Associated Correlates of Social Comparison Threat to Working Memory Capacity

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Abstract

Social comparison serves as an important and common evaluative tool for assessing one's self, and it is associated with various positive and negative outcomes, the same negative outcomes that have been found to hinder working memory performance. A preliminary study suggests that introducing an academically-oriented upward social comparison – a comparison with another of higher academic achievement – hinders working memory capacity when contrasted with a downward comparison group and a no-comparison group (Peper & Lloyd, 2015). The present study aims to replicate Peper and Lloyd's (2015) findings and assess additional psychological and physiological variables to delineate potential moderators and mediators of this phenomenon. Additional variables include affect, state and trait anxiety, self-esteem contingency, extraversion, sympathetic nervous system arousal, and salivary cortisol concentrations.

Keywords: social comparison, working memory, threat

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Introduction

Working memory (WM) is an executive function essential for many aspects of cognition. An executive function, WM evolved from the similar concept of short-term memory to include dynamic manipulation and processing of information while simultaneously maintaining other relevant chunks for ease of use (Baddeley, 2012). Some consider WM synonymous with consciousness – a mental desk space for present thoughts and concerns, to evaluate problems, produce solutions, and organize ideas. As important as WM is, there exist threats to its optimal performance. Threats to WM function and capacity has been the subject of much research, and the root of many of these threats are theorized to be mediated by stress, anxiety, and negative mood. One of these threats, as demonstrated by a recent pilot study, appears to be the suggestion of an upward social comparison (Peper & Lloyd, 2015).

Simply, social comparison involves contrasting oneself with another. The process of making social comparisons is largely automatic and most often involves contrasting relative ability/competency, opinions, and/or warmth/trustworthiness (Kruglanski & Mayseless, 1990; Swencionis & Fiske, 2014). Social comparison is divided into two categories: downward comparison and upward comparison. A downward comparison occurs when some individual contrasts themselves with another they perceive as worse off than themselves. Oppositely, an upward comparison arises when an individual compares themselves with another they perceive as better. Evolutionary theories postulate social comparison originally served to aid survival in early humans, but this social cognition is still active today and aids in self-esteem establishment.

Primarily, people engage in social comparison to gather information about themselves in relation to others. From an evolutionary perspective, the human propensity for social comparison developed as a function of danger assessment regarding another person (their warmth/trustworthiness and competence; Fiske, Cuddy, & Glick, 2006). Social comparison, then, answers the following questions: Is this person more likely to help or harm me? Would they be able to successfully accomplish their intention? There appears to be a stronger propensity to assess another's competence in relation to one's own rather than assess another's opinions, for another's competence could mean life or death (Swencionis & Fiske, 2014). Beyond danger assessment, implications follow the evaluation of another in relation to the self when disparities exist between the juxtaposed abilities.

Downward comparisons with others less competent or fortunate can be beneficial to the comparing individual. Such benefits include increasing subjective well-being and positive self-evaluations (Wood, Taylor, & Lichtman, 1985). Willis' (1981) prominent theory of downward comparison highlights the human drive for self-enhancement and the motivation to experience the positive benefits from engaging in a downward comparison. Most often, making a downward comparison leads to a positive self-evaluation and self-enhancement (Kruglanski & Mayseless, 1990; Wheeler & Miyake, 1992; Wood, Taylor, & Lichtman, 1985).

However, downward comparison has also been found to worsen mood compared to upward comparison (Aspinwall & Taylor, 1993). In Aspinwall and Taylor's (1993) study, participants completed an affect questionnaire before listening to one of two possible student interviews to invoke social comparison. The student in the first interview described a highly successful academic career and reported a rich social life, inducing an upward comparison. Conversely, in the downward condition, participants listened to an interviewed student report a dismal university experience. Listening to the downward comparison significantly reduced reported affect compared to those who listened to the upward social comparison. Hearing a tale about another less fortunate is drastically different than learning about outperforming others in a cognitive task, though.

Another study by Zell and Alicke (2009), pitting upward comparison and downward comparison against each other based on verbal reasoning performance, found the opposite effects as Aspinwall and Taylor (1993). Zell and Alicke (2009) had participants complete a verbal reasoning task, and the participants received feedback informing them that they outperformed only 40% of other students in their school (upward comparison) or that they outperformed 80% of other students in their school (downward comparison). After receiving feedback, participants completed self-evaluations and affect measures. Participants in the downward comparison, believing they outperformed 80% of their school, reported significantly more positive self evaluations (η^2 = .26) and positive affect (η^2 = .19). Although the literature varies in the reports of the impact of social comparison, many different studies have observed multiple deleterious consequences of upward social comparison.

Research on upward comparison highlight the many possible negative outcomes when some individual experiences an unfavorable comparison, including reduced subjective well-being, stress, induced negative affect, unbidden ruminative thoughts, and WM interference (Buunk et al., 1990; Mendes, Blascovich, Major, & Seery, 2001; Muller & Fayant, 2010; Peper & Lloyd, 2015; Wheeler & Miyake, 1992). Physiological evidence suggests that exposure to an upward comparison increases autonomic nervous system arousal, stress, and cardiovascular reactivity consistent with threat experience (Mendes, Blascovich, Major, & Seery, 2001). According to Muller and Fayant (2010), when individuals feel threatened by an upward comparison, they experience negative affect and likely encounter ruminative or intrusive thoughts regarding the subsequent negative self-evaluation which commandeer limited cognitive resources. Interestingly, once a participant feels inferior compared to another, the presence of the superior other is unnecessary to demonstrate the effect of upward comparison (Muller & Butera, 2007), and Peper and Lloyd (2015) found merely telling participants their scores would be compared to academically superior others hindered WM performance compared to downward comparison or no-comparison groups. However, in academic settings, upward comparison has been shown to improve performance when the individual did not feel threatened by the comparison (e.g. Blanton, Buunk, Gibbens & Kuyper, 1999). Perhaps whether an individual feels threatened by an upward social comparison depends on their self-esteem.

Self-esteem is the affective conclusion we hold regarding our self-worth. To reach this affective conclusion, one evaluates their own merits and faults, often without objectivity; and frequently in respect to others via social comparison (Campbell & Sedikides, 1999). Kernis (2003) divided self-esteem into two additional categories beyond high (positive feelings about self) and low (negative feelings about self): fragile and secure. Fragile self-esteem is marked by defensiveness (i.e. exaggerated affective reactivity to evaluative feedback), instability, and ingenuineness (e.g. self-reported opinion of oneself incongruent with implicit self-esteem; Kernis, 2003; Kernis, Lakey, & Heppner, 2008).

Secure self-esteem, however, is distinguished by little defensiveness, high stability, and genuineness. A study looking at the differences between secure and fragile self-esteem found individuals possessing markers of secure self-esteem (stable, genuine) presented significantly lower rates of verbal defensiveness compared to individuals exhibiting markers of fragile self-esteem (instable, ingenuine) when faced with an ego threat (Kernis, Lakey, & Heppner, 2008). Individuals with fragile self-esteem show greater emotional reactivity and reliance on self-regulatory cognitions in response to ego threat – a threat to self-esteem (Baumeister, Smart, & Boden, 1996; Campbell, Hoyle, & Bradfield, 2011; Kernis, Lakey, & Heppner, 2008). Heppner and Kernis (2011) suggest self-esteem contingency – the degree to which one's self-esteem depends upon external factors such as feedback and social comparison – serves as a marker of fragile self-esteem and can be measured with Crocker, Luhtanen, Cooper, and Bouvrette's (2003) Contingencies of Self-Worth Scale.

As self-esteem is often evaluated via social comparison and an unfavorable comparison can induce a negative self-evaluation, a threatening comparison could act as an ego threat. Thus, individuals with highly contingent self-esteems may encounter the negative outcomes from a perceived upward comparison more than individuals with lowly contingent self-esteems. Evidence suggests threatening upward comparisons result in multiple negative outcomes – stress, ruminative thoughts, and negative affect – many of which have been shown to interfere with WM function.

WM is a complex concept and plays a role in many higher order executive functions pivotal to cognition (Baddeley, 2012; Daneman & Merikle, 1996). One model of WM was created and continually refined by Alan Baddeley. Baddeley and Hitch's (1974) original multicomponent model of WM consisted of a visuospatial sketchpad (visual and spatial short-term memory) and phonological loop (semantic rehearsal), both of which guided by a central executive (attentional control). In the original model, the central executive was nestled between the other components. Another component, the episodic buffer (which maintains chunks of information for immediate availability), was added to the WM model later (Baddeley, 2000). All components except the central executive interact with long term memory stores. This new model held the central executive above the other three short-term components. The three maintained interplay between one another, upwardly with the central executive, and downwardly with long-term memory.

Baddeley (2012) stated that a significant reason for revaluating his original model and adding the component of episodic buffer was because Daneman and Carpenter's (1980) influential development of the reading span task. Their reading span task, later refined by Kane and colleagues (2004), captured WM's dynamic nature of simultaneous information processing and storage by requiring someone to read a sentence, decide whether that sentence made sense or was nonsensical, then store a random letter for later recall. A series, from three to seven, of sentence-letter pairs are presented, then followed by a screen instructing an individual to choose the correct letters in the order they were originally presented from twelve possible letters. The number of correctly recalled letter sequences, a max of 75, represents a person's reading span – an operational definition of working memory capacity (WMC). WMC, the capacity in which an individual can maintain and manipulate information relevant to the task at hand, assessed with a reading span task, positively correlates with reading ability, reasoning ability, verbal SAT scores, verbal fluency (Daneman & Carpenter, 1980; Daneman, 1991), and is a robust indicator of language comprehension (Daneman & Merikle, 1996). The importance of optimal WM performance across different situations is obvious, but evidence suggests threats to WM function exist, such as stereotype threat.

Stereotype threat is a phenomenon where individuals possessing characteristics about which negative stereotypes exist (e.g. women and poorer math ability) perform worse on cognitively demanding tasks than they are capable of when aware of said stereotype (Schmader, Johns, & Forbes, 2008). Research suggests that this effect of stereotype threat results from hindered WM performance (Beilock, Rydell, & McConnell, 2007; Schmader & Johns, 2003). Schmader, Johns, and Forbes (2008) hypothesize three causes of the WM performance deficits: neurocognitive impairment due to stress, propensity to self-monitor performance, and the presence (and effort to remove) intrusive negative thoughts and emotions. All three of these hypothesized consequences influencing WM resemble outcomes of social comparison. The first cause is a function of nervous system arousal, and the second and third reduce WM performance by commandeering cognitive resources otherwise devoted to a WM-demanding task.

Participants experiencing social stress, induced with the Trier Social Stress Test (a well-established social stressor) and confirmed with salivary cortisol samples, perform significantly worse on an n-back task compared to participants who did not experience the social stressor (Schoofs, Preuss, & Wolf, 2008) Moreover, results from a neuroimaging study that evoked acute psychological stress with selected aversive movie clips in an fMRI indicated acute psychological stress reduced activity in the dorsolateral prefrontal cortex – a region of interest strongly associated with WM function (Desposito & Postle, 2015) – and other executive function networks during an n-back task (Qin, Hermans, van Marle, Luo, & Fernández, 2009). Although, participant n-back performance in Qin and colleagues' study did not significantly differ between the stressed and un-stressed groups, suggesting a certain threshold of stress may have to be reached before n-back performance deficits occur. An additional threat to WM function appears to be upward social comparison.

Peper and Lloyd's (2015) pilot study on social comparison and WMC found significant within subject shifts in WMC when a social comparison was subsequently introduced between an upward comparison group (*n* = 10, 3 female) and downward comparison (*n* = 9, 4 female) and no-comparison groups (*n* = 10, 4 female). All participants were undergraduate students enrolled at the University of Minnesota, Duluth, so the social comparison was academically-oriented. Participant's completed a reading span task, took a five-minute break, returned, and took a second reading span task. Immediately before the second reading span task, participants in the downward comparison group were told their scores on the next task would be compared to scores of high-school students, while participants in the upward comparison group were told their scores on the next task would be compared to scores of Ph.D. graduates. Participants in the no-comparison group were told to try their best before completing the second reading span task. The reading spans of those in the no-comparison and downward comparison groups slightly improved between the first and second tasks, suggesting a practice or familiarity effect. In the upward comparison group, scores slightly decreased, negating the putative practice or familiarity effect. Within this paradigm, negation of the practice/familiarity effects seen in the no-comparison group is considered WM interference, a disruption in short-term memory performance. A significant main effect of trial (between task 1 and task 2) was found, $F(1, 23) = 11.72$, $p < .01$, $\eta^2 = .34$, as well as a significant trial-by-group interaction, $F(2, 23) = 7.21$, $p < .01$, $\eta^2 = .39$. 39% of the variance in the task performance disparities between trials can be accounted for by comparison groups, but this effect could be inflated due to the small sample size. Learning more about the nature of this strong effect is worthy of exploration.

The present study, a conceptual replication of Peper and Lloyd's (2015) within-subject design, aims to test whether contingent self-esteem moderates and trait anxiety exacerbates the effect of social comparison on WMC, whether extraversion buffers the effect, and if salivary cortisol response, autonomic nervous system arousal, and/or negative affect mediate the effect. By adding additional comparison groups, an even comparison (comparison with other undergraduates within their class) and slight upward comparison (comparison with graduate students), further intricacies of academic social comparison may be uncovered. We hypothesize improvement in reading spans between the first and second task in the no-comparison and downward comparison groups, akin to the pilot study. However, the downward comparison group is predicted to experience performance differing from the control group when contingent self-esteem is high. In the even comparison group, we hypothesize contingent self-esteem, to influence reading spans on the second task. Participants in the slight upward group, we hypothesize, will not improve their reading spans on the second task, particularly evident in those with highly contingent self-esteem. Moreover, we hypothesize replication of Peper and Lloyd's (2015) findings and that participants in the upward comparison group will not improve their reading spans on the second task, and the reading spans of participants with highly contingent self-esteem will be particularly affected by the upward comparison influence. Overall, we hypothesize individuals with highly contingent self-esteem will display the negative effects of social comparison more than their low contingent self-esteem counterparts. Finally, we look to find whether autonomic nervous system arousal, elevated salivary cortisol, and/or greater negative affect significantly correlate with stagnated or reduced reading spans between the first and second task.

Method

Participants

Undergraduate students (*n* = 50; 30 female; *M*age = 19.82, *SD* = 1.535) were recruited from psychology courses for which they received class credit for participation. Of the participants, 88% identified as white, 6% identified as Asian, 4% as Black, and 2% as Hispanic. Subjects were randomly assigned to one of five comparison groups: no-comparison (*n* = 10; 6 female), downward comparison (*n* = 10; 6 female), even comparison (*n* = 10; 7 female), slight upward comparison (*n* = 10; 5 female), and upward comparison (*n* = 10; 6 female). Participants were asked not to eat, drink, smoke, or exercise one hour prior to the study. Additionally, inclusion criteria limited participation to those with English as a first language, for the reading span task requires full comprehension of English.

Procedure

Data collection took place at either 9am or 11am and counterbalanced within each group to control for natural, daily cortisol fluctuation (Hellhammer & Schubert, 2012). Each session lasted approximately 100 minutes. Upon arrival in the lab, participants read and signed consent forms which described the purpose of the experiment as a test looking for correlates of individual WM variation. After signing their consent form and providing their demographic information, participants provided their first, baseline saliva sample. Participants then completed a paper version of the Positive Affect Negative Affect Schedule (PANAS; Watson et al., 1988), State-Trait Anxiety Inventory (STAI; Speilberger et al., 1983), and the Contingencies of Self-Worth Scale (Crocker et al., 2003) disguised as an extroversion and academic personality trait survey. Following the self-report measures, participants sat in a chair facing a computer monitor with a mouse near their left hand. They had time to practice using the mouse before the tasks began. Electrodes were connected to the fore and ring fingers of their right hand. Once the electrodes were connected, the participants began their first reading span task. With the first reading span task completed, participants gave a second saliva sample. After a five-minute break, the research confederate evoked a potential social comparison immediately before a second reading span task. The comparison was evoked by telling the participant: "Your scores on this next task will be compared to scores of (assigned comparison group). Please try your best." Participants in the no-comparison group were only told to, "please try your best." With the second reading span task completed, participants gave a third saliva sample before the electrodes are disconnected. Then, participants again completed the PANAS and the state portion of the STAI. A fourth saliva sample was gathered upon completing the final self-report measures. At the end of the semester in which the participant partook in the study, they received a debriefing email, thus reducing the risk of contamination.

Materials

Daneman and Carpenter's (1980) reading span task, modified by Kane and colleagues (2004), exhibited an acceptable Cronbach's alpha (α) of .78 and test-retest correlations ranging from .70 to .80 over minutes, weeks, and 3 months (Conway et al., 2005). The reading span task's construct, convergent, predictive, and discriminant validity were also deemed acceptable by Conway and colleagues' (2005) assessment. A second task was developed using the same code and software but presented sentences of similar length and complexity used in the pilot study. Both span tasks were used, and the presentation counterbalanced to control for order effects.

The Contingencies of Self-Worth Scale (CSWS) is 35-item self-report measure assessing seven domains upon which one's self-esteem depends, and includes: other's approval, appearance, competition, academic competence, family support, virtue, and god's love (Crocker et al., 2003). Across demographics, each subscale demonstrated sufficient reliability (α's greater than .77), and each subscale was considered adequately valid. For the sake of parsimony and time, and because those subscales are less theoretically relevant, the questions assessing appearance, family support, virtue, and god's love were removed from the measure. Thus, 15 items remained of the measure used in the present study, some of which are reverse coded. The items consist of statements that describe one's dependence on comparative feedback from others to determine their self-worth/self-esteem, and individuals rate these statements from 1 (strongly disagree) to 7 (strongly agree). Eight statements from the Big Five Inventory's extraversion subscale (John, Donahue, & Kentle, 1991) were borrowed to disguise the CSWS and avoid contamination. The extraversion subscale has a good test-retest reliability within the range of .76 and .83 and a strong internal consistency (α = .86; Gosling, Rentfrow, &

Swann, 2003). 23 items totaled the masked CSWS that was titled, “Extraversion and Academic Personality”.

The PANAS and STAI are widely used in the literature and both considered sufficiently reliable and valid (Spielberger et al., 1983; Watson et al., 1988). For the PANAS, individuals rate, from 1 being not all to 5 being extremely, the extent to which they currently feel 20 different (positive and negative) emotion words. Authors report satisfactory internal consistency for the PANAS when assessing affect at that moment (average α = .87; Watson et al., 1988). In the STAI, which boasts a strong internal constancy (average α > .89) and solid test-retest reliability (average r = .88), individuals complete two forms consisting of 20 question each (Barnes, Harp, & Jung, 2002). The first form assesses state anxiety, asking how one feels *right now*; whereas the second form measures trait anxiety, questioning how one *generally feels* (Spielberger et al., 1983).

Electrodermal activity – galvanic skin response – was measured with a Biopac psychophysiological monitoring system and processed with Acknowledge 4.4 software. Electrodes were placed on the fore and ring finger of the right hand, and data was collected in 3.5-minute intervals starting at the beginning of each reading span task. The number of skin conductance responses, their mean and max amplitude, and shift in tonic amplitude were analyzed. .001 microsiemens served as the minimum threshold for a skin conductance response

Saliva samples (> .5 mL) were collected were collected at approximately 10 minutes, 50 minutes, 80 minutes, and 100 minutes after participant arrival, staggered around tasks (i.e. -55, -5, + 20, and + 40 minutes from stressor onset). Samples were collected through passive drooling and were stored at -20 degrees C. Upon completion of data collection, samples were assessed for cortisol concentrations in ng/mL with enzyme linked immunosorbent assays (ELISA) and spectrophotometry at the University of Minnesota, Duluth Medical School, according to standard procedure (IBL-America, 2017). Results were calculated with the recommended 4 Parameter Logistics method. Each sample was duplicated for validation of accuracy, and those two concentrations were averaged for a final value used in statistical analyses. One participant failed to produce enough saliva, so the control group had one less set of cortisol data points than the other groups.

Power Analysis

A power analysis, using G*Power, for a mixed-method ANOVA with 5 groups, 2 measurements, an alpha of .05, power of .80, and an estimated effect size of .29 recommend using a sample of 130 participants. Although 150 was the goal, to add more power beyond what the analysis suggested, only data from 50 participants was collected.

Statistical Analysis

Variables involved in analysis included comparison group, first reading span, second reading span, affect, state and trait anxiety, contingency of self-esteem, extroversion, sympathetic nervous system arousal, and salivary cortisol concentrations. A series of 5 x 2 mixed-method ANOVA assessed social comparison's influence on repeated measure variables. Within comparison groups, the SPSS regression extension PROCESS by Andrew F. Hayes was intended to be used to assess moderation and mediation effects. Simple multiple regression and correlations between shift variables (T2 – T1) were performed as additional, secondary analyses. Analyzing shift scores rids each variable of between subject variance, and using GSR shift scores has the additional advantage of controlling for differences in electrode connectivity across subjects.

Results

ANOVAS

A series of 5x2 mixed method ANOVAS were used to assess between group differences in within subject measures of reading span, positive affect, negative affect, state anxiety, GSR mean amplitude, and GSR max amplitude. Within subject contrasts for reading span revealed a significant main effect of trial (first versus second measurement), $F(1, 45) = 5.461$, $p = .024$, $\eta^2 = .108$, though the interaction between group and trial was not $F(4, 45) = .65$, $p = .624$, $\eta^2 = .055$. Furthermore, no significant two-way interaction between reading span trial and sex of the participant was found, and no significant three-way interaction between reading span trial, group, and sex was found. These results suggest that the only effect observed was a practice or familiarity effect of the task, because means for each group improved between T1 and T2. Another significant main effect was found using within subject contrasts for cortisol concentration across all groups, $F(1, 44) = 60.088$, $p < .001$, $\eta^2 = .475$. All four samples for all groups decreased over time. However, the interaction between group and cortisol was not significant, $F(4, 44) = 1.054$, $p = .391$, $\eta^2 = .087$. Moreover, for negative affect, positive affect, state anxiety, GSR mean amplitude and GSR max amplitude no significant main effect of trial (between the first and second measurement) nor a trial by group interaction was found. See Figures 1-7 for graphs of mean changes between groups of each repeated measure variable across the two measures.

There was a significant between subject effect of group on negative affect across groups, $F(4, 45) = 2.82$, $p = .036$, $\eta^2 = .201$. Post-hoc comparisons indicated significant group differences, with the even comparison group having significantly higher negative affect than the control group ($p = .018$), the downward comparison group ($p = .033$), and the upward comparison group ($p = .003$). See Figure 3 for graphical representation of group differences across both trials.

Additionally, results indicated a significant between subject effect of group on state anxiety, $F(4, 45) = 2.97$, $p = .029$, $\eta^2 = .209$. Post-hoc comparisons revealed significant group differences between the downward and upward condition ($p = .049$) with the downward group reporting significantly more state anxiety. Furthermore, the even comparison condition also reported significantly higher subjective anxiety than the upward comparison condition ($p =.001$). A visual breakdown of state anxiety scores can be seen in Figure 4. No further significant between subject effects were found.

Variance and Variable Means

Levene's test for homogeneity of variance was non-significant for all repeated measure variables except negative affect, which was significant, Levene's = 2.71, p = .042. This suggests that for all variables excepting negative affect, the variance across groups was relatively homogeneous. However, graphically, the distribution shows greater reading span shift (T2 – T1) variance in the comparison groups than in the control group. See Figure 8 and Figure 9 for shift score distributions in each group for reading span and negative affect respectively. See Table 2 for group mean score shift and standard deviation for each variable.

Correlations and Curve Estimations

Because the study was underpowered and because the primary hypotheses were not found significant despite many theoretically concurrent trends in the means, extensive secondary outcomes were explored, looking into directly relevant relationships between variables. Correlations between potential moderating variables and repeated measure shift values for the entire sample can be seen in Table 4. See Table 5 for the same correlations for the comparison conditions. The most theoretically relevant will be discussed.

Two-tailed tests revealed that in both the entire sample and the comparison conditions alone (N = 40), reading span shift was significantly negatively related to the shift in negative affect and the shift in GSR max amplitude, albeit to different extents. For the four comparison conditions, reading span shift showed a stronger association with negative affect shift (r = -.41, p = .008) and GSR max amplitude shift (r = -.42, p = .007) than when assessing all five treatment groups – reading span was correlated with negative affect shift (r = -.35, p = .012) and with GSR max amplitude shift (r = -.33, p = .018) – suggesting distinct consequences in the face of social comparison. Additionally, a curve estimation showed a near significant positive linear relationship between the baseline GSR mean amplitude and the cortisol concentration of the first, baseline sample across all groups, F (1, 47) = 4.062, p = .050, R^2 =.08. This helps to validate the GSR measurements. Finally, no meaningful correlations with GSR tonic and number of skin conductance responses were found.

Multiple Regression

A hierarchical multiple regression analyzed the predicting power of four variables – GSR max amplitude shift, negative affect shift, extroversion, and total CSW – with reading span shift as the outcome variable. Only the four comparison groups were included in the regression. Sex and age were used in the first model as control variables. Each shift variable, including the outcome variable, was square root transformed before the shift (i.e. [SQRT(T2)] – [SQRT(T1)]) to better meet assumptions. Correlations and collinearity statistics revealed no issues of multicollinearity – all tolerance scores between .76 - .94, VIFs between 1.05 – 1.31. A Durbin-Watson value of 2.08 revealed an independence of residuals. Graphs of standardized residuals against standardized predictor values indicated homoscedadicty of variance. However, a histogram of residuals revealed slight non-normality, and one participant had scores exerting undue influence on the regression according to mahalanobis distance and covariance scores. However, that individual's scores were within a reasonable range, so bootstrapping was used for a more robust regression to combat non-normality of residuals and the influential case.

Model 1, using sex and age as control predictors, was not a significant predictor of reading span shift, $F(2, 37) = .114$, $p = .893$, $R^2 = .006$. However, when GSR max amplitude shift, negative affect shift, extroversion, and total CSW (the sum total of approval, competitiveness, and academic subscales of the CSWS) were added in Model 2, it was significant, $F(6, 33) = 3.39$, $p = .004$, $R^2 = .426$. Model 2 significantly predicted reading span shift better than Model 1 ($\Delta F = 6.028$, $p = .001$, $\Delta R^2 = .42$), accounting for an additional 42% of the variance in reading span shift across the comparison groups. Within Model 2, both negative affect shift ($B = -0.645$, $\beta = .403$ $t(33) = -2.805$, $p = .008$, 95% *BCa CI* [-1.11, -0.18]) and GSR max amplitude shift (B = -2.836, β = -.388, $t(33)$ = -2.658, p = .012, *BCa CI* [-5.01, -.67]) were significant predictors of comparison groups' reading span shift; as each variable increased in the model, reading span shift decreased. A breakdown of models 1 and 2 can be seen in Table 3.

Discussion

Although many studies have looked at the consequences of social comparison, few, if any, have explored the influence of social comparison on cognition. As many of the effects of social comparison, particularly those documented from upward comparison, have been factors that hinder WM performance, that is what the present study investigated. The first hypothesis stated that various levels of social comparison would differentially affect WMC in a predictable manner. No evidence of this was found. The second hypothesis examined whether the effect of the first hypothesis was mediated by affect change, anxiety, and/or a physiological stress response; and moderated by contingent self-esteem, extroversion, and or trait anxiety. Because the first hypothesis was not supported, the second hypothesis was abandoned. Secondary, exploratory analyses, however, revealed some interesting findings worth further examination.

Results from the present study found no significant difference between levels of academically oriented social comparison – downward, even, slight upward, and upward – and that of the no-comparison control. This differs drastically from Peper and Lloyd's (2015) preliminary findings which showed the same upward comparison had a deleterious effect on WMC compared to the control and downward comparison groups. There exist multiple potential reasons for this discrepancy, including differences in session length and participant demand. The preliminary study took approximately twenty minutes, whereas the present study required five times as much time. With longer session times, the risk of boredom increases. Furthermore, the increased session time was due to a greater number of tasks and measures, from two in the preliminary to twelve in the present, taxing and tiring the participants more in the present study. Fatigue in the present study's control group can be inferred from their mean reading span shift scores and negative GSR shift scores, the lowest means in each (Table 2). Conversely, the control group had the highest reading span shift in the preliminary study when the demand was less. Therefore, in the present study, when the demand and possibility for fatigue was high, the social comparison invocation appeared to have motivated the four comparison groups beyond that of the control group. With a similar trend as observed in the preliminary study, participants in the downward comparison group improved their reading spans by a margin nearly twice that of the upward comparison group.

While the results of the present study differed from the preliminary study, the findings resemble the social comparison literature in its entirety: social comparison, either upward or downward, can be beneficial to some and harmful to others. While typically downward social comparison results in positive outcomes (e.g. Wheeler & Miyake, 1992; Willis, 1981; Wood, Taylor, & Lichtman, 1985), downward comparisons can lead to negative consequences, such as negative affect, especially when individuals reported a low sense of control (e.g. Buunk, Collins, Taylor, VanYperen, & Dakof, 1990). In the present study, with the downward comparison group in the model, negative affect shift was negatively associated with WM shift with an overall medium effect size (R^2 = .168) across all comparison groups.

Moreover, upward comparison induces various unfortunate outcomes, but it has also been shown to enhance academic performance (Blanton, Buunk, Gibbons, & Kuyper, 1999). The study involved predicting an individual's academic performance from their choice of comparison targets, and the results indicated those who compare themselves to higher scoring others performed well themselves, but only when the individual considered themselves better than their peers and had a higher self-esteem. Another study found students more likely to do well in college when they reportedly compared their performance to other's who scored "high", but students who reportedly compared their performance to other's who simply did "better" showed no such benefit (Buunk, et al., 1990). Upward comparison appears to benefit academic performance when the comparison does not make the one making the comparison feel inferior in contrast, but it can hinder performance when the comparer feels threatened by the comparison. While some people perhaps view the upward comparison as, "I am not as good as them," others may think of it more like, "I can be as good as them if I work hard enough." These opposing views represent thought patterns consistent with fixed and growth mindsets respectively, a variable worthy of exploration as a potential moderator.

Perhaps the current ambiguous findings are then due in part to the academic nature of the social comparison. In this case, participants who aimed high felt motivated by the comparison and improved, while others felt threatened, and their performance declined. This postulation matches GSR results showing no association between mean amplitude, or general arousal, shift and reading span shift, while indicating a strong negative association (and a medium effect, R^2 = .177) between max amplitude, or peak arousal, shift and reading span shift. An elevated yet steady arousal might suggest greater attentiveness, whereas greater peak arousals might indicate an erratic and threatened sympathetic nervous system response. Furthermore, reading span variance increased slightly from 174.76 (T1) to 228.13 (T2), evidencing wider variability in reading span scores facing social comparison.

The ambiguity in reaction to either upward or downward comparison, according to Suls, Martin, and Wheeler (2002), suggests two things about each direction. A downward comparison can convey both that the comparer is advantaged but, also, that their current success could lessen. In an upward comparison, the comparer can feel disadvantaged but, also, that their performance could improve.

Overall, the comparison groups exhibited a theoretically fitting trend: a rise in negative affect and peak physiological arousal marked a decrease in WM performance, and this effect was buffered by extroversion, and was observed to a greater extent among individuals reporting higher contingent self-esteems. Although the latter two variables were statistically insignificant, the model itself had a large effect size, $R^2 = .426$, accounting for 42.6% of the variance in WM performance. While group differences between levels of social comparison failed to illicit statistical significance, perhaps in part due to the severe lack of power, associations between hypothesized variables were still uncovered and illuminate the mechanisms through which social comparison can hinder cognitive functioning.

A stressful testing environment – a spooky physiology lab – could also explain for the discrepancy between the present and preliminary study. This idea is supported by the high cortisol concentrations participants exhibited in their first samples Circulating cortisol levels peak between two and three hours after one's normal awakening time, then decrease steadily until midnight unless otherwise influenced by stress, consumption of food or other substances, or exercise – to name a few (Dorn, Lucke, Loucks, & Berga, 2007). This can be seen clearly in Figure 7. Furthermore, an independent samples t-test revealed greater baseline (T1) salivary cortisol concentrations in participants in the 9am timeslot (*M* =8.69, *SD* 3.52) compared to the 11am timeslot (*M* =6.09, *SD* = 2.46), $t(47) = 3.042$, $p = .004$. However, while most observed salivary cortisol concentrations fell within Salmetrics's normative data range, between 1.12 – 13.48ng/mL (Salimetrics, 2016), the mean cortisol concentration in the present sample was higher, with a few scores exceeding 13.48ng/mL. The stressful testing environment could have wiped out any subtle group differences, the procedure not being stressful enough to evoke any changes in salivary cortisol. Even the Trier Social Stress Test, designed specifically to induce social stress, occasionally fails to increase cortisol levels significantly (Kudielka et al., 2007). The cortisol data combined with the GSR findings suggest that threatening social comparisons are stressful enough to pique the sympathetic nervous system but not enough to surmount the heightened endocrine system.

Limitations and Future Directions

As a novel research question, experimental precedence was lacking, and much was learned by the conductance of this study. Primarily, this study had substantial limitations, including power, possible researcher bias, low manipulation salience, and a lacking generalizability. Future studies, however, will take note of current drawbacks and eliminate them, while examining related questions.

A post hoc power analysis noted a 5 x 2 mixed method ANOVA with a primary outcome being the within-between interaction (e.g. reading span trial by group), and with parameters set to the present study's, requires a critical F value of 2.578, larger than what was observed for any repeated measure variable. If time had allowed, the goal of 150 participants would have provided more power, though with the observed effect size for reading span trial by group ($\eta^2 = .055$), still not enough to reach significance. Plus, the number of groups – five, in total – requires a greater effect to illicit a distinct difference between groups. Future studies will limit the number of groups to only those most relevant to the population studied, lending power to the study. Further power could be provided with a greater effect size, possibly supplemented with a more salient manipulation.

A possibly weak manipulation of the independent variable could be considered a limitation of the present study. The primary independent variable, comparison group membership, was manipulated by simply telling participants their scores would be compared to others. This manipulation could have been more prominent. While Muller and Butera (2007) reported that the comparison other need not be present to illicit an effect as long as the participant felt threatened by the social comparison, the presence of the comparison other – or at least a photo of them accompanied by textual information describing a competence-based comparison – would ensure a more salient and credible manipulation. Furthermore, the presence and mere implication of a comparison with another would improve the present findings generalizability with its more naturalistic nature. Additional stakes could be included to add both salience and generalizability.

In the real world, the important moments in which one may experience and feel threatened by social comparison often have high stakes (e.g. job interview). Therefore, someone in those situations is motivated to do their best. The present study involved no such motivating factors. Participants received class credit or a gift card regardless of their performance. A future experiment would include an incentive – say, a monetary bonus for “meeting or exceeding the performance” of a comparison group – to motivate participants and boost the external validity of the findings. Another way to increase the manipulation’s salience would be to simply provide a photo of the comparison other above biographical text information before the cognitive task.

Future studies could show a photo of a comparison other to the participant, after obtaining consent to falsely photograph the participant themselves, to illicit a more concrete social comparison. This method, beyond increasing manipulation salience, would enhance internal validity by reducing experimenter bias and could be used to test additional related research questions. Coding the task to randomly assign participants to comparison groups allows the confederate to be blind to the group membership of the participant. Thus, experimenter bias would be removed. A limitation of the present study is the fact that the research confederate knew the group to which the participant had been randomly assigned. The confederate had to then interact with the participants and invoke the verbal social comparison, chancing unconscious alteration of their behavior depending on participant group membership. Coding the manipulation into the cognitive task would remove the risk posed by experimental bias. Moreover, presenting the manipulation – social comparison based on photo and relevant text information – as a part of the cognitive task establishes a paradigm that permits investigation of a wide range of related research questions.

Research questions that could be examined with the above paradigm include examining the impact of the comparison other’s facial warmth, masculinity, and additional cognitive functions. By manipulating the facial features of the comparison other along a warmth/coldness axis, one could examine whether warmth of the other’s appearance influence the effect of the social comparison. This may be particularly relevant as Swencionis and Fiske (2014) hypothesize facial warmth serves as a primary factor for social comparison, indicating, in part, whether the comparison other poses a threat. Similarly, one could explore the role of masculinity on the impact of social comparison, for facial masculinity is perceived as an indicator of social dominance and physical prowess (Oosterhof & Todorov, 2008). Dominant facial features are more likely to be perceived as threatening too, particularly for men. Additional experiments could examine the role of physical attractiveness and the influence of a differential gender comparison on cognition.

Furthermore, this paradigm to could be employed with any computerized cognitive task, enabling the examination of social comparison’s influence on cognitions such as spatial WM and verbal fluency. One could also implement this paradigm easily within an fMRI to uncover neural correlates associated with threatening social comparisons. From there, one could evaluate social comparison in a naturalistic setting, perhaps as a mock interview or mock standardized testing situation. Assessing social comparison across multiple domains and in various settings would improve the generalizability deficits in the present experiment.

Firstly, the present study was conducted in a psychophysiology lab, hardly a setting in which people normally experience social comparison. Moreover, the sample included undergraduates enrolled at the University of Minnesota, Duluth who were primarily white. Due to the undergraduate sample, the social comparison was academic in nature.

Therefore, the present findings cannot be generalized beyond this primarily white, undergraduate population. However, the results, though exploratory and varying somewhat from the hypotheses, warrant greater study with wider samples and across multiple domains beyond academia.

Conclusion

The present study found that social comparison across all levels could pose a threat to WM performance, and that performance degradation was associated with increases in negative affect and greater peak skin conductance responses. In that same model, although statistically insignificant, higher contingent self-esteem scores were associated with decreases in WM function, whereas extroversion appeared to act as a protective factor against potentially deleterious outcomes of social comparison.

As a cognitive pillar, understanding anything posing a threat to optimal WM function would benefit psychology and the people at risk. Assuming the pervasiveness of social comparisons suggested by social comparison theory, one may find themselves in situations that potentially threaten WM function daily. Indeed, situations with the highest stakes – job interviews, dissertation and thesis defenses, etcetera – often involve the presence of, and possible unconscious social comparison with, others of greater perceived competence. Even casual situations, such as a student’s meeting with an academic advisor or a manager meeting with an employee, could degrade WM function, and thus hinder effective communication. There are many circumstances in which one desires optimal cognitive functioning in the presence of others, therefore the implications of social comparison threat are widespread. Understanding the nature of this phenomenon moves the field closer to finding protective factors and potential interventions to reduce its adverse effects, so further research is needed and will be completed.

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Table 1.

Reading Span Scores (T1 and T2)

	T1		T2	
	M	*SE*	*M*	*SE*
Control	37.5	4.34	38.6	4.55
Down	35.1	4.34	39.6	4.55
Even	35.2	4.34	44.3	4.55
S. Up	34.7	4.34	37.7	4.55
Up	33.1	4.34	35.4	4.55

Table 2.

Score Shift (T2 – T1)

	Reading Span		Positive Affect		Negative Affect		State Anxiety		GSR mean amp.		GSR max amp.	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Control	1.1	5.86	3.1	5.23	-3.1	2.99	-4.3	7.39	-.03	.10	-.01	.25
Down	4.5	16.41	-.6	5.30	-2.4	3.06	-1.6	8.40	-.02	.07	.03	.32
Even	9.1	12.22	-.3	4.55	.50	8.57	4.2	15.17	.02	.11	.03	.29
S. Up	3.0	13.55	-1.9	5.26	3.0	7.73	1	11.17	.05	.14	.02	.09
Up	2.3	9.78	-2.0	2.91	.2	1.61	.3	6.09	.04	.06	.04	.06

Table 3.

Comparison Groups' Multiple Regression

	Reading Span Shift	
Variables	Model 1 *b*	Model 2 *b*
Constant	1.41	1.92
Sex	-.039	.14
Age	-.059	-.07
Negative affect shift		-.40**
GSR max amplitude shift		-.39*
Extroversion		.16
Total CSWS		-.19
R^2	.006	.426
F	.114	4.077**
ΔR^2		.420
ΔF		6.028**

Note. $N = 40$; All predictor beta values except the constant were standardized

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

Table 4.

Full Sample Shift Scores and Secondary Outcome Measures Correlations

Note. *N* = 50; RS-S = Reading span shift; PA-S = Positive affect shift; NA-S = Negative affect shift; SA-S = State anxiety component of the STAI

	RS-S	PA-S	NA-S	SA-S	GSR Me-S	GSR Ma-S	GSR Ton-S	SCRs	Extro	CSW Total	ApCSW	AcCSW	CoCSW	T-Anx.
RS-S														
PA-S	.18													
NA-S	-.35*	-.25												
SA-S	-.22	-.32*	.76**											
GSR Me-S	-.22	.02	.25	.23										
GSR Max-S	-.33*	-.05	-.26	.32*	.62**									
GSR Ton-S	.06	.08	-.12	-.01	-.32*	-.1								
SCRs	-.12	.03	.30*	.36*	.22	.1	-.05							
Extro	.15	-.15	.19	.33	-.04	.09	.26	.23						
CSW Total	-.2	-.10	.09	-.09	-.22	-.07	-.06	-.09	-.28*					
ApCSW	-.15	.03	.01	-.16	.01	-.05	-.27	-.07	-.44*	.61**				
AcCSW	-.08	-.08	-.05	-.19	-.25	-.22	-.07	-.12	-.27	.75**	.27			
CoCSW	.15	-.24	-.20	-.07	-.02	.03	.01	-.17	-.17	.02	.09	.23		
T-Anx	-.02	.17	.05	-.26	-.22	-.25	-.13	-.21	-.61**	.45*	.39*	.51**	.16	

shift; GSR Me-S = GSR mean amplitude shift; GSR Max-S = GSR max amplitude shift; GSR Ton-S = GSR challenge condition tonic shift; SCRs = number of challenge condition skin conductance responses; Extro = Extroversion; CSW Total = Sum of CSWS subscales; ApCSW = Approval subscale of the CSWS; AcCSW = Academic subscale of the CSWS; CoCSW = Competition subscale of the CSWS; T-Anxiety = Trait component of the STAI

*$p < .05$ (two-tailed), **$p < .01$ (two-tailed)

Table 5.

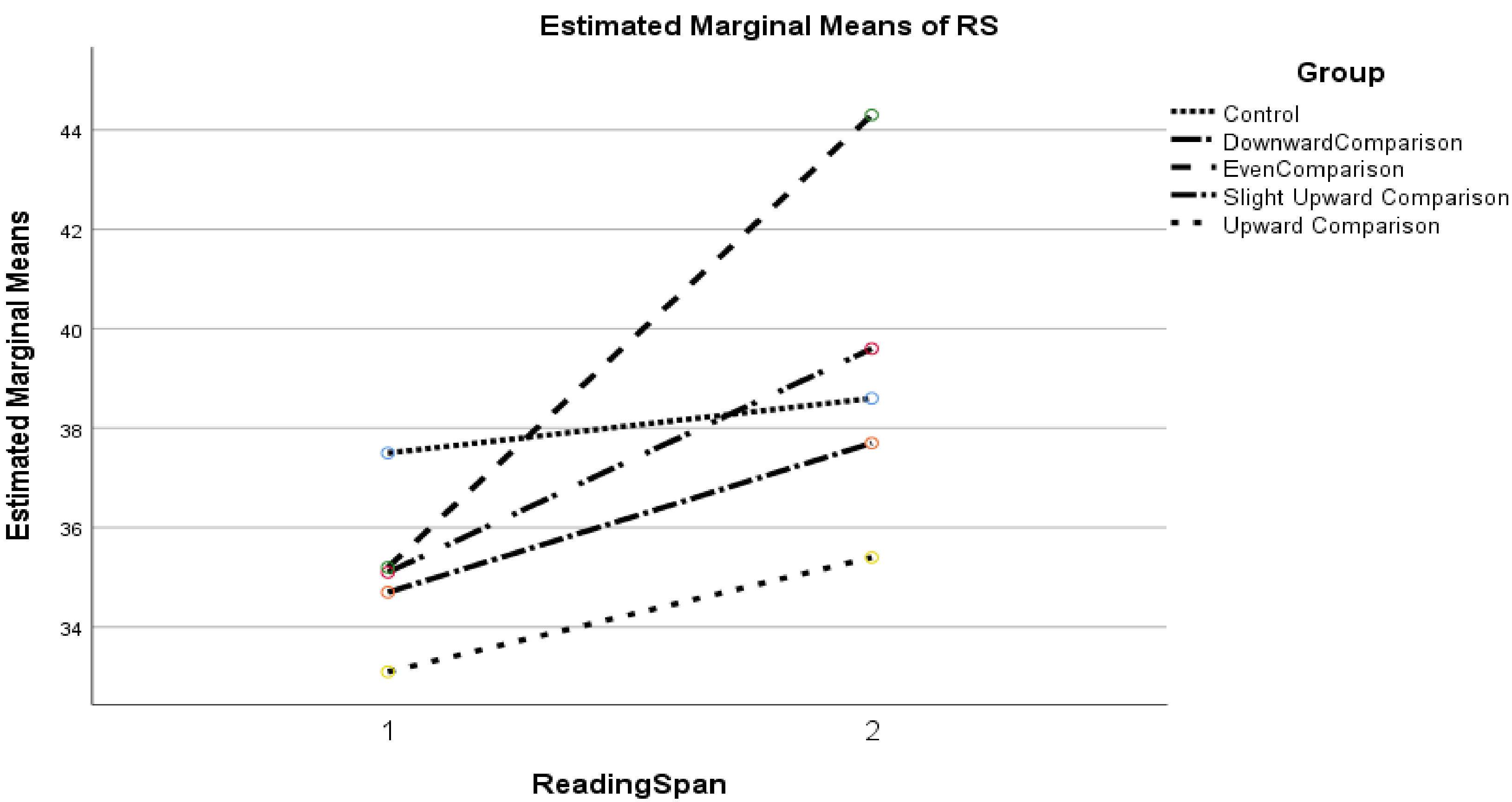
Comparison Groups' Shift Scores and Secondary Outcome Measures Correlations

	RS-S	PA-S	NA-S	SA-S	GSR Me-S	GSR Ma-S	GSR Ton-S	SCRs	Extro	CSW Total	ApCSW	AcCSW	CoCSW	T-Anx.
RS-S														
PA-S	.27													
NA-S	-.41**	-.13												
SA-S	-.28	-.22	.76**											
GSR Me-S	-.29	-.09	.30	.31										
GSR Max-S	-.42**	-.26	,35*	.45**	.53**									
GSR Ton-S	.12	.00	-.09	-.01	-.32*	-.1								
SCRs	-.13	.07	.33*	.41**	.28	.26	-.06							
Extro	.15	-.03	.10	.23	.08	.27	.30	.32						
CSW Total	-.25	-.16	.14	-.05	-.30	-.10	-.02	-.06	-.27					
ApCSW	-.18	-.04	.04	-.16	-.03	-.06	-.30	.00	-.54**	.63**				
AcCSW	-.12	-.13	.01	-.13	-.32	-.30	-.01	-.15	-.22	.78**	.35*			
CoCSW	.12	-.24	-.24	-.11	-.09	.00	.05	.18	-.18	.06	.06	.26		
T-Anx	-.01	.02	.08	-.16	-.25	-.29	-.16	-.26	-.65**	.48*	.39*	.57**	.22	

Note. *N* = 40 RS-S = Reading span shift; PA-S = Positive affect shift; NA-S = Negative affect shift; SA-S = State anxiety component of the STAI shift; GSR Me-S = GSR mean amplitude shift; GSR Max-S = GSR max amplitude shift; GSR Ton-S = GSR challenge condition tonic shift; SCRs = number of challenge condition skin conductance responses; Extro = Extroversion; CSW Total = Sum of CSWS subscales; ApCSW = Approval subscale of the CSWS; AcCSW = Academic subscale of the CSWS; CoCSW = Competition subscale of the CSWS; T-Anxiety = Trait component of the STAI

**p* < .05 (two-tailed), ***p* < .01 (two-tailed)

Figure 1.



Estimated Marginal Means of RS
Estimated Marginal Means
44
42
40
38
36
34
1
2
ReadingSpan
Group
Control
DownwardComparison
EvenComparison
Slight Upward Comparison
Upward Comparison

Figure 2.

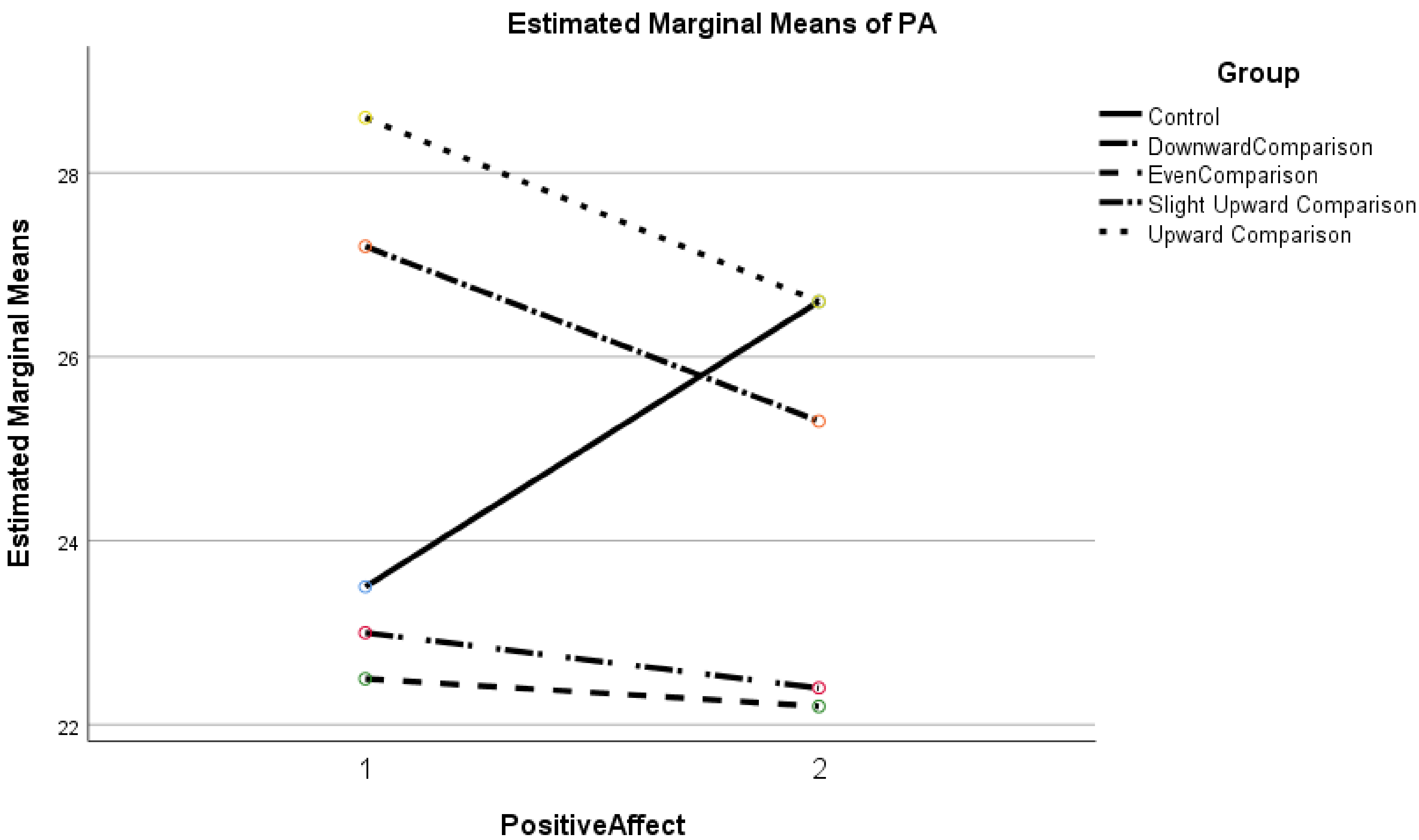
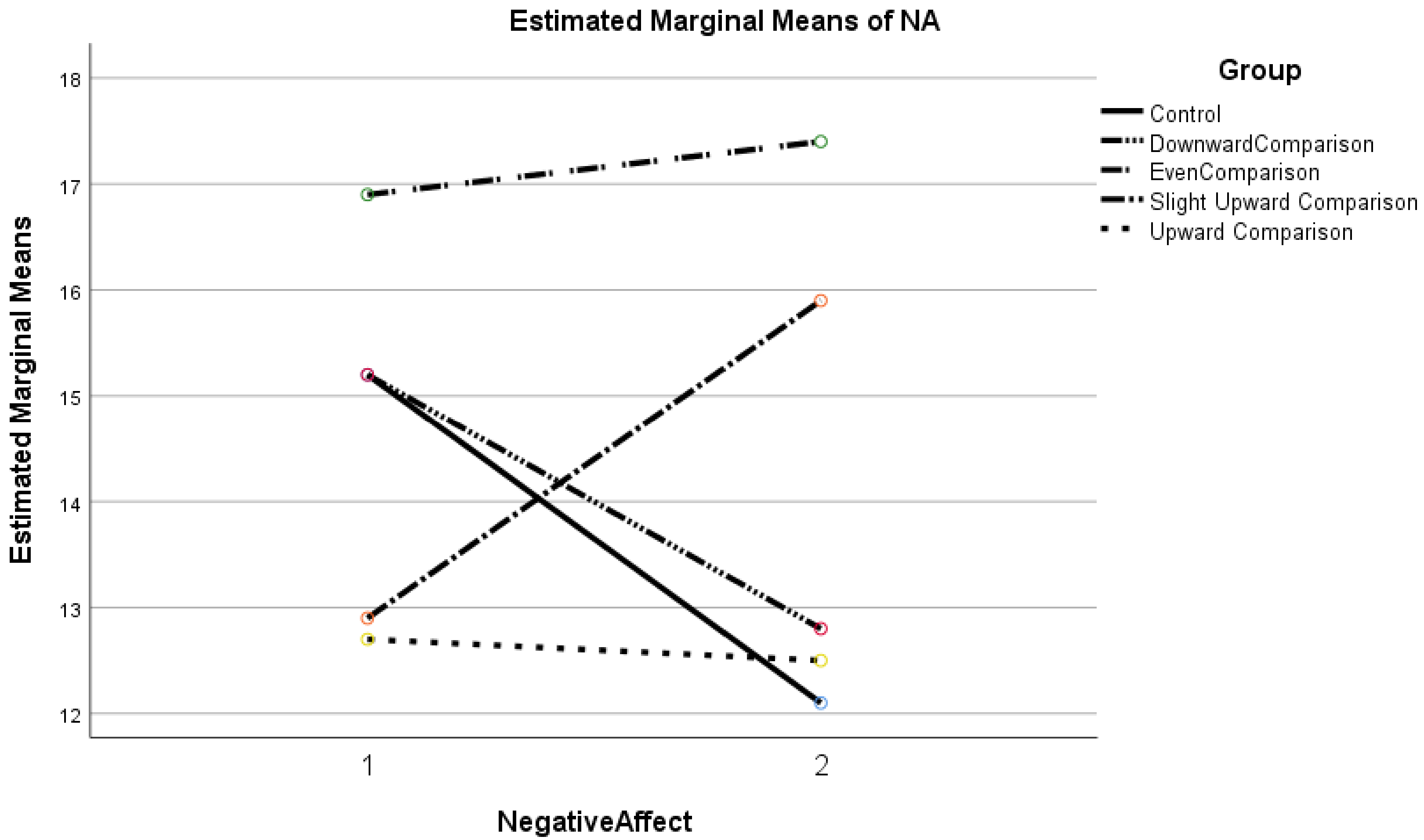
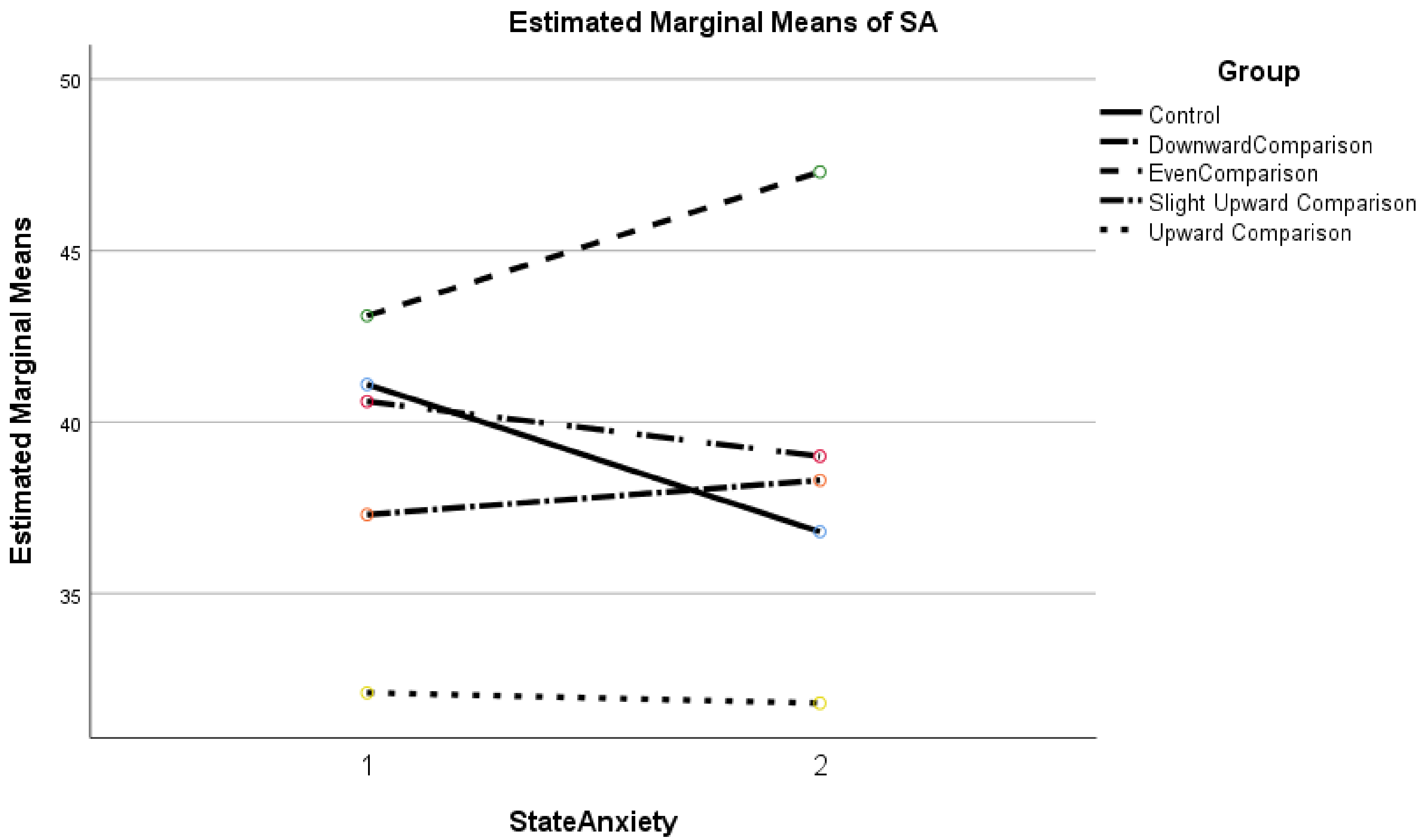

Estimated Marginal Means of PA
Group
Control
DownwardComparison
EvenComparison
Slight Upward Comparison
Upward Comparison
Estimated Marginal Means
28
26
24
22
1
2
PositiveAffect

Figure 3.



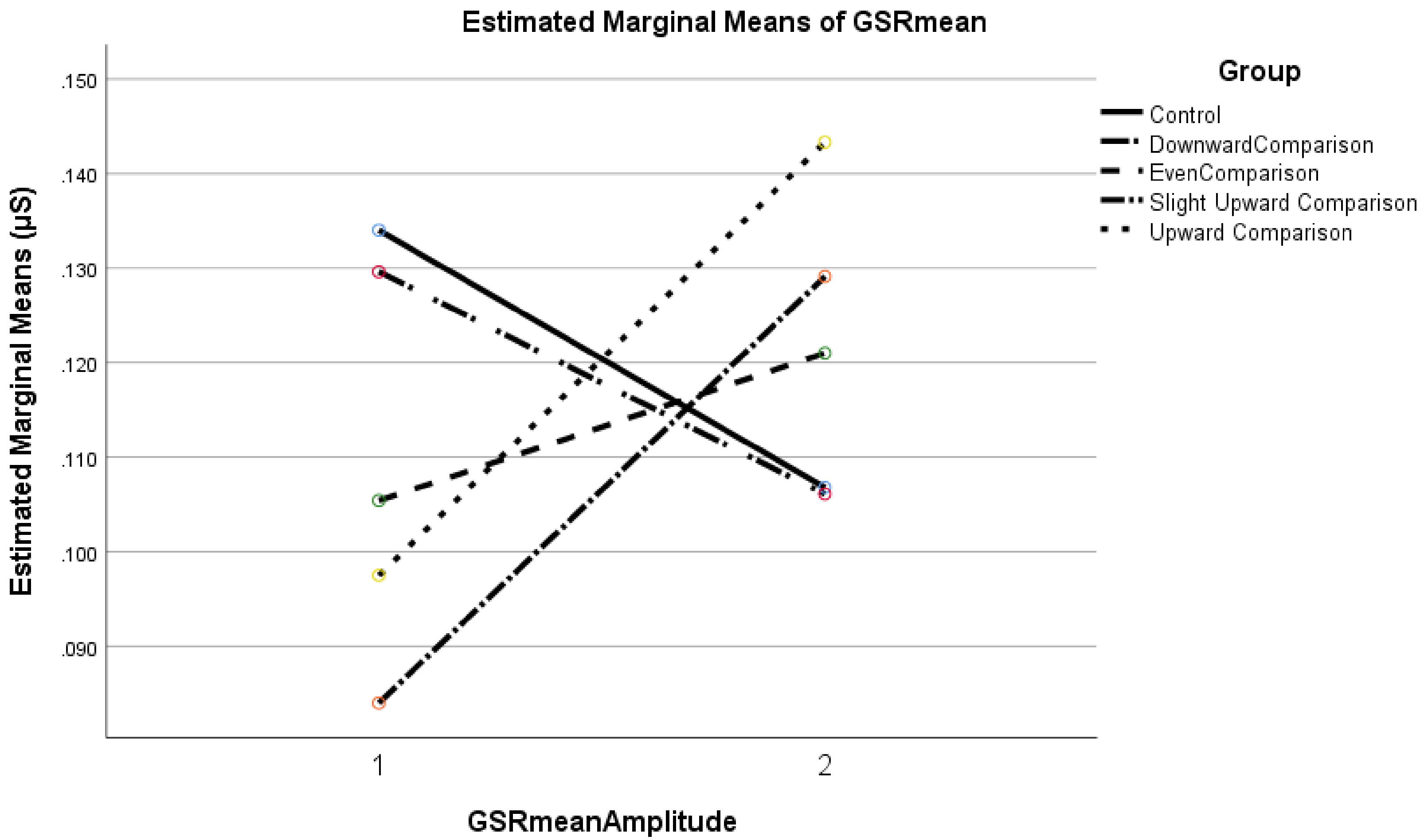
Estimated Marginal Means of NA
Estimated Marginal Means
18
17
16
15
14
13
12
1
2
NegativeAffect
Group
Control
DownwardComparison
EvenComparison
Slight Upward Comparison
Upward Comparison

Figure 4.



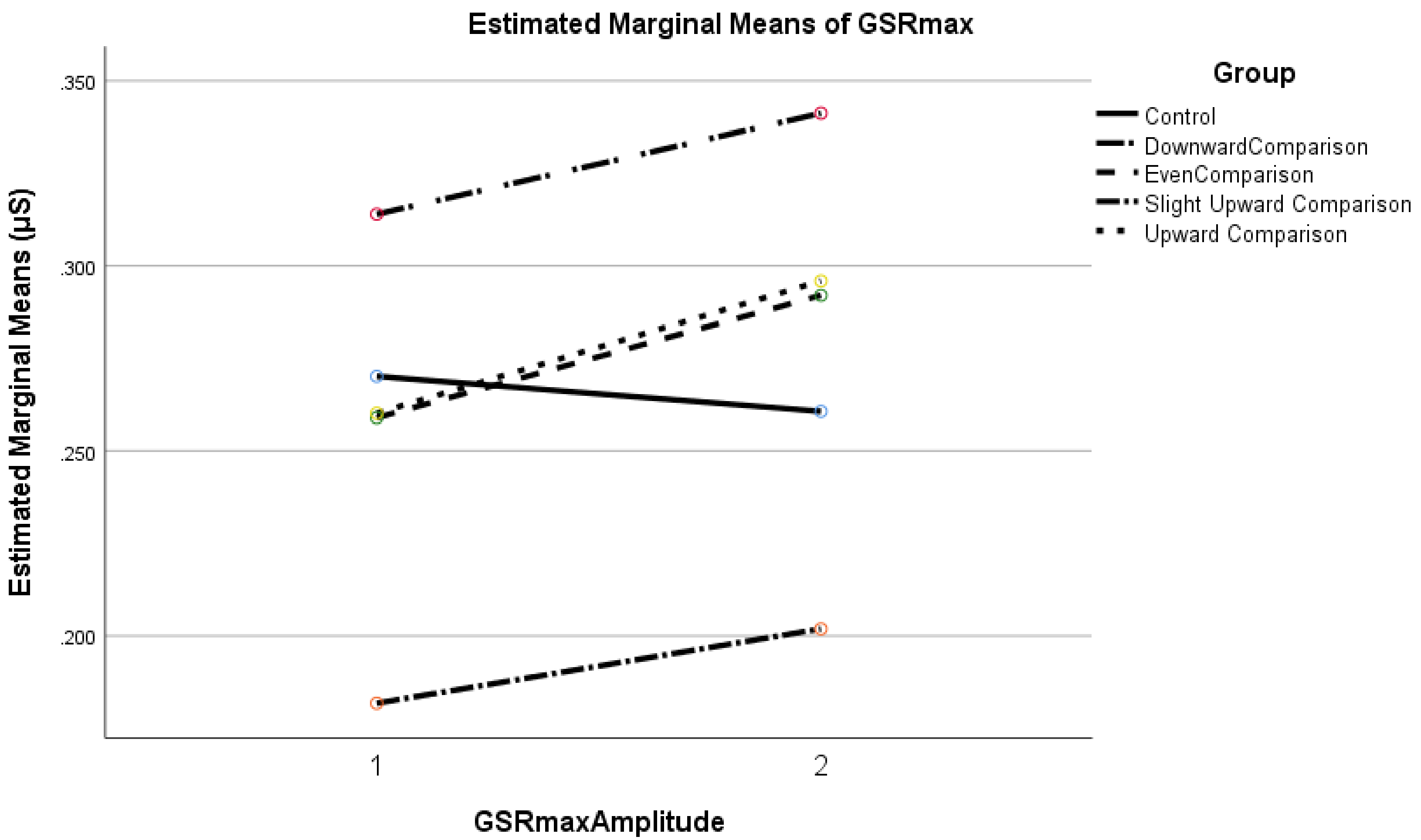
Estimated Marginal Means of SA
Estimated Marginal Means
50
45
40
35
1
2
StateAnxiety
Group
Control
DownwardComparison
EvenComparison
Slight Upward Comparison
Upward Comparison

Figure 5.



Estimated Marginal Means of GSRmean
Estimated Marginal Means (µS)
.150
.140
.130
.120
.110
.100
.090
1
2
GSRmeanAmplitude
Group
Control
DownwardComparison
EvenComparison
Slight Upward Comparison
Upward Comparison

Figure 6.



Estimated Marginal Means of GSRmax
Group
Control
DownwardComparison
EvenComparison
Slight Upward Comparison
Upward Comparison
.350
.300
.250
.200
Estimated Marginal Means (µS)
1
2
GSRmaxAmplitude

Figure 7.

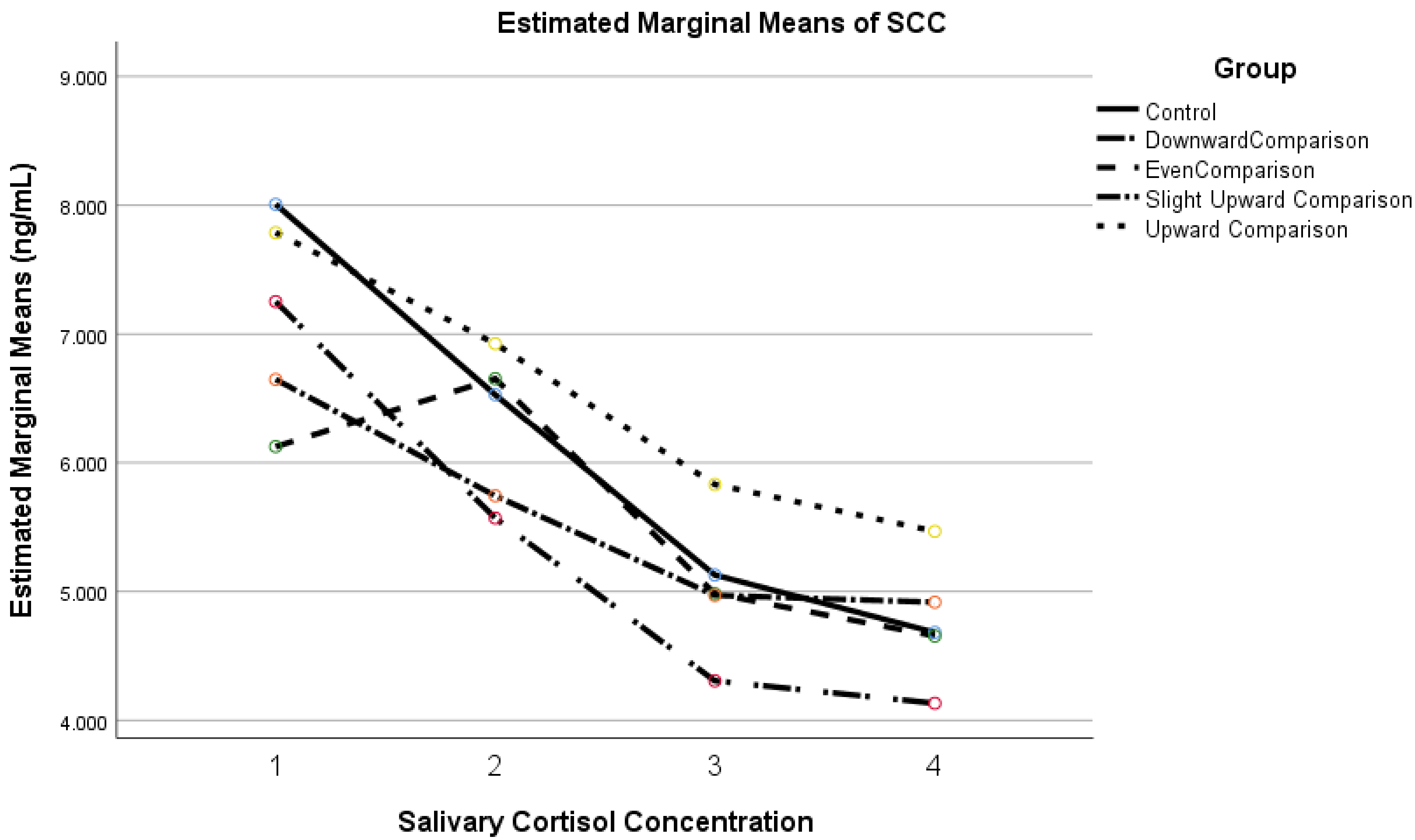
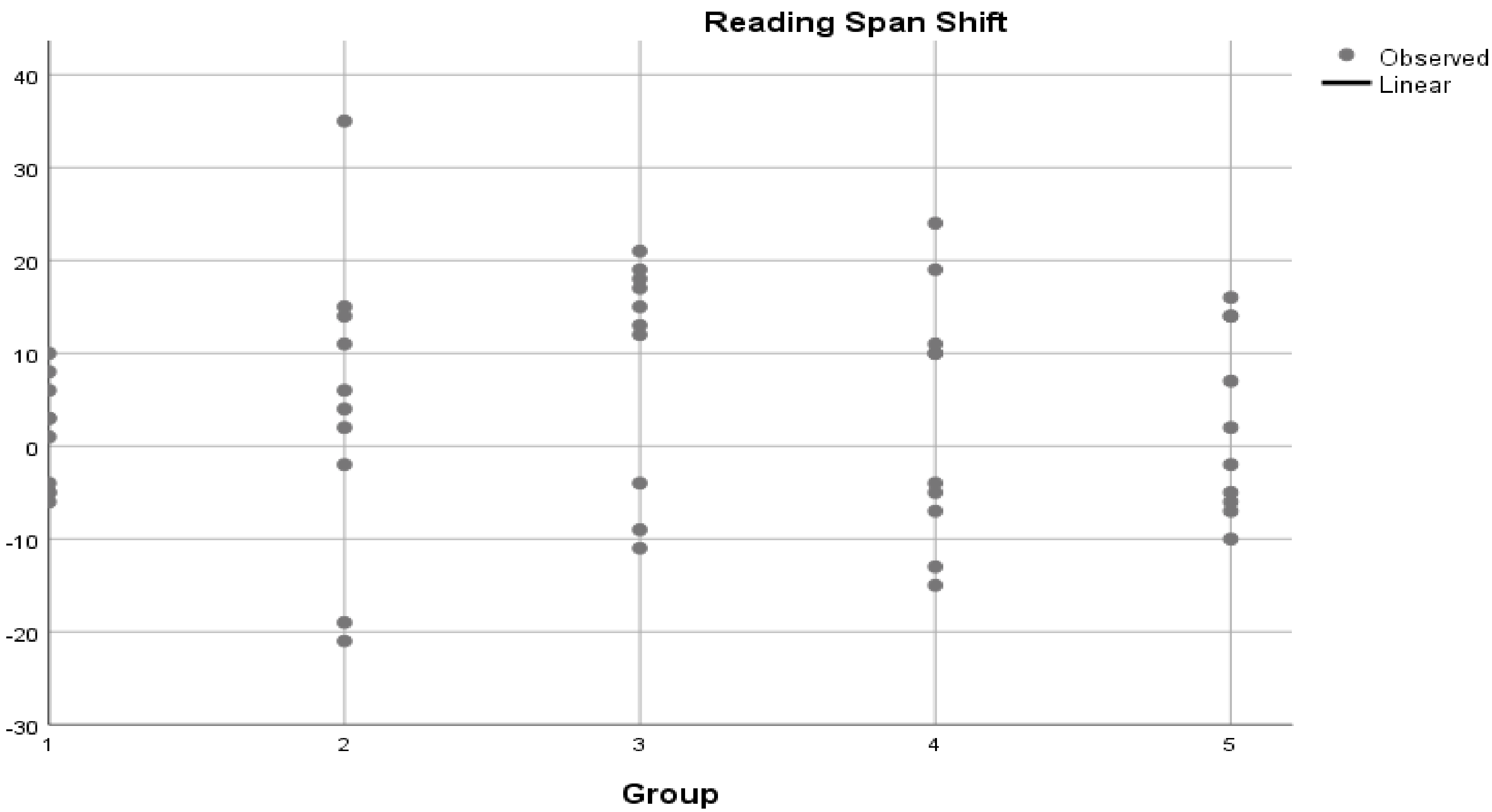
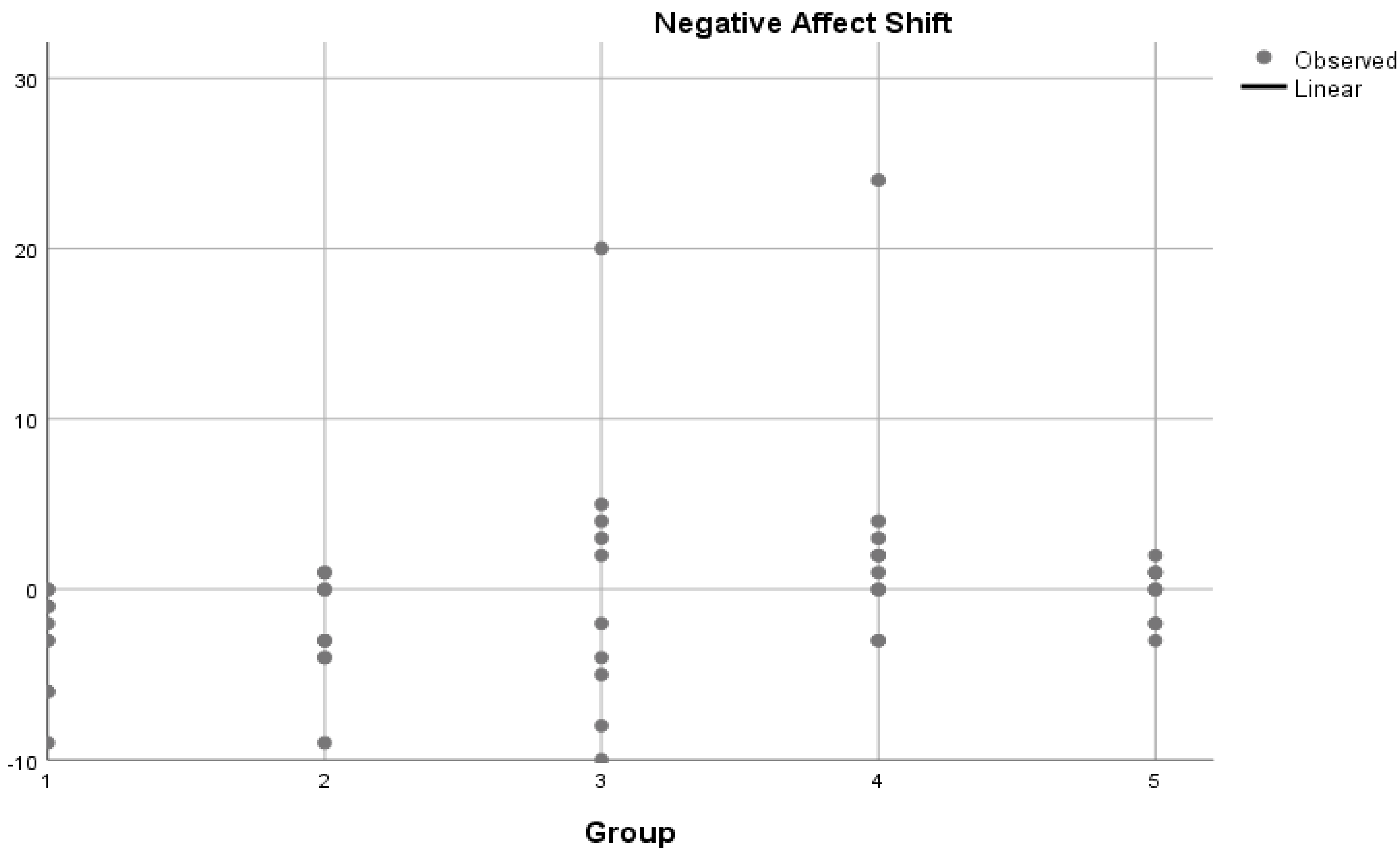

Estimated Marginal Means of SCC
Group
Control
DownwardComparison
EvenComparison
Slight Upward Comparison
Upward Comparison
9.000
8.000
7.000
6.000
5.000
4.000
Estimated Marginal Means (ng/mL)
1
2
3
4
Salivary Cortisol Concentration

Figure 8.



Note. Group 1 = control; Group 2 = downward comparison; Group 3 = even comparison; Group 4 = slight upward comparison; Group 5 = upward comparison

Figure 9.



Note. Group 1 = control; Group 2 = downward comparison; Group 3 = even comparison; Group 4 = slight upward comparison; Group 5 = upward comparison