The Pegasus Review: UCF Undergraduate Research Journal

Volume 12 | Issue 2 Article 5

2020

# Effects on Interpretation Bias, Mood, and Physical Tension During Mobile Device Usage: An Examination of Slumped, Upright, and Lying Down Postures

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**Vol. 12.2:** 45-56

URJ

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UNIVERSITY OF CENTRAL FLORIDA
UNDERGRADUATE RESEARCH JOURNAL

**Published**
**February 17th, 2021**

# Effects on Interpretation Bias, Mood, and Physical Tension During Mobile Device Usage: An Examination of Slumped, Upright, and Lying Down Postures

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**ABSTRACT:** The purpose of this study was to examine the effects of posture on interpretation bias, mood, and physical tension when using a mobile device. Participants were randomly assigned to one of three conditions: sitting slumped, sitting upright, or lying down. They were then asked to unscramble emotional and neutral sentences to measure interpretation bias. Self-reported measurements were used to measure mood and physical tension. No significant differences were found in the type of sentence unscrambled when sitting slumped and upright. When lying down, participants unscrambled fewer neutral sentences compared to emotional sentences. Physical tension was found to mediate the relationship between posture (slumped and upright) and mood. The results of this study provide insight into possible confounding variables influencing the relationship between posture and mood. Additionally, we showed that emotional content is processed differently compared to neutral content when lying down. Further research is needed to understand how psychological well-being is affected by physical tension caused by posture when using a mobile device.

**KEYWORDS:** embodied cognition; slumped; upright; lying down; physical tension

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## INTRODUCTION

According to the American Psychological Association (2017), 99% of the adult population in the United States possesses an electronic device, e.g., a computer, smartphone, tablet, or television. People engage with these mobile devices whether they are sitting in a doctor's office, walking around a supermarket, or lying down in bed. The excessive use of mobile devices could lead to both physical and psychological problems. Many studies have reported that people frequently look down when they use mobile devices, which increases head and neck flexion (Albin & McLoone, 2014; Dennerlein, 2015; Gold et al., 2012; Guan et al., 2016, 2015; Lee, Kang, & Shin, 2014). When people flex their neck to use their smartphones, they experience a tension that makes their head feel like it weighs up to 27 kg, which could lead to neck and back problems (Robles, 2019).

Other studies have considered the role that whole-body posture plays in emotional responses. Researchers reported that sitting with the back straight is associated with higher self-esteem and improved mood compared to slumped posture (Nair et al., 2015). Emotional stimuli also influences posture; a study suggested that when participants generated words associated with failure and disappointment, their posture height declined compared to the participants that generated words associated with success and pride (Oosterwijk, Rottevel, Fischer, & Hess, 2009). Other studies reported that posture is important for recovering from negative mood, meaning that people are less likely to recover from negative mood when they were in a slumped posture (Veenstra, Schneider, & Koole, 2016). Furthermore, studies have found that slumped posture is associated with helpless behavior and a decrease in energy level compared to upright posture (Peper & Lin, 2012; Riskind & Gotay, 1982). According to these findings, posture plays an important role in both positive and negative emotions.

Given that body posture changes based on the usability of electronic devices, postures used for engaging with mobile devices and computers might affect cognitive processing. For example, a study investigating the effect of stress response on posture found that sitting upright resulted in an improved rate of speech compared to sitting slumped (Nair et al., 2015). The theory that the human body influences the mind is known as embodied cognition, which is the idea that the physical human body plays a significant role in cognitive processing (Wilson, 2015). When an individual is feeling upset, his or her emotions are reflected in their slouched or slumped posture. Moreover, patients with major depressive disorder showed increased head flexion and increased curvature of the spine (Canales et al., 2010). The posture of patients with major depressive disorder is similar to the body posture often used when engaging with mobile devices. Since mobile device users usually bend their necks forward to use their phones, this posture could affect their cognitive processes. Therefore, it is important to consider how sitting slumped might affect mood and cognition compared to other postures.

The present study was interested in determining whether specific postures, manipulated by the use of electronic devices, influence cognitive bias. In this context, cognitive bias refers to the misguidance of decisions and judgments in cognitive processes. An example of this concept would be memory bias, which influences what an individual may or may not recall. Previous research provided evidence of embodiment effects on depressive memory bias, suggesting that depressed patients who were sitting slumped recalled more negative words compared to those who were sitting upright (Michalak, Mischnat, & Teismann, 2014). Given the connection between memory bias and embodiment, this study examines how postural manipulation influences interpretation bias. Interpretation bias is the tendency to negatively or positively interpret ambiguous information (Huppert et al., 2003). Interpreting information negatively has been associated with social anxiety and depression (Amir, Beard, & Bower, 2005; Huppert et al., 2003; Joormann, Waugh, & Gotlib, 2015).

Given that people often interpret text messages on their phones, it is important to investigate whether posture negatively influences their interpretation. In addition, the effects of posture on interpretation would not only provide insight into how these certain postures used for engaging with mobile devices affects cognitive processes, but could be applied clinically to further develop embodied treatments.

The goal of this research study is to first determine whether postures when using mobile devices have an effect on interpretation bias when completing the Scrambled Sentences Test; then observe whether posture influences performance when completing the Scrambled Sentences Test; and finally determine if differences in reported mood and reported physical tension were dependent on posture.

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## METHODS

We conducted a mixed-methods experiment to determine the effects of posture on performance when using mobile devices. The independent variables were posture (3 groups: sitting slumped, sitting upright, and lying down) and sentence type (2 tasks: emotional sentences and neutral sentences). All conditions were randomized and equally counterbalanced. The upright posture group sat in an office chair and were asked to keep their back straight while an iPad holder was used to place the device at their eye level. The slumped posture group sat on a stool and were asked to hold the iPad mini on their lap throughout the entire study to maintain the slumped posture. The lying down group lay with their face and torso facing up and were asked to hold the iPad.

*Participants*

This research study collected 170 participants overall. Twenty participants were removed because they either missed manipulation checks or did not fully complete the study. The final sample size included 150 participants (78 female and 72 male). The participants' ages ranged from 18-32 ($M$ = 18.71, $SD$ = 1.93). Overall, 51 participants sat slumped, 50 participants sat upright, and 49 participants lay down. All participants agreed to the informed consent before participating in the study.

*Apparatus*

The mobile device used in this study was a first-generation iPad mini. An office chair without armrests was used for the upright posture condition to provide enough back support for participants to maintain an upright posture. A height-adjustable stand was used to place the iPad mini at the eye level of the participants in the upright posture condition, preventing participants from flexing their necks when engaging with the device. A stool without armrests or back support was used for the slumped posture condition. Since participants lacked back support, they were forced to flex their neck and lean towards the iPad mini, which was placed on their lap. A massage table was used for the lying down condition. Participants in this were asked to hold the iPad.

*Materials*

This study used Qualtrics Survey Software. The Scrambled Sentences Test (SST), developed by Wenzlaff and Bates (1998), was used to measure interpretation biases. The SST consists of 40 scrambled sentences (20 emotional and 20 neutral sentences), each six words in length. The participants unscrambled each sentence to form a grammatically correct statement using only five of the six words presented. Each emotional sentence featured both negative and positive target words. For example, in the scrambled sentence "life interesting my boring generally is" *interesting* (positive) and *boring* (negative) are the target words. The neutral sentences did not contain emotional content, e.g., "to books read magazines I prefer" with *books* and *magazines* as the target words.

Participants were instructed to unscramble the sentences as quickly as possible. Each scrambled sentence was first displayed for 8 seconds. After the sentence was displayed, the participants were asked to unscramble the sentence within 14 seconds. Participants unscrambled the sentences by ranking each word in order to form a grammatically correct complete sentence. The extra word that participants did not choose was placed behind a line as shown in Figure 1.

The scrambled sentences were divided into four blocks, each containing ten sentences. The second and fourth blocks included a cognitive load condition to reduce participant's conscious efforts to create socially desirable sentences. Similar to previous research that used the SST, the cognitive load task was presented at the beginning of the block. Participants were asked to memorize a six-digit number within 8 seconds and were asked to recall the memorized number (Everaert et al., 2017; Rude et al., 2002). At the end of the second and fourth blocks, a prompt asked them to enter the six-digit number.

To reduce priming effects, neutral scrambled sentences were presented after one or two emotional sentences were presented. The interpretation bias was calculated as the ratio of negatively selected target words over the amount of correctly unscrambled emotional sentences.

*Procedure*

This study was conducted in a laboratory. Participants were asked if they had any back or neck problems prior to participating in the study. Those who reported any type of back or neck problems were not eligible to participate. Participants began with an informed consent and were asked to press "yes" if they agreed with the conditions of the study. Each participant was randomly assigned to one of three conditions: sitting upright, sitting slumped,

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and lying down (see Figure 2).

Once participants were in their assigned postures, they were told that the study will investigate how people hold mobile devices when completing a task to reduce the awareness of their posture. About one minute after their postures were manipulated, participants self-reported their mood and physical tension, which were equally counterbalanced. Once they reported their mood and physical tension, they were instructed to complete the Scrambled Sentences Test (SST). Prior to beginning the actual SST, the participants completed a training phase. This training consisted of an explanation of the task and three trials of the SST with neutral content. The training phase was followed by a testing phase, which included all 40 scrambled sentences. After the SST, participants were asked to report their mood and physical tension again. The duration of time between the first and second time participants reported their mood and physical tension ranged from 24.73 to 31.95 minutes ($M$ = 26.48, $SD$ = 1.22). After the second time participants reported their physical tension and mood, participants were asked to fill out demographic questions. Once the participants completed all of the tasks in the study, they were asked to stretch their arms to reduce the effects of the posture.

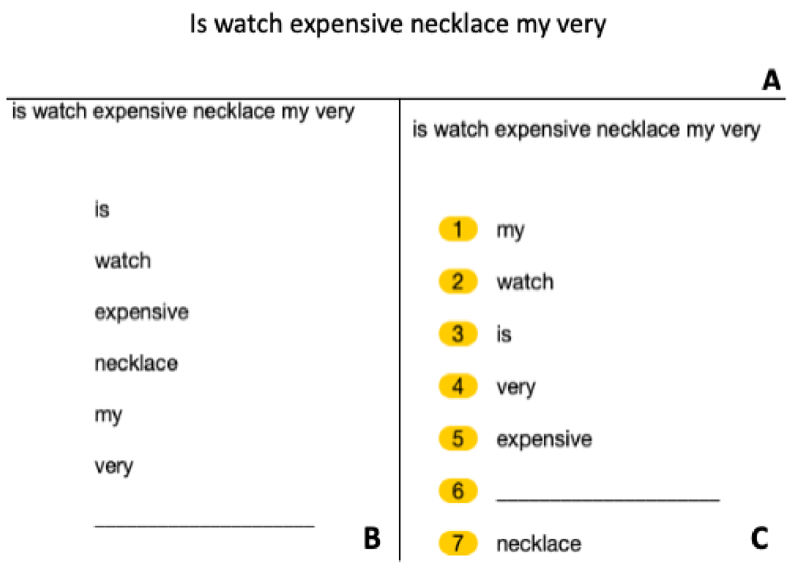


*Figure 1. A screenshot of a scrambled sentence task completed on the Qualtrics Survey Software. A: The scrambled sentence displayed for 8 seconds. B: The unscrambling sentence task displayed for 14 seconds. C: Example of a way to unscramble the sentence by placing the extra word behind the line.*

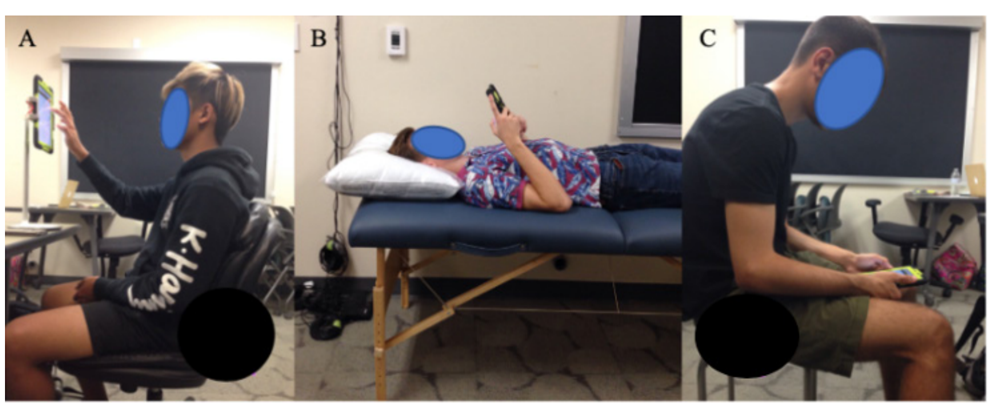


*Figure 2. Postures that were manipulated. A: Sitting upright. B: Lying down. C: Sitting slumped*

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## RESULTS

*Analysis for Postures and Interpretation Bias*

The main focus of this analysis was to determine whether posture influences interpretation bias, which is calculated as the number of negative words selected in the grammatically correct emotional sentences that were unscrambled. Therefore, a between-factors one-way ANOVA for posture as the independent variables was performed on the number of negative or positive words that were chosen when unscrambling emotional sentences. The results of the ANOVA indicated that there was no significant difference for the amount of negative words ($F$ (2, 147) = 1.12, $p$ = .33, $\eta_p^2$ = .02) or positive words ($F$ (2, 147) = 0.52, $p$ = .59, $\eta_p^2$ = .01) chosen in emotional sentences (see Figure 3).

*Analysis for Postures and Performance of Unscrambling Sentences*

Data screening procedures were performed on the data collected for this study. Responses with reaction times above three standard deviations from the average and sentences that were not correctly unscrambled were omitted from the analysis. These omissions overall constituted 10.71% of the data.

A 3 (posture) x 2 (sentence type) repeated measures ANOVA was conducted to determine differences in the number of neutral or emotional sentences. The "posture" variable (3 groups: sitting slumped, sitting upright, and lying down) was a between-subjects variable. The "sentence type" variable (2 groups: neutral and emotional) was a within-subjects variable. The results of the ANOVA suggested that there is no main effect for sentence type ($F$ (1, 144) = .79, $p$ = .38, $\eta_p^2$ = .01) or posture ($F$ (2, 147) = 0.36, $p$ = .70, $\eta_p^2$ = .01). However, a significant interaction was found between sentence type and position ($F$ (2, 144) = 3.33, $p$ = .04, $\eta_p^2$ = .04). As illustrated in Figure 4, post-hoc paired t-tests indicated no significant differences for sitting slumped ($t$ (50) = .08, $p$ = .93) or sitting upright ($t$ (49) = -.81, $p$ =.42). However, the participants who were lying down unscrambled fewer neutral sentences ($M$ = 17.57, $SD$ = 2.00) than emotional ones ($M$ = 18.27, $SD$ = 1.54, $t$ (48) = 2.51, $p$ = .016).

*Analysis for Postures and Self-Reported Mood and Physical Tension*

A between-factors one-way ANCOVA with posture as the independent variable was performed on changes in self-reported mood. The change scores for mood were calculated by subtracting the second reported mood from the initial reported mood. The first reported mood was used as a covariate. The results of the ANCOVA

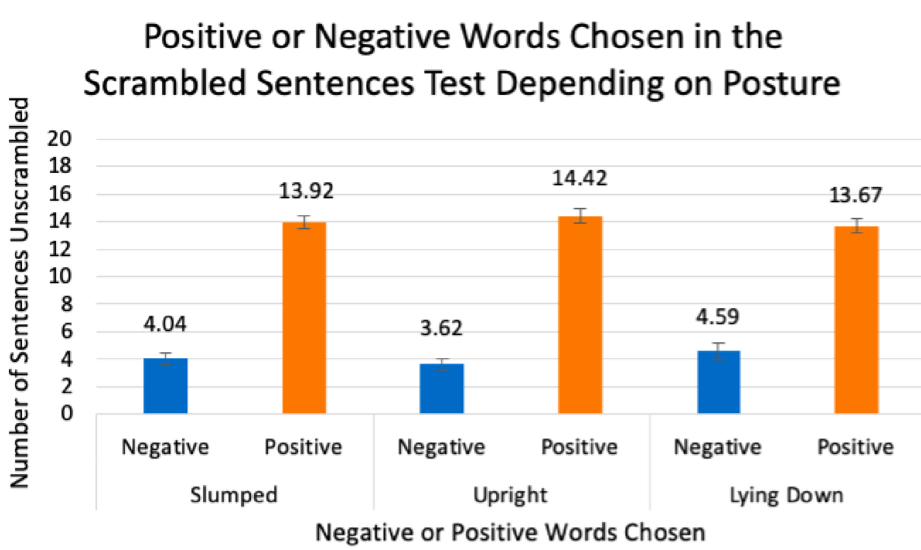


*Figure 3. Positive or negative words chosen in the Scrambled Sentences Test depending on posture. Error bars represent the standard error of the mean.*

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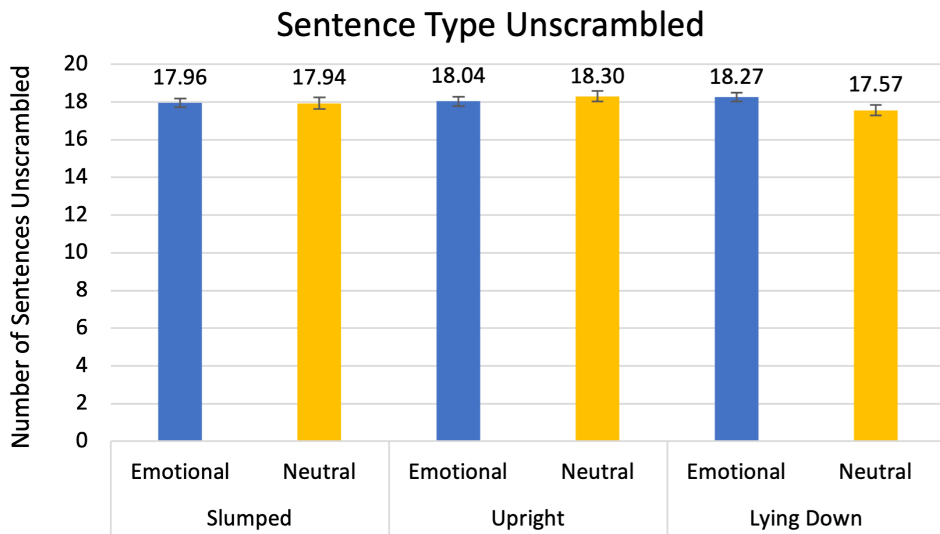


*Figure 4. Differences in unscrambling neutral or emotional sentences based on postural manipulations. Error bars represent the standard error of the mean.*

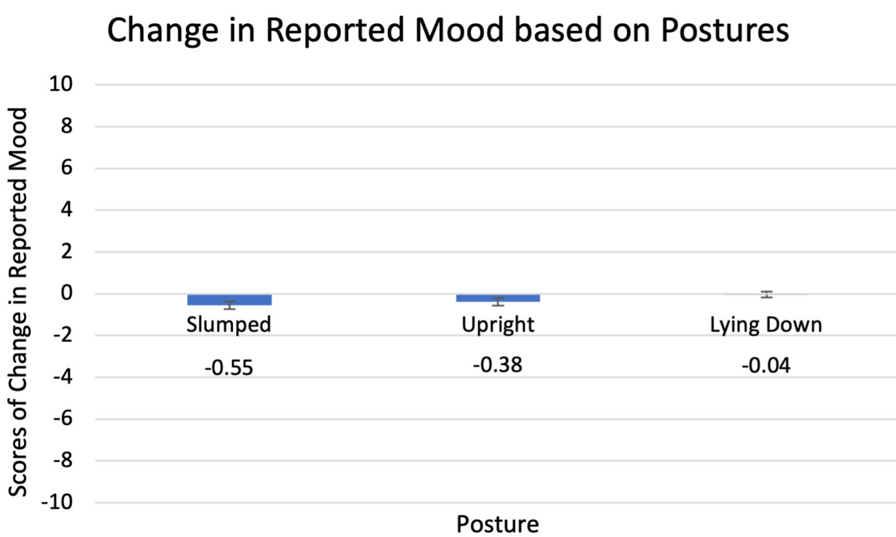


*Figure 5. Change of reported mood based on postures. More negative scores indicate more negative mood. Error bars represent the standard error of the mean.*

suggested no significant differences in change in reported mood based on posture ($F$ (2, 144) = 0.69, $p$ = .51, $\eta_p^2$ = .01). A significant main effect was found on first reported mood ($F$ (1, 144) = 5.70, $p$ = .02, $\eta_p^2$ = .04). However, no significant interaction was found between first reported mood and postures ($F$ (2, 144) = 0.33, $p$ = 0.72, $\eta_p^2$ = .01). The changes in reported mood are depicted in Figure 5.

A between factors one-way ANOVA for posture as the independent variable was carried out on changes in reported physical tension. The change scores for physical tension were calculated by subtracting the second reported physical tension from the initial reported physical tension. The results of the ANOVA suggested that posture influenced the amount of physical tension that participants reported ($F$ (2,147) = 6.04, $p$ = .003, $\eta_p^2$ = .08). LSD post-hoc tests (see Figure 6) showed that those who were slumped reported more physical tension

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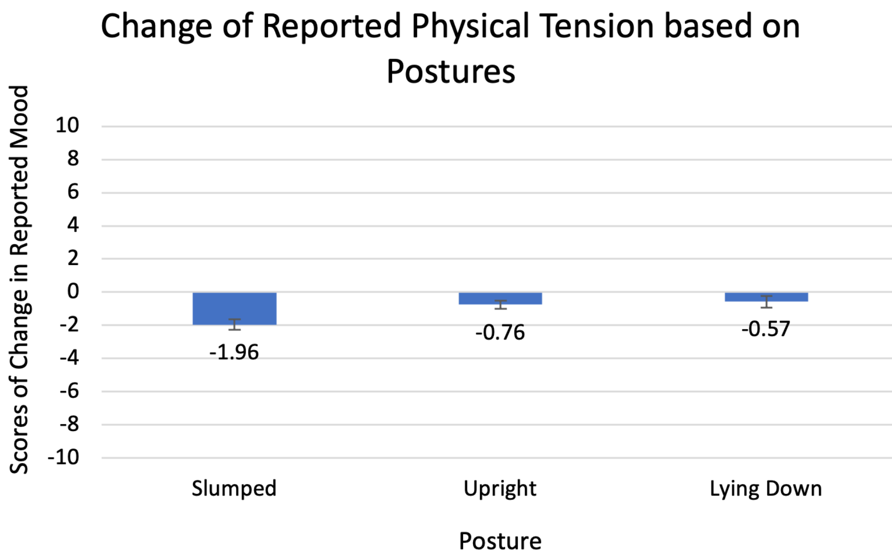


*Figure 6. Change of reported physical tension based on postures. Physical tension is based on how physically relaxed participants felt. More negative scores indicate feeling more physically tensed. Error bars represent the standard error of the mean.*

than those who were sitting upright ($p$ = .006) and lying down ($p$ = .002). No significant difference in reported physical tension was found between those sitting upright and lying down ($p$ = .67).

A bivariate correlation was carried out to examine the relationship between reported physical tension and reported mood. The results suggested a correlation between these variables ($r$ (148) = .38, $p < .001$).

A mediation analysis was conducted to assess the possibility of confounding variables. This possibility is based on the influence of posture on change in physical tension but not in mood. In addition, reported physical tension was found to be associated with reported mood. A mediated model where physical tension change score mediates the relationship between posture and change scores in mood was tested. The score of first reported mood was used as a covariate. To simplify interpretation of the physical tension mediating effects between posture and mood, this analysis used binary variables for postures. Given these parameters, the lying down condition was omitted from this analysis. The results of the mediation model suggest that the unstandardized regression coefficient between postures and change scores in physical tension is statistically significant, as is as the unstandardized regression coefficient between change scores in physical tension and mood (see Table 1). The direct effect $B$ = 0.13 of postures on reported mood was not found to be statistically significant ($p$ = .61). However, at the 95% confidence level, the indirect effect $B$ = 0.28 of mood contains a true mean between 0.05 and 0.42. According to Gardner and Altman (1986), confidence intervals can be used as an indication to determine whether an analysis is statistically significant. Given that the confidence interval does not contain a value of zero, the effect was determined to be significant at $p < .05$. An illustration of the mediated model is provided in Figure 7. In addition, the $F$-test of overall significance is displayed in Table 2.

## DISCUSSION

*Postures and Interpretation Bias*

The first goal of this study was to determine whether posture when using mobile devices affects interpretation bias as measured by the Scrambled Sentences Test. The lack of significant differences xin interpretation bias depending on posture was surprising, given that previous research found memory bias to be influenced by slumped or upright posture (Michalak, Mischnat, & Teismann, 2014). A possible explanation of this result is the previous study's specific examination of depressed patients. Essentially, a depressed sample is more likely to show negative biases compared to a non-depressed sample. This research study did not collect information on the frequency of participant's anxiety and depression

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| Diagram | Variables | B | *t* (df) | 95% *CI* |
|---|---|---|---|---|
| Model 1 | Constant | 0.24 | *t* (98) = 0.34 | [-1.16, 1.65] |
| | Postures and Mood | 0.15 | *t* (98) = 0.60 | [-0.35, 0.65] |
| | Covariate and Mood | -0.13 | *t* (98) = -1.64 | [-0.28, 0.03] |
| Model 2 | Constant | 0.72 | *t* (97) = 1.07 | [-0.61, 2.04] |
| | Postures and Physical Tension | 1.18 | *t* (97) = 2.92* | [0.34, 1.98] |
| | Physical Tension and Mood | 0.24 | *t* (97) = 4.02 ** | [0.12, 0.35] |
| | Postures and Mood | 0.13 | *t* (97) = -0.52 | [-0.61, 0.35] |
| | Covariate and Mood | -0.09 | *t* (97) = -0.09 | [-0.24, 0.05] |

*Table 1. Unstandardized coefficients for change scores in physical tension mediation effects on change scores in mood. *p<.05, **p<.001.*

| Diagram | Variables | $R^2$, *F*-test |
|---|---|---|
| Model 1 | Postures and Mood | $R^2$ = .03, (*F* (2, 98) = 1.57, *p* = .21 |
| Model 2 | Postures and Physical Tension | $R^2$ = .31, (*F* (2, 98) = 1.57, *p* = .01 |
| | Postures, Physical Tension, Mood, and Covariate | $R^2$ = .17 (*F* (3, 97) = 6.61, *p* < .001 |

*Table 2. F-test of overall significance for change scores in physical tension mediation effects on change scores in mood.*

symptoms. However, a study reviewing cognitive biases in youth depression found sufficient evidence that interpretation bias is a predictor of youth depression; but mixed evidence was found for memory bias (Platt et al., 2017). Given this mixed evidence on the predictors of depression on memory bias, researchers should carefully consider the role of memory bias in embodiment effects.

*Postures and Performance of Unscrambling Sentences*

The second goal of the study was to observe whether there is a difference in the effect of posture (i.e., sitting, standing, and lying down) on performance (i.e., unscrambling fewer sentences) when completing the Scrambled Sentences Test. The finding that participants unscrambled the same number of sentences regardless of whether they were sitting slumped or upright was surprising. A possible explanation of this result is the previous experience of participants using their smartphones or tablet with or without back support, which may have interfered with the results of the study. Moreover, it is possible that posture does not affect performance when unscrambling sentences. Future research should investigate how often people engage with their mobile devices when lying down.

In addition, the findings of this study indicated that the content of the sentence, i.e., whether it is neutral or emotional, matters. Although no significant differences were found for the upright and slumped postures, those who were lying down unscrambled fewer neutral sentences compared to emotional ones. For the emotional sentences, no significant differences were found between postures when participants chose a

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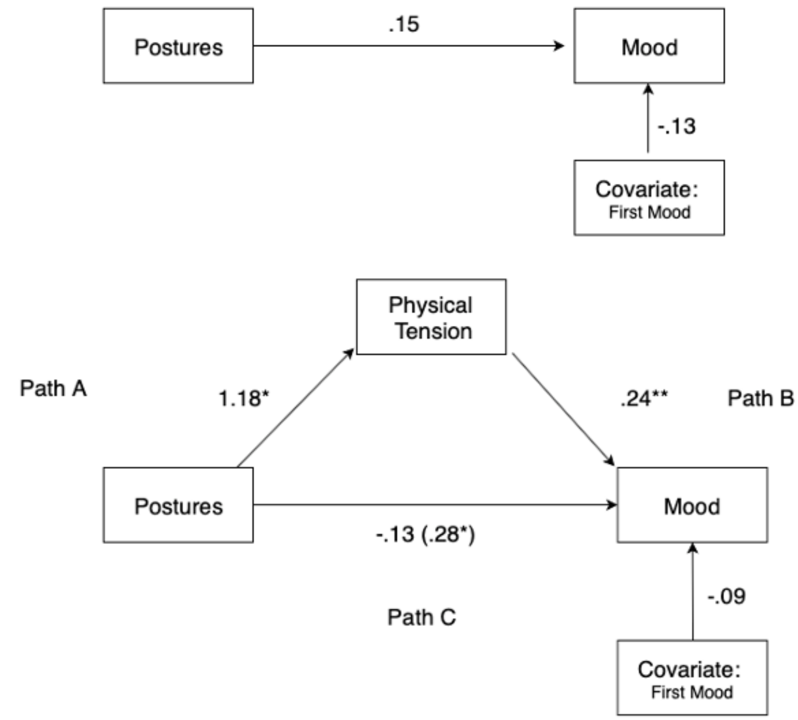


*Figure 7. The model above illustrates the unstandardized regression coefficients for postures estimating change in reported mood, mediated by reported change in physical tension, and controlling for first reported mood. Physical tension is based on how physically relaxed participants felt. The top model displays the total effect of postures on mood. The bottom model displays the mediation model, which includes both direct and indirect (parenthesis) effects. The indirect effect size was determined through 5,000 bootstrapped samples. *p<.05, **p<.001.*

positive or negative answer. The result of the lying down position unscrambling fewer neutral sentences compared to emotional ones may be a result of participants who were lying down being aroused differently than those who were sitting. The Yerkes-Dodson Law suggests that performance decreases when a stimulus is too intense or dull (Yerkes & Dodson, 1908). Emotional content possibly aroused participants regardless of their posture. However, lying down possibly led to lower arousal compared to sitting when exposed to neutral stimuli.

A possible explanation for this result may be that people are aroused differently when exposed to a neutral stimulus when lying down compared to sitting positions, either slumped or sitting upright. Further research is needed to understand how certain positions, such as lying down, lead to lower arousal when exposed to a neutral stimulus. Future research should also use psychophysiological measures instead of self-reported measures to determine differences in arousal caused by stimuli with or without emotional content when lying down.

*Postures and Self-Reported Mood and Physical Tension*

The third goal of this study was to determine if differences in reported physical tension and reported mood were dependent on posture. The study suggested that there is a significant difference in physical tension between those sitting upright, sitting slumped, and lying down. Sitting slumped caused more physical tension compared to sitting upright or lying down, which means that increased neck flexion, particularly when engaging with smartphones or tablets, leads to greater muscular tension. The increased physical tension when sitting slumped supports research suggesting that increased head flexion is associated with musculoskeletal pain (Andersen et al., 2003).

The lack of significant differences in reported mood was surprising, given that embodied research studies found that slumped posture leads to negative energy level or mood (Nair et al., 2015; Oosterwijk, Rotteveel, Fischer, & Hess, 2009; Pepper & Lin, 2012; Veenstra, Schneider, & Koole, 2016). A possible explanation of

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why this occurred is inconsistency in mood measurement techniques used in embodied studies. This study measured mood in a simplistic manner; however, other research studies measured mood via generating sad words, Profile of Mood States, or Affect Valuation Index (Nair et al., 2015; Oosterwijk, Rotteveel, Fischer, & Hess, 2009; Veenstra, Schneider, & Koole, 2016). It is possible that the way that mood is measured may interfere with the results of the study. Researchers should carefully consider which measurements of mood to use when conducting embodied research.

Another possible reason why postures did not seem to influence mood is the possibility of confounding variables mediating embodiment effects on mood. This study found physical tension to be a mediator between posture (sitting slumped and sitting upright) and mood. According to the American Chiropractic Association (n.d.), poor posture leads to stress, weak postural muscles, excessive muscle strain, and increases chances of being injured. Furthermore, the American Psychological Association (n.d.) found that stress increases muscle tension, which leads to pain in areas of shoulders, neck, and head. It is possible that poor posture, i.e., sitting slumped when using a mobile device, leads to increased muscular tension or stress, which impacts a participant's mood. Additional research is needed to understand how variables such as stress and muscle tension play a role in embodiment effects on mood.

Furthermore, the present study had an average time of 26 minutes between the pre-mood and post-mood self-report. A previous study found a difference in energy level after 2-3 minutes when comparing slumped and upright posture (Peper, & Lin, 2012). Other studies found a link between using devices for more than 2-3 hours a day and musculoskeletal pain (Hakala, Rimpelä, Saarni, & Salminen, 2006). It is possible that poor posture when using mobile devices could influence mood, muscular discomfort, and pain after using the device for a long period of time. However, it is not clear how long it takes to detect differences in mood and muscular tension depending on posture. Future studies should use a longitudinal research design to observe embodiment effects on mood and muscular tension.

## CONCLUSION

The present study investigated how postures in mobile device usage influenced interpretation bias, physical tension, and mood. Although no embodiment effects were found on interpretation bias, those lying down were found to be worse at unscrambling neutral sentence than they were at unscrambling emotional ones. In addition, physical tension was found to mediate the relationship between posture (slumped and upright) and mood. It is important to consider confounding variables such as stress or muscle tension when investigating embodiment effects on mood and cognitive biases. Future research should use physiological measurements, such as electromyography (EMG) electrodes, to examine muscle contractions generated by electrical impulses. This data will allow for a better understanding of the role of physical tension in the relationship between posture and mood. Furthermore, given that it is common for people to use their smartphones in bed, it is worth investigating the cognitive effects of lying down when engaging with mobile devices. The present study is one of the first to examine cognitive effects of lying down when engaging with mobile devices.

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