Chewing Gum Modifies State-Anxiety and Alertness under Conditions of Social Stress

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Abstract

Objectives: The finding that chewing gum can moderate state-anxiety under conditions of acute stress[1] has proved difficult to replicate.[2,4] The present study examines the extent to which chewing gum can moderate state-anxiety under conditions of acute social stress.

Method: In a between-participants design, 36 participants completed a task comprising a mock job interview (a variation on the Trier Social Stress Task[3], which included a mental arithmetic component) whilst either chewing gum or without gum. Self-rated measures of mood and anxiety were taken at baseline, after a 10-minute presentation preparation stage, after the 10-minute presentation, and following a 5-minute recovery stage.

Results: Post-presentation measures reflected increased state-anxiety and decrease self-rated calmness and contentedness. Chewing gum attenuated the rise in state-anxiety whilst increasing self-rated alertness. Chewing gum did not affect contentedness or calmness.

Conclusions: The findings indicate that chewing gum can act to reduce anxiety under conditions of acute social stress: a finding consistent with Scholey et al.[1] Furthermore, the data add to the growing body of literature demonstrating that chewing gum can increase alertness.[1,2,4,5]

Keywords: Alertness; Anxiety; Chewing gum: Stress.

Introduction

The present study assesses the moderating effect of chewing gum on state-anxiety and self-rated mood following the completion of a social stressor task. Although a number of previous studies have examined the effect of chewing gum on cognitive-load, impasse, and noise-induced stress[1,2,4,6], the results have proved variable. For example, Scholey, Haskell, Robertson, Kennedy, Milne, and Wetherell[1] required participants to complete a 20-minute multi-tasking cognitive-load stressor whilst either chewing or not chewing gum. Chewing gum acted to reduce cortisol secretion whilst attenuating the post-task increase in both self-rated stress and state-anxiety. In addition, chewing gum increased self-rated alertness.

Scholey et al.[1] proposed that chewing gum can affect stress and mood via distinct mechanisms. They propose first, that, increased cerebral blood flow following the chewing of gum[7] reduces stress via increased cerebral delivery of oxygenated blood[8] and glucose[9]. Furthermore, following a stressor, increased glucose metabolism in the rostral medial prefrontal cortex (areas BA9 and BA10) has been related to reductions in salivary cortisol concentrations.[10] It is plausible then, that increased cerebral blood flow following the chewing of gum[7] may increase glucose delivery to such areas [8] (see also [9]) and reduce cortisol levels. Their second proposal, suggests that the flavour of gum affects mood. This second proposition is supported by the finding of heightened self-rated alertness when participants were exposed to a peppermint odour[11]. However, the mechanisms underpinning mood elevation and stress reduction are beyond the scope of the present study.

Notwithstanding the recognised physiological effects of chewing gum, attempts to replicate the attenuating effects of chewing gum on stress have produced mixed results. For instance, Johnson, Jenks, Miles. Albert, and Cox,[2] using a similar design to that described by Scholey et al.[1], reported a null effect of chewing gum on self-rated state-anxiety and both self-rated

and physiological stress following the cognitive-load stressor. Similarly, Torney, Johnson, and Miles[6] reported a null effect of chewing gum on self-rated stress following an insoluble anagram task[12]. More recently, Smith[4] required participants to complete a range of cognitive tasks whilst simultaneously exposing them to 75 dBA of industrial noise. Chewing gum failed to impact anxiety levels, but, in opposition to Scholey et al.[1], was associated with elevated cortisol levels. These findings were interpreted as evidence for heightened alertness following the chewing of gum [4] (see also [1,2,5]). There is, however, survey data suggesting that chewing gum may be used as a coping strategy under stressful conditions.[13] In a web-based sample of 2,248 full time workers, those who chewed gum reported lower levels of both life and work-related stress (see also [14]).

The current study assesses the extent to which the effects of chewing gum on both self-rated mood and state-anxiety persist under conditions of social stress. Participants were exposed to an acute social stress test (a variation on the Trier Social Stress Task: TSST[3]) whilst either chewing gum or not chewing gum. Participants provided self-rated measures of both mood and state-anxiety. It is predicted that anticipation of the TSST in addition to the experience of the presentation will have a negative effect on both mood and anxiety, such that anxiety will increase and mood will decrease pre-TSST and post-TSST compared to the baseline measures. It is expected that measures of mood and anxiety will return to normalised baseline measures from the 5-minute post-task recovery period. Premised on the proposition that chewing gum affects mood under conditions of acute social-evaluative stress, we predict that gum will slow the decrease in both self-rated contentedness and calmness. In addition, chewing gum should significantly reduce state-anxiety. Finally, consistent with the most robust effects on alertness,[1,2,4,13] chewing gum should significantly elevate alertness levels.

Method

Participants: Thirty-six (5 males, 31 females, mean age = 20 years 5 months) non-smoking Coventry University Psychology undergraduates participated in exchange for course credit. All participants were regular chewing gum users but none chewed in excess of ten times per week. All participants reported that they were free from both concurrent medication and illicit drug use. Participants were instructed to refrain from caffeine, alcohol, and chewing gum on the morning of testing and asked to not consume food up to one hour prior to testing. Participants were assigned at random to either the chewing gum or no chewing gum condition. Ethical approval was obtained from the Coventry University Ethics Committee.

Materials: Participants completed both the Bond-Lader Visual Analogue Mood Scale (VAMS)[15] and the State-Trait Anxiety Inventory (STAI).[16] The Bond-Lader VAMS comprises 16 mood questions, with mood antonyms anchoring either end of a 100mm line. It provides scores for alertness, contentedness, and calmness. Participants are instructed to rate, via a mark on each antonym-pairing line, how they are feeling at that moment. The STAI comprises 40 statements each assessing either state or trait-anxiety. For each statement participants respond on a four-point likert scale indicating the extent to which they agree with each statement.

At three distinct task stages, participants in the chewing gum condition were provided with a single pellet of Wrigley's Extra, spearmint-flavoured, sugar-free gum.

Design: A 4x2 mixed design was employed where the first factor was within-participants and refers to task stage (baseline, pre-stressor, post-stressor, recovery) and the second factor was between-participants and refers to chewing gum condition (chewing gum versus no chewing gum). The dependent measures were self-rated anxiety (both state and trait), alertness, contentedness, and calmness.

Procedure: Participants were tested between 11:00hrs and 14:00hrs. The stressor task was a variation on the Trier Social Stress Task (TSST).[3] Participants were tested in same-condition pairs (i.e. both receiving gum or both not receiving gum) and each member of the pair observed the other pair-member complete the stressor task (cortisol and self-rated anxiety reactivity to the TSST has been found to be equivalent for participants tested individually or in groups [17]).

Participants entered the laboratory in pairs and independently completed self-rated measures of both mood and anxiety. Following the baseline measures, participants were informed that the study required them to participate in a video-recorded presentation to a panel of two psychologists. Participants were informed that the psychologists were experts in both verbal and non-verbal communication. At this juncture participants provided additional consent on the hitherto unknown TSST component of the task. Participants were given the option to withdraw at this point and receive full research credits. The TSST comprises three distinct stages. For the first, preparatory stage, participants were allotted 10-minutes to prepare individually for the interview during which they were required to provide evidence justifying their suitability for a graduate position of their choice.

For the second (presentation) stage, participants delivered their 5-minutes presentation to the panel comprising two psychologists, who were members of staff from the Psychology Department at Coventry University. Paired participants gave their presentations in succession, i.e. participant 1 followed by participant 2, and each participant observed the other's presentation. Participants were informed that if their presentation concluded within 5-minutes they were to remain silent until that period had elapsed. Following the two presentations, paired participant 1 was given a 5-minute subtraction task, in which they were required to repeatedly subtract 7 from a 4-digit number. Participants responded verbally and

any errors were corrected verbally (by the panel). Participant 1 performed the subtraction task followed by participant 2.

For the third, recovery, stage, participants were instructed to relax for a 5-minute period.

Participants in the gum condition received a fresh piece of gum at the start of each of the three task stages. These participants were required to chew at a normal rate throughout each of the task stages. At the end of each task stage, all participants completed the self-rated measures of state-anxiety and mood. Participants in the gum condition removed their gum prior to the completion of these measures.

Statistical Analysis: An independent sample t-test was computed to confirm a null difference for trait-anxiety scores between the gum-chewing and no-gum groups. Two-way (2x4) mixed design analysis of variance (ANOVA) was computed to compare the between-participant gum and no-gum conditions across the four within-participant experimental stages (baseline, pre TSST, post-TSST, and recovery). For the state anxiety analysis, trait anxiety was included as a covariable in the 2x4 ANCOVA.

Results

Group Trait-Anxiety Differences: To confirm a null difference in trait anxiety scores the gum and no-gum groups were compared via an independent samples t-test and revealed a non-significant difference, $t(34)=0.67$, $p=0.51$.

TSST Effects: To assess the extent to which the TSST produced the predicted increase in self-rated state-anxiety and decrease in self-rated mood, we examined the main effect of experimental stage in the ANOVAs. The TSST significantly affected state anxiety ($F(3,99)=5.38$, $MSe=40.39$, $p=0.002$, *partial* $\mu^2=0.14$), wherein post-hoc Bonferroni corrected comparisons ($p=0.008$), revealed that state anxiety was significantly greater at pre-TSST and

post-TSST relative to baseline and recovery stages (see Figure 1). The TSST significantly affected self-rated contentedness ($F(3,102)=16.08$, $MSe=75.38$, $p<0.001$, *partial* $\mu^2=0.32$). Post hoc comparisons ($p=0.008$) revealed that participants were significantly more content at baseline compared to pre-TSST. Furthermore, participants were significantly more content at recovery compared to both pre-TSST and post-TSST (see Figure 2). The TSST significantly affected self-rated calmness ($F(3,102)=20.21$, $MSe=284.04$, $p<0.001$, *partial* $\mu^2=0.37$). Post hoc comparisons ($p=0.008$) revealed that participants were significantly calmer at both baseline and recovery compared to both pre-TSST and post-TSST (see Figure 3). The TSST had not effects on self-rated alertness, $F(3,102)=0.36$, $MSe=72.33$, $p=0.78$, *partial* $\mu^2=0.01$ (see Figure 4).

Gum Effect: To assess the extent to which chewing gum impacted on anxiety and mood (alertness, contentedness, and calmness) the main effect of gum condition and interactions between gum and stage were examined.

State-Anxiety: Figure 1 shows mean self-rated state-anxiety scores for the gum and no-gum groups at baseline and each of the three task stages. State anxiety was significantly lower in the gum condition ($F(1,33)=4.91$, $MSe=175.57$, $p=0.03$, *partial* $\mu^2=0.13$; adjusted ANCOVA mean gum = 35.24, no-gum = 40.16). The interaction between gum and task stage approached significance ($F(3,99)=2.58$, $MSe=40.39$, $p=0.06$, *partial* $\mu^2=0.07$). Preliminary investigative comparisons for the gum and no gum group at each stage, revealed some evidence to suggest that the effects of gum were additive across each stage of the TSST: mean difference for the baseline stage = 1.11 ($t(34) = 0.52$, $p = 0.61$), mean difference for the preparatory stage = 5.61 ($t(34) = 1.55$, $p = 0.13$), mean difference for the interview stage = 7.78 ($t(34) = 2.27$, $p = 0.03$), mean difference for the recovery phase = 7.22 ($t(34) = 2.68$, $p = 0.01$).

Figure 1 about here please

Self-Rated Measures of Contentedness and Calmness: For contentedness (see Figure 2) the main effect of gum was non-significant ($F(1,34)=1.59$, $MSe=790.83$, $p=0.22$, *partial* $\mu^2=0.05$), as was the gum by stage interaction ($F<1$).

Figure 2 about here please

For calmness (see Figure 3) the main effect of gum was non-significant ($F<1$) as was the gum by stage interaction ($F<1$).

Figure 3 about here please

Self-Rated Alertness: Figure 4 shows mean self-rated state alertness scores for the gum and no-gum groups at baseline and each of the three task stages. The main effect of gum was non-significant, $F(1,34)=2.01$, $MSe=554.82$, $p=0.17$, *partial* $\mu^2=0.06$. However, the interaction between gum and task stage was significant, $F(3,102)=2.98$, $MSe=72.33$, $p=0.04$, *partial* $\mu^2=0.08$. Preliminary investigative comparisons for the gum and no gum group at each stage revealed some evidence to suggest that the effects of gum were additive across each stage of the TSST: mean difference for the baseline stage = 0.50 ($t(34) = 0.14$, $p = 0.89$), mean

difference for the preparatory stage = 3.80 ($t(34) = 0.80$, $p = 0.43$), mean difference for the interview stage = 8.66 ($t(34) = 1.69$, $p = 0.10$), and mean difference for the recovery stage = 11.51 ($t(34) = 2.15$, $p = 0.04$).

Figure 4 about here please

Discussion

The modified TSST successfully increased self-rated state-anxiety and decreased both self-rated contentedness and calmness. Participants showed changes from baseline at pre-TSST due to the anticipation of the stressor. Those changes remained (relative to baseline) at post-TSST and returned to levels comparable with baseline following the recovery phase. Importantly, participants who chewed gum reported reduced levels of self-rated state anxiety and elevated levels of self-rated alertness in comparison to the no-gum participants. The two findings are consistent with Scholey et al.'s[1] study where participants who chewed gum reported reduced state-anxiety and increased self-rated alertness following an acute cognitive-load stressor. Consistent with past studies[1,2,6], chewing gum had no effect on either self-rated calmness or contentedness.

The TSST was divided into three stages: preparatory, presentation, and recovery. We did not explicitly examine which stages were influenced by gum, as no stage received gum in isolation. However, analysis of the anxiety and alertness data did provide some support for the proposition that the effects of gum increased as participants completed each task stage (however, it should be noted that although state anxiety was significantly lower in the gum

condition, the stage by gum interaction narrowly failed to reach significance, p=0.06). The idea that the effects of gum are incremental and not acutely habituated is consistent with survey data, in which a range of health benefits were evident in the gum group following chronic stress exposure[13]. Furthermore, incremental effects on alertness are consistent with Tucha and Simpson[18] who reported that chewing gum had a beneficial effect on sustained attention but only towards the end of the task. They speculate that unspecified biological processes following the chewing of gum (e.g. increased cerebral blood [19]) need to gradually accumulate in order to reach a threshold of facilitation.

The beneficial effects of gum on alertness contribute to past literature suggesting that gum chewing may assist in real life operations such as driving [4]. Moreover, the present findings coupled with Scholey et al.[1], indicate that such elevation occurs also when in an anxious/stressed state. Such findings indicate that gum may reduce anxiety and focus attention under conditions of acute stress, e.g. examination, interview etc. However, what is unclear is the extent to which those effects are related; for example, is the increase in alertness epiphenomenal to perceptions of anxiety being reduced? Furthermore, it is currently unclear the extent to which individuals may habituate to the benefits of this intervention.

We have shown that both self-rated calmness and contentedness were immune to the effects of chewing gum. However, it should be acknowledged that with a sample of 36 the study is somewhat underpowered. Indeed, using G Power Software 3.0.1, a sample size of 73 would be required to detect a significant medium effect size at power = 0.8. Notwithstanding issues of power, the absence of gum effects on contentedness and calmness are consistent with both Scholey et al.[1], Johnson et al.[2] and Smith.[5] Moreover, it is important to note that the effect sizes for the main effect of gum and the gum by stage interaction was small for both contentedness (μ^2= 0.02 and 0.05, respectively) and calmness (μ^2= 0.03 and 0.02, respectively).

The absence of gum effects on both contentedness and calmness is curious in the context of reduced anxiety. One might intuitively expect a degree of relation between these variables. The extent of this relationship was examined by conducting correlations on the difference between baseline and post-TSST scores for state-anxiety, contentedness, and calmness. Although the correlation with state-anxiety was significant for both calmness (r=-0.44, p=0.007) and contentedness (r=-0.54, p=0.001), the effect sizes were moderate, illustrating that the constructs do not perfectly overlie. Indeed, this curious finding is consistent with Scholey et al. (2009), who despite effects of gum on state-anxiety, found resistance to gum effects for both contentedness and calmness. Such immunity may be interpreted within Shek's[20] proposed framework of state-anxiety comprising three independent sub-factors: calmness, happiness, and anxiety presence. Since gum was found to have no effect on calmness, it is plausible that the decrease in state-anxiety when chewing gum in the present study is a result of an effect on anxiety presence and/or happiness (but not calmness). It is not known to what extent previous studies[1-2] induced social stress/anxiety. Such disparities in social stress might explain why Johnson et al.'s[2] partial replication of Scholey et al.[1] was unable to reproduce the effects of chewing gum on stress and state-anxiety. Future studies should, therefore, include measures that examine social stress and cognitive load stress in order to disambiguate the effects of gum. Indeed, to gain more insight into the effects of gum on state-anxiety, future studies should also seek to use scales that allow differentiation between cognitive components of anxiety (e.g. worry) and the somatic symptoms of anxiety (e.g. sweaty palms).

Our current finding that chewing gum acted to increase self-rated alertness under conditions of stress is consistent with Scholey et al.[1], Johnson et al.[2], and Smith.[4,13] Additional evidence from our laboratory[21] demonstrating that chewing gum can positively influence alertness is evidenced by the attenuation of the increase in pupillary unrest (a measure of daytime

sleepiness) whilst chewing gum. The exact alerting mechanism is, however, unclear. Heightened alertness might be an artefact of chewing gum increasing both cerebral blood flow[7] and/or cerebral activity[19]. Alternatively, alertness may be influenced via the mint flavour of the gum.

In conclusion, we have shown that chewing gum acted to (1) reduce self-rated state anxiety and (2) increased self-rated alertness under conditions of acute social stress. The study provides, therefore, insight into the conditions under which chewing gum can ameliorate mood under stress. Furthermore, the data contribute to the growing body of literature suggesting that chewing gum can enhance alertness. Future studies are required in order to examine further the extent to which (1) such mood changes whilst chewing gum are reflected physiologically (e.g. does chewing gum, relative to no-gum, reduce cortisol levels under conditions of social stress) and (2) the effects are specific to flavour and/or mastication.

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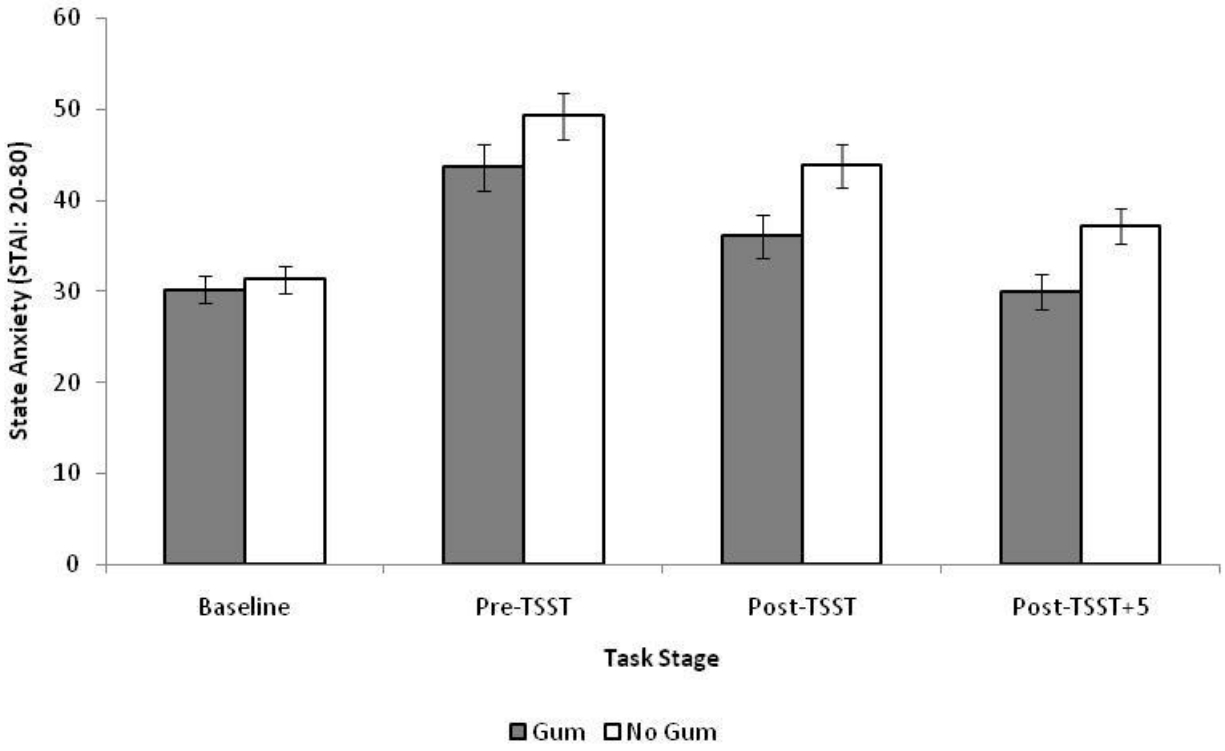

Figure 1: Mean self-rated state anxiety at each task stage for the chewing gum and no chewing gum conditions. Error bars denote +/- SEM.

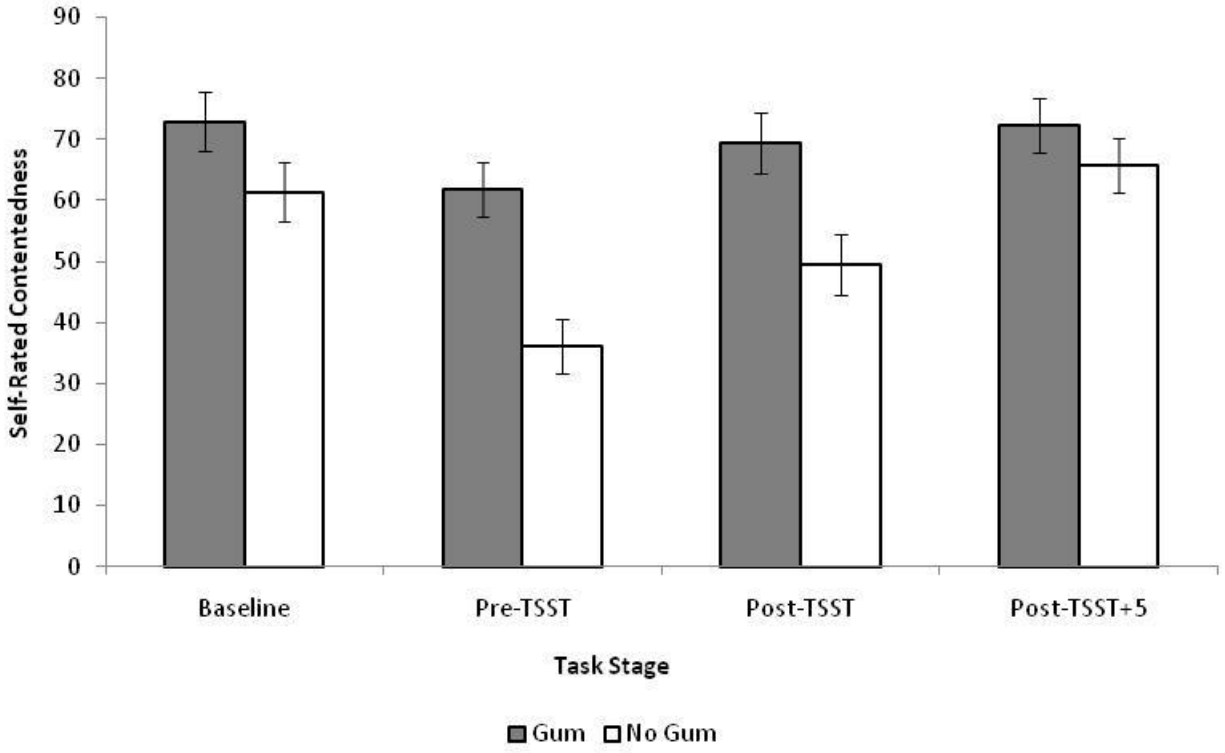

Figure 2: Mean self-rated contentedness at each task stage for the chewing gum and no chewing gum conditions. Error bars denote +/- SEM.

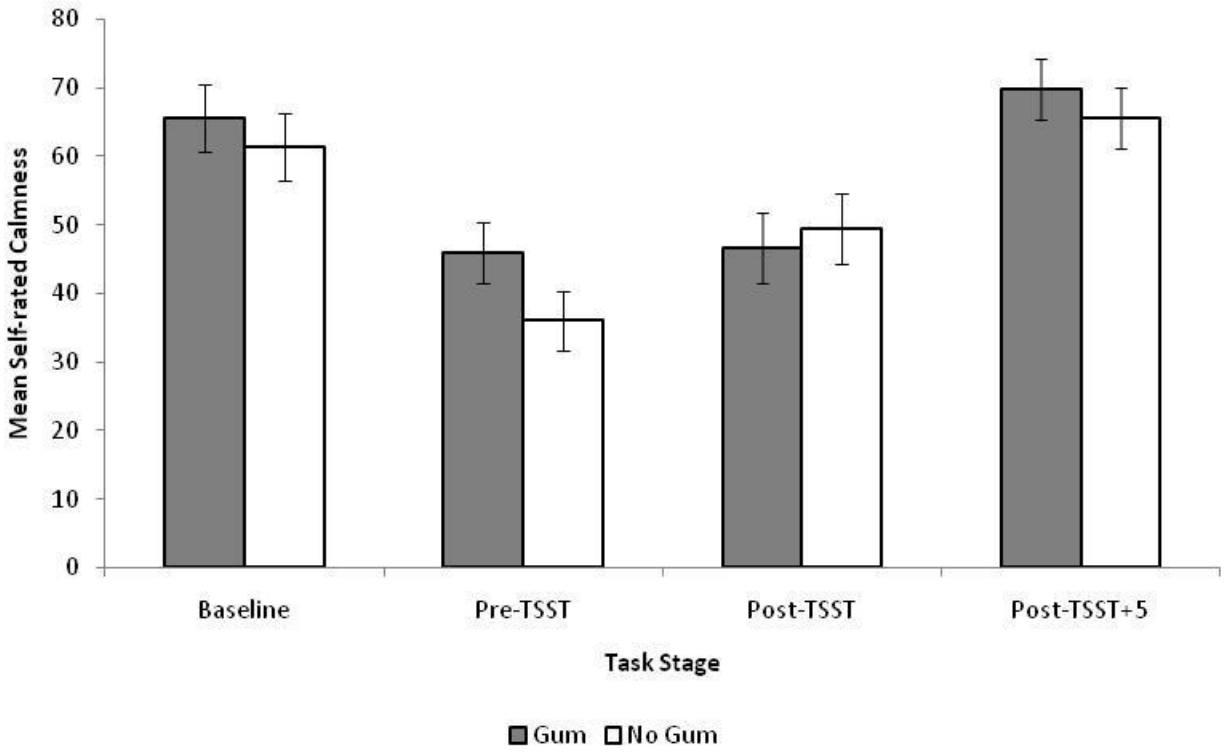

Figure 3: Mean self-rated calmness at each task stage for the chewing gum and no chewing gum conditions. Error bars denote +/- SEM.

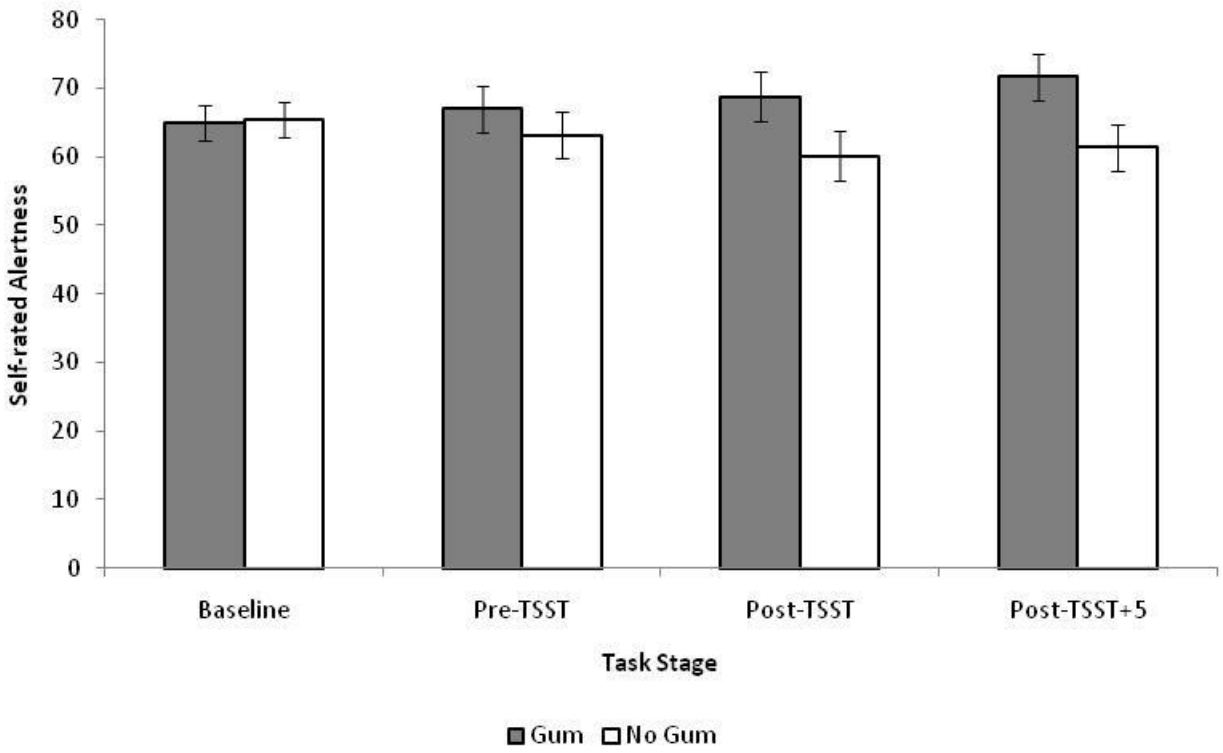

Figure 4: Mean self-rated state alertness at each task stage for the chewing gum and no chewing gum conditions. Error bars denote +/- SEM.