our study being the longest and lacking posture effects, it could be argued that posture effects dissipated during the protocol, as participants may have acclimated to the manipulation over time. Affect ratings provide some insight, as younger adults in stooped postures declined marginally more than their upright counterparts. Unfortunately, all groups' affect declined over time, irrespective of posture, and these differences dissipated after controlling for pre-experiment affect and well-being. With neither affect or memory being influenced by the postural manipulation, the length of the experiment and time spent in the posture may have contributed to these null results. This remains speculative, however, as the influence of time spent in a posture was not explicitly tested in past work and showed no relationship to key variables in the present study.

Lastly, participant awareness could also play a role. If these effects are indeed subconscious and not the product of overt expectancy, past evidence should reflect this; however, in all previous studies, there is no indication that participant awareness was assessed or controlled. In our study, we controlled for expectancy effects by asking participants if they thought their posture was being tested. No participant suspected that their posture was being assessed. The present null findings suggest that participant awareness (or the lack thereof) should be considered when studying posture effects. The present study found no significant posture effects, and no evidence of participant awareness on memory performance.

In past work, posture effects were observed; however, most prior studies did not assess participant awareness regarding the posture manipulation. Perhaps expectancy regarding the role of posture could be a factor contributing to the influence of posture on memory in past studies. For instance, some prior studies provide participants a fictitious cover story regarding the impact of posture on a distractor task in order to reduce expectancy effects (e.g., Nair et al., 2014; Veenstra, Schneider, & Koole, 2016). However, by even linking performance on any metric to posture, participants could be clued into how posture influences cognitive processing, which could influence resultant task performance. Future studies should address this possibility, as expectancy could be pivotal to determining when and to what extent posture effects will emerge.

Memory, mood, and posture. Although the methodological differences mentioned above could have contributed to the lack of posture effects on memory in the current study, past research has highlighted the role of mood. Past evidence suggests that mood is related to posture (e.g., Michalak et al., 2009; Veenstra, Schneider, & Koole, 2017); however, mood and posture may be linked separately from memory processes. As a result, a convoluted picture begins to form between memory, mood, and posture.

Enhanced positive emotions and heightened energy levels are associated with upright postures (Wilkes, Kydd, Sagar, & Broadbent, 2017). In contrast, stooped postures are associated with lower energy levels (Peper & Lin, 2012) and more negative affect (Veenstra, Schneider, & Koole, 2017). However, these mood effects and memory effects do not seem to relate to one another. Michalak and colleagues (2009) illustrated how individuals with MDD exhibited specific postures and that information processing biases track with postural changes; however, processing biases introduced by a postural manipulation were not explained by changes in mood (Michalak, Mischnat, & Teismann, 2014). Furthermore, when affect changes are related to posture, such effects have not been previously related to memory (e.g., Veenstra, Schneider, & Koole, 2017).

Over the course of the present study, there were no significant changes in mood as a result of posture, and if changes did occur, they were very small in magnitude and not necessarily in a negative direction for all people. Of note, the interaction between mood and posture was marginally significant for younger adults with those in a stooped posture reporting more decline in mood over time compared to those who were upright. However, the effect was mitigated when controlling for individual differences in pre-experiment well-being. Thus, mood changes in the present study were more influenced by individual differences than the posture manipulation.

Past work has not adequately accounted for individual differences in affect and global well-being, as affect during a task is typically the dependent variable, and individual differences in global affect and well-being are not assessed (e.g., Veenstra, Schneider, & Koole, 2017). The link between posture and depressive symptomology in early studies may also provide insight as to why posture change may be most influential on mood and cognition among individuals who are already experiencing increased general negative affect and diminished subjective well-being (e.g., Michalak, Mischnat, & Teismann, 2014).

Furthermore, all mood assessments were unrelated to memory in this study. Although this is not necessarily contradictory to past research, it is difficult to explain. If negative affect is producing the information processing bias, experiments should show that adopting specific postural states precedes or exacerbates affect changes, which in turn biases memory. This has not been the case in past research and was not the case in the present study. It is unknown if posture influences mood and memory through separate or similar processes. The relationship between mood, memory, and posture must be better understood and modeled, requiring further theoretical and empirical examination.

As a final explanation, posture effects on mood and memory may have been absent in the present study due to the bi-valent approach taken when presenting affective stimuli. Congruent with prior emotional aging research, positive and negative words were grouped together, irrespective of the specific emotion represented. Due to existing evidence that older adults may demonstrate differential preferences/alignment with certain negative states (i.e., sadness; Kunzmann & Grühn, 2005; Seider, Shiota, Whalen, & Levenson, 2011; Shiota & Levenson, 2009), domain-general negativity effects may not emerge in a stooped posture. Perhaps utilizing a discrete emotions approach could determine whether posture differentially affects emotion-specific cognitive biases across adulthood and old age.

Limitations and Future Directions

As hinted earlier, a key methodological limitation of this study was the unequal distribution of abstract and concrete words within the valence categories. A follow-up study should be conducted with equal distributions of abstract and concrete words to rule out the possibility that these effects result from stimulus inconsistencies. There should also be an investigation as to whether or not other types of semantic decision-making tasks result in similar age-related biases. Perhaps if these same words were categorized based on valence rather than semantic merits, this may have accentuated emotion effects and minimized the influence of word type. Furthermore, if participants were biased in their initial selections (e.g., more likely to categorize words as positive), this could influence their subsequent memory performance beyond arousal or actual word valence.

Many limitations were discussed in probing explanations for the lack of posture effects in the present study. Work must be conducted on identifying how best to measure and manipulate (e.g., how much, when, under what instruction) posture. Due to the discrepancy in memory processes within recall and recognition tasks, a study should be conducted that directly compares performance on a recall task and recognition task as a function of age and posture. This should identify if the subtle effects emerge when task demands are higher (i.e. during recall). Furthermore, this literature should utilize tasks that require more active recall by assessing continuous performance across a protocol, at several time points, rather than a single retrieval period. For example, performance could be assessed on a working memory task, both before and after a posture manipulation, to assess how posture influences actual changes in performance.

Past work investigating the influence of posture on mood recovery has shown the importance of spontaneous reactivity (Veenstra, Schneider, & Koole, 2017). Utilizing mood induction paradigms (e.g., viewing emotionally evocative film clips) may shine light on how mood and posture relate, both behaviorally (i.e. self-report data) and through psychophysiological means. Monitoring internal response systems of the body (e.g., cardiorespiratory) during these tasks would allow for a richer analysis of near real-time psychophysiological reactivity to emotional experiences in certain postural states. Importantly, memory should be included in this work to interrogate how mood and memory relate to posture, both independently and in tandem.

Finally, more research needs to be done addressing the theoretical postulates of maturation dualism. If mind-body connectivity degrades into later life, it is important to know to what extent and in what situations. Within this study, proprioceptive sensations were investigated, albeit by manipulation alone; however, autonomic reactivity and interoceptive ability were not. Again, psychophysiological studies could provide insight into how these processes may change due to postural manipulation. It remains to be seen as to whether these other aspects of mind-body connectivity thought to degrade with age truly do impact emotion-cognition links into later life.

Conclusion

Given the present results, some instances of older adults' positive preferences were observed; however, an important boundary condition of word type was revealed. Future work must attempt to replicate these results as well as extend this paradigm to other semantic decision frames. Unfortunately, posture did not have any effect on affective word processing in this study. This contradicts previous studies that utilized younger adult samples; however, this provides little conclusive evidence in favor or against a maturational dualism argument for mind-body connectivity across the lifespan. Posture may still interact with emotional processes, potentially in conjunction with mood-congruency effects, but these effects were not examined in this experiment. This study breaks new ground by integrating disparate areas of research, and even though findings were not wholly conclusive, there is reason to continue investigating how processing of affective words may be modulated by methodology, physiology, and age.

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