Suppressing Sympathetic Nervous System Activity and Appraisals of Stress:

Implications for Depression

Hasan Mustafic

The University of North Carolina at Chapel Hill
Abstract

Stress is important to study because of the abundance of stressors and the potential impact it has on health. The impact of stress can vary based on the cognitive appraisal of the stressor. Lazarus and Folkman (1984) define cognitive appraisals as the process of interpreting an event and its different features, with respect to its impact on the individual. Cognitive appraisals consist of two types of appraisals: challenge and threat, which are associated with different affective outcomes.

The main purpose of this study is to see if blocking sympathetic nervous system activity influences the types of cognitive appraisals made in the face of a stressor. The SNS is specifically examined because it plays a major role in physiological arousal. The SNS was suppressed via the beta-blocker propranolol to test whether participants who received the drug would have higher challenge appraisals. Participants were randomly assigned to either a placebo group or beta-blocker group, and both groups later completed the Trier Social Stress Test. An affect measure (PANAS) associated with performance on the TSST was given pre-and-post TSST. The main hypothesis that individuals in the propranolol condition will make higher challenge appraisals and lower threat appraisals than those in the placebo condition was not supported. However, propranolol did have an impact on affective differences between groups. Individuals in the propranolol condition had lower negative affect pre-stress and post-stress compared to the placebo. These findings are discussed in the context of health and depression.
Stress is a feeling that everyone inevitably experiences, and not coping with stress effectively can lead to detrimental effects. For example, increased levels of stress have negative effects on both physical and mental health. A review by Slavich (2016) lists a variety of health conditions affected by stress, such as cardiovascular disease, accelerated biological aging, certain types of cancers, and anxiety disorders. Stress also plays a significant role in the development and maintenance of depression. The National Institute of Mental Health (2016) reported that 6.7% of all U.S. adults experienced at least one major episode of depression in 2015. Depression is one of the most prevalent mental illnesses, and if stress is a possible cause of depression, then a better understanding of how stressors are appraised and responded to physiologically could lead to better treatments for depression. Research by Anyan and Hjemdal (2016) suggests that resilience explains the relationship between depression and stress, such that individuals who positively cope with stress are less likely to develop depression and anxiety compared to individuals who negatively cope with stress. The directionality of this relationship suggests that stress is a predictor of depression, as opposed to depression causing heightened levels of stress. There is an established connection between depression and stress, so the next step is to examine how stress is managed and interpreted.

Stress is an internal reaction to an external stimulus, so basically stress is the body’s response to something in the environment. Stress responses are not limited to current situations, because a person can think about a future event and become stressed in anticipation of that event. This last point is important because it highlights the idea that people can become stressed as a result of their construal of a situation, in the absence of an objective stressor. The immediate interpretation of a situation, and how it pertains to someone personally is termed a cognitive appraisal. The two major components that influence the type of cognitive appraisal that occurs in
the face of stress are primary appraisals and secondary appraisals. Folkman and Lazarus (1984) developed the theory of cognitive appraisal, which describes primary appraisals as the perception of a threat, and secondary appraisals as the perception of resources one has to cope with the situations. Generally, people have two types of cognitive appraisals when presented with a stressful situation or task: challenge appraisals, and threat appraisals. People do not exclusively make either challenge or threat appraisals, but rather have different levels of both appraisals. A person with higher challenge appraisals should theoretically have lower threat appraisals, but it is possible to have varying levels of both because they are subscales of an overall cognitive appraisal. Another reason for overlap between challenge and threat appraisals is because cognitive appraisals are an interpretation of an event, so subjectivity naturally plays a role. For instance, one aspect of the stressor could lead to higher challenge appraisals, but another aspect of it could lead to higher threat appraisals for the same person. According to Tomaka, Blascovich, Kelsey, and Leitten (1993) Challenge appraisals involve seeing the stressful task as an opportunity for a gain, which is more likely to occur when individuals feel they have adequate resources to deal with the task – hence it is interpreted it as a challenge. Threat appraisals are the opposite of this: they occur when people view the stressful task as a chance for loss, and when they do not feel like they have the resources to cope.

Prior research has demonstrated that cognitive appraisals influence cortisol, which is directly related to stress (Harvey, Nathens, Bandiera, & LeBlanc, 2010). Higher challenge appraisals are associated with lower levels of subjective stress in a stressful situation or task, while higher threat appraisals are associated with higher levels. This idea is supported by the research of Tomaka et al. (1993) which found that threat appraisals are linked with higher levels of subjective stress compared to challenge appraisals, which remained true for a variety of stress
tasks. This is one of the first studies to examine the relationship between stress and cognitive appraisals, and it suggests that the interpretation of a stressful situation or task plays a major role in the subjective experience of stress. The underlying physiology in cognitive appraisals could explain why this relationship exists.

Cognitive appraisals involve the interpretation of a situation, but there is also a physiological response that occurs in conjunction with this interpretation. Research by Tomaka et al. (1993) provides details about how cognitive appraisals affect physiological responses such as cardiac reactivity, vascular reactivity, and skin conductance reactivity. These particular physiological responses were examined because they are associated with elevated levels of arousal. This previous study establishes that there is a physiological response associated with cognitive appraisals; specifically, there is a relationship between cognitive appraisals and activation of the sympathetic nervous system. In other words, physiology plays a role in cognitive appraisals, but the extent of that role is unknown. Previous studies have found correlations between cognitive appraisals and subjective stress (Skinner & Brewer, 2002) but the directionality of this effect is still unknown. This is the gap in the cognitive appraisal literature that the current study aims to fill. The role of the sympathetic nervous system in cognitive appraisals of stress can be examined by manipulating the SNS to see the subsequent effect on cognitive appraisals.

The sympathetic nervous system was specifically manipulated via a beta-blocker. Beta-blockers are commonly prescribed to people with hypertension because they lower heart rate and blood pressure. The hormone norepinephrine is primarily responsible for increases in arousal, so beta-blockers work by blocking the beta-adrenergic receptors in the heart, which prevents norepinephrine from binding to the receptors (Bristow, 1997). The beta-blocker propranolol was
specifically used because its effectiveness was established decades ago (Prichard & Gillam, 1969) and according to the American Heart Association (2017), it is still prescribed today for hypertension. Beta-blockers are primarily used to treat hypertension, but they also have additional effects because of the impact on the heart and sympathetic nervous system. Research by Kathol et al. (1980) showed that propranolol was associated with a reduction in symptoms in individuals with chronic anxiety disorders. This supports the idea that modifying a physiological reaction can lead to changes in cognition.

The sympathetic nervous system needs to be manipulated to see the effects that it has on cognitive appraisals in response to a stress task. The sympathetic nervous system is responsible for the biological responses such as increased heartbeat when experiencing stress, which affects appraisals. Benschop et al. (1994) found that using propranolol to block beta-adrenergic receptors coincides with a decreased physiological response to stress in the sympathetic nervous system. The physiological aspects of challenge and threat appraisals are influenced by the sympathetic nervous system (Tomaka et al., 1993), so theoretically such appraisals could be altered by a beta-blocker. This information is relevant to the current study because it validates the use of beta-blockers to suppress sympathetic nervous system activity. Cortisol is stress-induced and increases activity in the sympathetic nervous system (Tsigos & Chrousos, 2002), so if beta-blockers reduce sympathetic nervous system activity there should be a lower stress response. As previously mentioned, higher challenge appraisals are associated with lower stress responses, and higher threat appraisals are linked with higher subjective stress responses (Tomaka et al., 1993). That is the expected interaction, but it is possible that the lack of physiological arousal leads to lower challenge appraisals, because the body is not preparing itself for a stressor.
This previous research outlines the effects perceptions of physiology can have on how high levels of stress are. A correlational-relationship between cognitive appraisals and physiology has been established, but the current study extends this work to examine if blocking physiological responses to stress experimentally influences cognitive appraisals and affect in the face of a stressor. Specifically, in the present study we test three hypotheses:

(1) Replicating prior research (Tomaka et al., 1993), we will examine if threat and challenge appraisals influence affective responses to stress. We predict that higher levels of threat will be associated with greater stressor-evoked changes in negative affect, while higher levels of challenge will be associated with lower stressor-evoked change in negative affect.

(2) Next, we will examine if blocking sympathetic nervous system activity with the beta-adrenergic receptor blocker, propranolol, influences affective responses to stress. We hypothesize that individuals in the propranolol condition will experience lower levels of negative affect than those in the placebo condition.

(3) Finally, and most critical to the present investigation, we will examine if blocking sympathetic nervous system activity influences the types of cognitive appraisals made in the face of a stressor. We hypothesize that individuals in the propranolol condition will make higher challenge appraisals and lower threat appraisals than those in the placebo condition.

Method

Participants

The participants for this study are part of a larger study examining the role of sympathetic nervous system activation in stress responding; data collection is still on-going, and thus, what is reported here is results for the participants run thus far (N = 14). The age range of the sample was 18-25 years old (20.07, 1.68). The sample consisted of 6 male participants and 8 female
participants. The sample was 64% Caucasian and 34% Asian. This demographic data for participants can be found in appendix E. The following eleven items are a part of the inclusion/exclusion criteria for the study: (1) having a current or having a history of physical illness, (2) presence or history of a psychiatric illness, (3) currently taking prescription medicine, (4) pregnant or planning on becoming pregnant, (5) Participating in a variety of health-compromising behaviors that alter stress physiology: extreme caffeine consumption, smoking cigarettes, and sleep issues, (6) BMI greater than 30, (7) anxiety of drawing blood, (8) any heart conditions, (9) history of fainting, (10) low pulse, which was measured at the beginning of the first session, and (11) low blood pressure, which was also measured at the beginning of the first session. Participants were recruited in a variety of ways, including flyers and in-class announcements at UNC.

**Procedure**

All participants completed their sessions at the same time of day to minimize physiological fluctuations related to circadian rhythm. All participants were randomized into two groups: propranolol or placebo. Both participants and experimenter were blind to random assignment. Participants arrived to the waiting room at 12:00 pm where they were greeted by the experimenter. The participants were taken to the lab where the session occurred, and were given their consent form to review, as well as a daily health inventory questionnaire to make sure they were eligible for the study. The questionnaire mainly assesses changes in physiology that would skew the results. The participants also had their vitals taken as a precaution to avoid possible fainting, given that propranolol reduces heart rate and blood pressure. At approximately 1:20 pm the participants were either administered a 40 mg dose of the beta-blocker propranolol or the placebo. The Trier Social Stress Test was introduced at 2:25 (TSST; Kirschbaum, Pirke, &
Hellhammer, 1993). The TSST is an acute stress test that evokes a biological and physiological response. The drug manipulation occurs before the TSST to see how big a role physiology plays during the stress task. Participants were instructed to prepare a ten-minute speech that they will have to give to trained evaluators. Participants were also asked to perform a challenging arithmetic task in addition to the ten-minute speech. The participants were informed in the consent that they would have to perform a role-play exercise during a cognitive performance task. The TSST was described as a cognitive performance task to ensure participants would be stressed by the task. A few minutes later, the participants were given the two measures if they agreed to continue with the TSST. The participants were then given two minutes to prepare for the verbal part of the TSST. After the two minutes had passed, the experimenter brought in the other two researchers who were the evaluators for the task. The participants gave a 10-minute speech on why they believe they are an ideal candidate for their dream job. Following the speech, the participants completed a 5-minute verbal math task. The two experimenters evaluated the participants with neutrality, so that there was no indication of positive or negative feedback. The participants were also recorded during the TSST, and they are made aware of this. Once the TSST is completed the participants completed questionnaires to measure their affective responses and cognitive appraisals while the TSST occurred and after it was finished.

Measures

Affective Responses. Affective responses to the TSST were measured using the Positive Affect/Negative Affect Scale (PANAS; Watson et al., 1988). The PANAS is a 20-item measure that assesses what emotions participants felt before and during the TSST. A likert scale from 1 (very slightly or not at all) to 5 (extremely) is used for all twenty items. Items such as “distressed” and “determined” are included, so that there is a range of emotions included. The
PANAS consists of ten items that are related to positive affect and ten that are related to negative affect, and so corresponding subscales were created. All 14 participants were included in the analyses for the PANAS.

Cognitive Appraisals. Cognitive appraisal responses to the TSST were measured using the Challenge and Threat Questionnaire (Blascovich & Mendes, 2000) The challenge and threat appraisal questionnaire is a two-part measure that assesses how participants appraise or interpret a stressful task or event. The pre-TSST challenge and threat appraisal questionnaire consists of twelve items. The post-TSST questionnaire consists of ten items. A likert scale from 1 (not at all) to 7 (extremely) was used to score the results of both questionnaires. The pre-TSST questionnaire has items such as, “The upcoming task is very demanding” and “I expect to perform well on this task.” The post-TSST questionnaire has similar items such as, “The task was very stressful” and “I believe I performed well on the task.”

The questionnaire is given before and after the TSST, but it is important to look at the questionnaire before the TSST to see what the challenge and threat appraisals are going into the TSST. The importance of pre-TSST challenge and threat appraisals is supported by the O’Donovan et al. (2012) finding that psychological reactions to the anticipation of an acute stressor are related to cellular aging. In line with the O’Donovan et al. (2012) methodology, four subscales were created from this measure. The four subscales for the challenge and threat appraisal questionnaire were the following: prospective threat, prospective challenge, retrospective threat, and retrospective challenge.

The sample for cognitive appraisal analyses were twelve participants, while the sample analyses that involved affect were fourteen participants. There is a discrepancy in the sample size because two participants completed an older version of the cognitive appraisal questionnaire,
which was changed starting with the third participant. The two participants were also in the propranolol condition, so when the groups were compared the size was uneven. There were eight participants in the placebo condition and four participants in the propranolol condition. A better comparison can be made when the larger study is complete because the sample consists of one hundred participants.

Results

Cognitive Appraisals and Affective Responses to Stress.

First, we tested the hypothesis that higher challenge appraisals before a stressor are associated with lower negative affect in response to the stressful task, while higher threat appraisals are associated with greater stressor-evoked negative affect. We examined this specifically in the placebo condition, in an attempt to replicate prior work. To examine this, a correlation between prospective cognitive appraisals (challenge, threat) and negative affect change from pre-to post-TSST was conducted. Prospective threat appraisals and negative affect change was positively correlated, $r(8) = .657$, $p = .07$. The correlation is approaching significance, and is in the expected direction, indicating that participants with higher prospective threat appraisals are experiencing more negative affect, which is indicative of a stronger stress response. The correlation between prospective challenge appraisals and negative affect change was also approaching significance and in the expected direction, $r(8) = -.643$, $p = .08$. These correlations partially support the first hypothesis, but due to the small sample size, only reached marginal significance. To expand the statistical power of this test, we elected to add in participants in the propranolol group in additional analyses.

The correlation between prospective threat appraisals and negative affect change becomes significant when participants in both the placebo and propranolol groups are included,
r(12) = .624, p = .03, as prospective threat appraisal scores increase, negative affect change from pre-to post-TSST also increases (See Fig. A1). The correlation between prospective challenge appraisals and negative affect change is negatively correlated and approaching significance, r(12) = -.52, p = .08, such that higher challenge appraisals are associated with a reduction in negative affect (See Fig. A2).

Additional correlational analyses were completed to examine the relationship between cognitive appraisals and positive affect change from pre-to post-TSST. The correlation between prospective threat appraisals and positive affect change is r(12) = .05, p = .872, and the correlation between prospective threat appraisals and positive affect change is, r(12) = -.238, p = .45. These correlations are fairly weak, which suggests that cognitive appraisals are more strongly associated with negative affect responses to stress compared to positive affect.

The last correlations conducted were between retrospective cognitive appraisals and negative affect change. The first correlation was between retrospective threat appraisals and negative affect change, r(12) = .30, p = .33. The correlation is in the expected direction and is approaching significance. However, the correlation between prospective threat appraisals and negative affect change is significant, which suggests that prospective threat appraisals play a more important role compared to retrospective threat appraisals. The final correlation was between retrospective challenge appraisals and negative affect change, r(12) = -.53, p = .07. This correlation is very similar to the prospective equivalent, so this reinforces the idea that prospective threat appraisals have the largest impact on outcome.

**Propranolol vs. Placebo: Affective Responses**

Next, we examined our second hypothesis, which was that blocking sympathetic nervous system activity using propranolol would influence affective states before and after a stressor.
compared to the placebo. To do this, we conducted independent samples t-tests comparing affective differences between the propranolol and placebo conditions. First, we examined if there were differences between the conditions on negative and positive affect prior to the TSST. The results from the independent samples t-test are consistent with our hypothesis, and showed that participants in the propranolol condition showed lower levels of pre-TSST negative affect (M = 1.09, SD = .19) compared to participants in the placebo condition (M = 1.26, SD = .30), but the difference failed to reach significance (t(12) = 1.19) (See Fig. B1). Also consistent with our hypothesis, we saw that participants in the propranolol condition had lower levels of pre-TSST positive affect (M = 1.58, SD = .54) compared to participants in the placebo condition (M = 1.95, SD = .75), this difference however, was not significant (t(12) = .08, p = .33) (See Fig. B2). Both the negative and positive affect means are lower in the propranolol condition compared to the placebo condition prior to the TSST. This could indicate that propranolol is reducing negative and positive affect.

Next, we examined if there were differences between the groups on negative and positive affect following the TSST. Once again, there was a difference in post-TSST negative affect between the propranolol condition (M = 1.18, SD = .35) and the placebo condition (M = 1.45, SD = .51), but the difference also failed to reach significance (t(12) = .54, p = .28) (See Fig. B1). Likewise, there was a difference in post-TSST positive affect in the propranolol condition (M = 1.61, SD = .52) and placebo (M = 2.21, SD = .63), the difference approached significance, but failed to do so (t(12) = .40, p = .08) (See Fig. B2). The same blunting effect on negative and positive affect is seen in these results as well.

Finally, we examined if there were differences between the groups on their change in affect in response to the TSST. Consistent with our hypothesis, there were differences in
negative affect change from post-TSST to pre-TSST between the propranolol condition (M = .09, SD = .28) and the placebo condition (M = .19, SD = .42), however it did not reach significance (t(12) = .50, p = .62). Lastly, there was a difference in positive affect change from post-to pre-TSST between propranolol (M = .03, SD = .43) and placebo (M = .26, SD = .77), but it did not reach significance (t(12) = .64, p = .52). None of the results are significant, but a pattern emerges that could offer insight into propranolol’s effects on affect. Participants in the propranolol condition showed lower levels of negative and positive affect for both pre-TSST and post-TSST time points. There were also smaller changes in negative and positive affect from pre-to-post TSST. This pattern will be further examined in the discussion section.

**Propranolol vs. Placebo: Cognitive Appraisals**

Lastly, we examined the main aim of this project: If blocking sympathetic nervous system activity influences levels of challenge and threat appraisals to a stressor. Consistent with our hypothesis, an independent samples t-test result showed that individuals in the propranolol condition showed higher levels of prospective challenge appraisals (M = 4.39, SD = .31) than individuals in the placebo condition (M = 4.28, SD = .33), though this difference failed to reach significance (t(10) = -.53, p = .49) (See Fig. C1). Also consistent with hypotheses, we found that individuals in the propranolol condition had lower levels of prospective threat appraisals (M = 3.45, SD = .99) compared to those in the placebo condition (M = 3.90, SD = 1.04), though again, this difference was not significant, t(10) = .71, p = .49 (See Fig. C2). Turning to retrospective cognitive appraisals, there was again no significant difference in retrospective challenge appraisals between the propranolol condition (M = 4.65, SD = .19) and the placebo condition (M = 4.55, SD = .63); t(10) = -.30, p = .77 (See Fig. C1), or in retrospective threat appraisals for the propranolol condition (M = 3.87, SD = .47) and the placebo condition (M = 4.09, SD = 1.17);
t(10) = .35, p = .73) (See Fig. C2), though results were in the predicted direction, with individuals in the propranolol condition making higher challenge appraisals and lower threat appraisals than those in the placebo condition. The results for all the independent samples t-test are summarized in Figure D1.

**Discussion**

Cognitive appraisals are an important topic to study because of the close relationship it shares with stress and affect. Stressors are abundant, unavoidable, and can have adverse consequences. This in turn makes cognitive appraisals more relevant to study because the type of appraisal can affect the amount of subjective stress experienced (Tomaka et al., 1993). The purpose of the study was to examine if suppressing sympathetic nervous system activity via a beta-blocker would lead to higher challenge appraisals. Connecting challenge appraisals with decreased sympathetic nervous system activation would be beneficial because it would shed light on a specific mechanism that impacts cognitive appraisals. Understanding the underlying processes of a relationship is vital because it allows for future studies to examine even more specific underlying processes in the relationship, which leads to an improved research literature on the topic. With that being said, this discussion section is based on preliminary results, but there are still promising takeaways that could be seen again in the principal study. Most of the results are not significant, but a pattern emerges for all three hypotheses that can be interpreted as important.

The aim of hypothesis 1 was to replicate previous research that higher challenge appraisals are associated with a smaller increase in negative affect in response to stress, and that higher threat appraisals are associated with a larger increase in negative affect. The results partially support this hypothesis, but due to a small sample size, the correlation between the
respective cognitive appraisals and negative affect change is only significant when both the propranolol and placebo groups are examined together. The correlation between prospective threat appraisals and negative affect change approaches significance in the placebo condition. The sample size is already small when both groups are included (N=12), so the effect may not be seen when just the placebo group is examined because of the smaller sample size (N=8).

According to Tomaka et al. (1993) threat appraisals are associated with higher subjective stress and a worse performance on the stress task. Participants with a higher threat score also showed higher negative affect scores as a result of the stress task. The correlation also showed that higher prospective challenge appraisals were associated with lower negative affect change scores. The correlations support the previous research by Tomaka et al. (1993) and hypothesis 1 because they are both in the expected directions, and the threat appraisal subscale has a significant correlation to negative affect change due to stress. Threat appraisals are associated with not having enough resources to cope with a given event, so a higher negative affect is the expected result because not being able to cope with a situation should evoke higher negative affect.

Cognitive appraisals appear to primarily be associated with negative affect, but positive affect also seems to be slightly impacted by the appraisal process. The correlation between prospective cognitive appraisals and positive affect change is weak and not significant in the current small sample, but the directionality is in the opposite direction of what is expected: Prospective threat appraisals are positively correlated with increases in positive affect from pre-to post-stress. Why might threat appraisals be associated with increases in positive affect? A possible explanation could be that participants who show stronger threat appraisals experience more of a sense of relief once the stressor is over. Participants who have higher threat appraisal scores are more likely to have higher negative affect coming into the stressor, but they are likely
to experience some positive emotions as a result of the stressor being over. It is important to reiterate that the correlation between prospective appraisals and positive affect change is weak, so the main effect still lies between prospective cognitive appraisals and negative affect change.

Prospective challenge and threat appraisals were focused on instead of retrospective challenge and threat appraisals because it was hypothesized that the interpretation going into a stressful event was more important to outcome than was the interpretation following the event, as has been shown in previous research (O’Donovan et al., 2012). Separate correlations were run between prospective cognitive appraisals and negative affect change as well as retrospective cognitive appraisals and negative affect change. The results support what was originally hypothesized: there was a significant correlation for prospective cognitive appraisals, but not for retrospective cognitive appraisals, which suggests that the interpretation of demands and resources before a stressful event has a bigger impact on affect than the interpretation following that event.

Turning to the experimental data, we examined how blocking sympathetic nervous system activation using the beta-adrenergic receptor drug propranolol influences affective responses to stress. The propranolol group had lower pre-stress negative affect and post-stress negative affect as well as lower pre-stress positive affect and post-stress positive affect, compared to the placebo group (although these results failed to reach significance). The propranolol group also had smaller positive and negative affect changes compared to the placebo group. Having lower negative and positive affect before and after the stress task as well as smaller changes in affect suggests that there is a blunting of affect in the propranolol condition. Propranolol lowers heart rate and blood pressure, so this affective blunting could be due to a lower arousal state caused by the beta-blocker. This pattern of affective blunting in the
The propranolol condition could have implications for depression and anxiety. High negative affect on the PANAS is associated with an increased likelihood to report distress, discomfort, and dissatisfaction over a period of time and irrespective of the event or situation (Watson & Clark, 1984). Negative affect has a large impact on both depression and anxiety because of the comorbidity between the two (Lamers et al., 2011). There is a great deal of symptom overlap between disorders, which is why they are so closely related (Gorman, 1996).

The primary goal of this study was to examine how blocking sympathetic nervous system activation would influence cognitive appraisals of a stressor. We hypothesized that participants would score higher on challenge appraisals and lower on threat appraisals if they had taken the beta-blocker, compared to placebo. We reasoned that using a beta-blocker to lower physiological arousal would lead to a modification in the interpretation participants had right before the stress task, such that they would see the stressor as more of a challenge and less of a threat. This is the first known study to examine if experimentally changing physiological responses to stress alters cognitive appraisal processes. However, the current results do not support this hypothesis because there were no significant differences in cognitive appraisals between the two conditions. The propranolol group had slightly higher challenge appraisals, and lower threat appraisals, before and after the stressor, but these differences are not statistically significant. The challenge appraisal differences between conditions are minor, and the threat appraisal differences are bigger but still not significant. There are still consistent differences between the two groups, which suggests there could possibly be statistically significant differences once a larger sample size is incorporated.

There are important limitations to the study that should be considered in light of these effects. The first limitation to consider is the small sample size. With only 12 participants split
into two conditions, it is difficult to detect effects, and the significant effects that are seen may be spurious. Data collection for this project is ongoing, and once the entire sample of 80 participants is run, we can be more confident in the significance tests. Another limitation is that we did not examine the physiological data. The physiological data is being collected and stored, but analyses will not be run on the data until all participants have completed the study.

These are preliminary findings, but the hypotheses cannot be supported. The results did partially support previous research on the impact of cognitive appraisals, but did not support the hypothesis that a beta-blocker would lead to higher challenge appraisals. The sample size is small, so the findings should be taken in context. With that being said, the study does have important implications for health and depression. There is a large emphasis placed on cognitions in depression, but not as much emphasis is placed on physiology. It is important to understand underlying processes like physiology because it could possibly influence cognitions. Future studies should examine the specific role physiology plays in depression. This study will also add to the cognitive appraisal literature because physiology was being manipulated. The literature has a well-established finding that cognitive appraisals have a relationship with affect, but the underlying processes of why this relationship exists have not been as extensively researched. The pattern of results suggest that the sympathetic nervous system does play a role in that relationship, so future studies should explore it in more depth. In sum, propranolol appears to blunt affect before and after a stressor, which suggests lowering sympathetic nervous system activation (physiological arousal) is responsible for the effect.
References


Appendix A

Figure A1

Association Between Prospective Challenge Appraisals and Change in Negative Affect to the TSST

Figure A2

Association Between Prospective Threat Appraisals and Change in Negative Affect to the TSST
Appendix B

Figure B1

Negative Affect Between Propranolol and Placebo for Pre and Post Stress

![Bar graph showing negative affect comparison between Propranolol and Placebo for pre and post stress.](image)

Figure B2

Positive Affect Between Propranolol and Placebo for Pre and Post Stress

![Bar graph showing positive affect comparison between Propranolol and Placebo for pre and post stress.](image)
Appendix C

Figure C1

Challenge Appraisals Between Propranolol and Placebo for Pre and Post Stress

Figure C2

Threat Appraisals Between Propranolol and Placebo for Pre and Post Stress
Figure D1

<table>
<thead>
<tr>
<th>Measure</th>
<th>Propranolol Group (N=4) Mean, SD</th>
<th>Placebo Group (N=8) Mean, SD</th>
<th>T-Test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Stress Challenge Appraisals</td>
<td>4.39, .31</td>
<td>4.28, .33</td>
<td>t(10) = -.53</td>
<td>.60</td>
</tr>
<tr>
<td>Pre-Stress Threat Appraisals</td>
<td>3.45, .99</td>
<td>3.90, 1.04</td>
<td>t(10) = .71</td>
<td>.49</td>
</tr>
<tr>
<td>Post-Stress Challenge Appraisals</td>
<td>4.65, .19</td>
<td>4.55, .63</td>
<td>t(10) = -.30</td>
<td>.77</td>
</tr>
<tr>
<td>Post-Stress Threat Appraisals</td>
<td>3.87, .47</td>
<td>4.09, 1.17</td>
<td>t(10) = .35</td>
<td>.73</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measure</th>
<th>Propranolol Group (N=6) Mean, SD</th>
<th>Placebo Group (N=8) Mean, SD</th>
<th>T-Test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Stress Negative Affect</td>
<td>1.09, .19</td>
<td>1.26, .30</td>
<td>t(12) = 1.19</td>
<td>.25</td>
</tr>
<tr>
<td>Pre-Stress Positive Affect</td>
<td>1.58, .54</td>
<td>1.95, .75</td>
<td>t(12) = 1.00</td>
<td>.33</td>
</tr>
<tr>
<td>Post-Stress Negative Affect</td>
<td>1.18, .35</td>
<td>1.45, .51</td>
<td>t(12) = 1.11</td>
<td>.28</td>
</tr>
<tr>
<td>Post-Stress Positive Affect</td>
<td>1.61, 52</td>
<td>2.21, .63</td>
<td>t(12) = 1.85</td>
<td>.08</td>
</tr>
<tr>
<td>Negative Affect Difference</td>
<td>.09, .28</td>
<td>.19, .42</td>
<td>t(12) = .50</td>
<td>.62</td>
</tr>
<tr>
<td>Positive Affect Difference</td>
<td>.03, .43</td>
<td>.26, .77</td>
<td>t(12) = .64</td>
<td>.52</td>
</tr>
</tbody>
</table>
Appendix E

### Age

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>14</td>
<td>18</td>
<td>25</td>
<td>20.07</td>
<td>1.685</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Sex

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1(Male)</td>
<td>6</td>
<td>42.9</td>
<td>42.9</td>
<td>42.9</td>
</tr>
<tr>
<td>2(Female)</td>
<td>8</td>
<td>57.1</td>
<td>57.1</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

### Background

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2(Caucasian)</td>
<td>5</td>
<td>35.7</td>
<td>35.7</td>
<td>35.7</td>
</tr>
<tr>
<td>5(Asian)</td>
<td>9</td>
<td>64.3</td>
<td>64.3</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>