BIS, BAS, and Bias: The Role of Personality and Cognitive Bias in Social Anxiety


1.1. Reinforcement sensitivity theory

Kimbrel's model is based largely upon the revised Reinforcement Sensitivity Theory of personality (rRST; Gray & McNaughton, 2000), which is a biologically-based model of personality. rRST proposes that individual differences in three major brain subsystems—the BIS, BAS, and, fight-flight-freeze system (FFFS)—are responsible for many of the individual differences observed in personality, psychopathology, and reinforcement sensitivity. The BAS is proposed to underlie reward-seeking behavior and impulsivity, whereas the FFFS is proposed to motivate avoidance and escape behaviors in response to conditioned and unconditioned aversive stimuli. In contrast, the primary task of the BIS is to resolve conflicts among competing goals (e.g., approach–avoidance conflicts). The BIS is proposed to accomplish this task by inhibiting behavior, increasing arousal, and assessing for risk. The BIS is also proposed to underlie the emotion of anxiety and the personality trait of neuroticism. Consistent with the position of Gray and McNaughton (2000) and contemporary research in this area (e.g., Tull, Gratz, Latzman, Kimbrel, & Lejuez, 2010), the current paper takes the position that existing self-report inventories of BIS and neuroticism assess combined BIS–FFFS sensitivity. Accordingly, the term "BIS–FFFS" is used throughout to refer to self-report measures of BIS based on earlier versions of the theory, whereas the terms "BIS" and "FFFS" refer to the neurobiological systems proposed by Gray.

1.2. BIS–FFFS and social anxiety

The current paper also takes the position that social anxiety is a dimensional construct, and that this dimension is positively associated with BIS–FFFS functioning (e.g., Kimbrel, Cobb, Mitchell, Hundt, & Nelson-Gray, 2008). For example, Kimbrel et al. (2010) reported positive associations between continuous measures of BIS–FFFS and social anxiety across three samples of adults, and Hundt, Mitchell, Kimbrel, and Nelson-Gray (2010) reported BIS–FFFS predicted decreased romantic activities, decreased social activities, and fewer leadership roles among college students. In addition, imaging studies report increased regional cerebral blood flow in key components of the BIS and FFFS (e.g., amygdala, hippocampus) among social phobics during anticipation of a public-speaking task (Tillfors et al., 2001).
1.3. Cognitive bias and social anxiety

Socially-anxious individuals often exhibit cognitive biases for negative social information (Kimbrel, 2008). For example, they tend to believe they will be negatively evaluated in social situations (Leary, Kowalski, & Campbell, 1988), expect more negative social events and fewer positive social events (Lucek & Salkovskis, 1988), and exhibit an attentional bias for threatening social information (Asmundson & Stein, 1994). Evidence regarding a memory bias among socially-anxious individuals has been more mixed. Breck and Smith (1983) reported a memory bias for negative social information among socially-anxious individuals using a free-recall task, but only when they thought they would have to interact with a stranger later on in the experiment. Similarly, Mansell and Clark (1999) reported individuals high on social anxiety recalled fewer positive self-referent words than individuals low on social anxiety when told they would have to give a speech prior to recall, but the bias did not occur when the social threat induction procedure was not used. In contrast, Rapee, McCallum, Melville, Ravenscroft, and Rodney (1994) did not employ a social threat induction procedure and failed to find a memory bias among individuals with social phobia across a variety of memory tasks. Together, these findings suggest memory biases for negative and social threatening information may only occur among socially-anxious individuals under conditions of imminent social threat (Kimbrel, 2008).

1.4. BIS and bias

Building upon the work of Gray and McNaughton (2000) and Eysenck (1997), Kimbrel (2008) proposed that the cognitive biases observed among socially-anxious individuals are the result of heightened BIS sensitivity. Specifically, because the BIS is proposed to engage in external and internal scanning for threat-relevant information in response to potentially threatening situations (Gray & McNaughton, 2000), Kimbrel proposed that the BIS is the personality/biological basis for many of the cognitive biases (e.g., memory bias, negative expectancies and beliefs, increased perception of threat) observed among socially-anxious individuals. Thus, cognitive biases for negative and threatening social information are proposed to mediate the effect of BIS on social anxiety under conditions of imminent social threat. While this model has not been tested directly, there is some indirect support for this proposal. For example, BIS–FFFS has been associated with a tendency to focus on negative information (Noguchi, Gohm, & Dalsky, 2006) and recall negatively-valenced words in a free-recall task (Gomez & Gomez, 2002).

1.5. BAS and social anxiety

While Kimbrel’s model primarily focuses on the role of BIS, low BAS is also proposed to play a significant, albeit modest, role in social anxiety due to the interdependent nature of the BIS–FFFS and BAS systems. This proposal is based on Corr’s (2002) joint-subsystems hypothesis, which posits that the BIS and BAS have antagonistic and facilitatory effects upon behavior and are functionally interdependent. Kimbrel (2008) proposed that low BAS represents an additional risk factor for social anxiety, and there is some evidence to support this position (e.g., Kimbrel et al., 2010).

1.6. Objective and hypotheses

The objective of the present research was to test whether cognitive biases for negative and threatening social information mediate the effects of BIS–FFFS and BAS on social anxiety. It was hypothesized that BIS–FFFS would be positively associated with negative cognitive bias and social anxiety, and that the effects of BIS–FFFS on social anxiety would be fully mediated by cognitive biases. BAS was predicted to be negatively associated with cognitive bias and social anxiety, and the effects of BAS on social anxiety were predicted to be mediated by cognitive biases as well. While no previous study has directly examined the relationship between BAS, bias, and social anxiety, the latter hypothesis is consistent with previous research demonstrating that decreased positive expectancies mediate the effect of low BAS on depression (Beevers & Meyer, 2002).

2. Methods

2.1. Participants

A total of 219 college students were recruited. Twelve participants scored above the recommended cut-off score of three or higher on the Infrequency Scale (Chapman & Chapman, 1986), which is indicative of a random response set. These participants were excluded from the analyses, yielding a final sample of 207 participants. The final sample was 67% female and 70% Caucasian, both of which were consistent with the university’s demographic profile. Participants’ mean age was 19.1 years (SD = 5.8). Fifty participants (24%) scored at or above the clinical cut-off score of 24 (M = 17.36, SD = 13.35) on the Social Phobia Scale (SPS; Heimberg, Mueller, Holt, Hope, & Liebowitz, 1992).

2.2. Procedure

In all, 24 separate study sessions were conducted. The mean number of participants per group was 9.1 (SD = 5.4). Participants initially completed measures of BIS–FFFS, BAS, and trait social anxiety. Next, participants underwent a social-threat induction procedure in which they were told they would be required to give an impromptu speech at the end of the study. Afterwards, participants completed a counter-balanced battery of cognitive bias measures assessing memory bias, belief bias, expectancy bias, and perception of threat, as each of these constructs is included in Kimbrel’s (2008) mediated model of social anxiety. Participants’ state anxiety was also assessed via self-report. Finally, participants performed brief impromptu speeches while audience members rated their level of anxiety during their speeches. Structural equation modeling (SEM) was used to compare the hypothesized model with several alternative models.

2.3. Self-report measures

The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia, Avila, Molto, & Caseras, 2001) was used to assess individual differences in BIS–FFFS and BAS sensitivity. The SPS (Mattick & Clarke, 1998) was used to assess trait social anxiety. The state version of the State-Trait Anxiety Inventory (STAI; Spielberger, Lushene, Vagg, & Jacobs, 1983) was used to assess state anxiety in anticipation of the speech task. The Negative Affect scale from the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) and the Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988) were also used to assess state anxiety and negative affect, respectively. The directions for the BAI and PANAS were altered so that participants were asked to rate the degree to which they were currently experiencing the items while they anticipated the impending speech task. Audience ratings of anxiety were obtained by having audience members rate participants’ state anxiety during the speech task on a five-point Likert scale that ranged from 1 = “not nervous at all” to 5 = “very nervous.” The audience ratings of anxiety for each participant were averaged across all available raters to produce an average
audience-rated anxiety score for each participant who gave a speech. The Self-Statements During Public-Speaking Scale (Hofmann & DiBartolo, 2000) was used to assess negative and positive beliefs; however, it was modified slightly so that participants were asked to endorse whether the self-statements were indicative of their current thoughts as they anticipated getting ready to complete the speech task. Participants also provided a Perception of Threat rating regarding the speech task. Specifically, each of the participants responded to the question “How threatened do you feel by the prospect of having to give a speech in front of your peers?” on a five-point Likert scale that ranged from 1 = “Not at all” to 5 = “Very.” Finally, a six-item Speech Expectancies Scale was created to assess participants’ expectancies regarding the speech task. The Speech Expectancies Scale was created because there were no available instruments to assess speech expectancies regarding an impending speech task. The scale consisted of six items and two subscales—Positive Speech Expectancies and Negative Speech Expectancies. It is available upon request from the first author. An example of a Negative Speech Expectancies item is “Please rate how likely you think it is that your peers will evaluate you negatively during the speech.” Participants rated each item on a five-point Likert scale that ranged from “1 = Not at all” to “5 = Very.” Internal consistency was .82 for the Positive Speech Expectancies Scale and .80 for Negative Speech Expectancies Scale.

2.4. Memory task

An incidental free recall task was used to assess memory bias. During the encoding phase, participants rated whether 38 words described how they thought others would view them during the speech task. Half of the words were negative (e.g., tense), whereas the other half were positive (e.g., confident). The majority of words were selected from previous studies examining biases among socially-anxious individuals (Mansell & Clark, 1999; Mathews, Mogg, May, & Eysenck, 1989). The first and last four words in the word list served as primacy and recency buffers and were not included in the statistical analysis of memory bias (Mansell & Clark, 1999). The test set of 30 words (15 negative words and 15 positive words) in the middle of the word list was equated on word length and word frequency. To control for serial position effects, three versions of the word list were produced.

2.5. Speech task

After the SPSRQ and SPS were completed, a social threat induction procedure was conducted in which participants were informed they would be giving speeches at the end of the study. They were then given 3 min to collect their thoughts about one of five controversial topics in the US, which included “should gay marriage be legalized?”, “should drugs be legalized?”, “should animal research be made illegal?”, “should tobacco be outlawed?”, and “wrestling and football: should females be allowed to compete?”. After the 3 min period was over, participants completed the memory task and the beliefs, expectancies, and perception of threat ratings forms in counter-balanced order. Next, participants completed the state anxiety measures in counter-balanced order. A random numbers table was then used to select participants for the speech. Once selected, participants were asked to go to the front of the classroom and to give their speech. Most speeches were less than a minute and none was longer than 3 min. While participants gave their speeches, research assistants and other participants rated how anxious the participant giving the speech appeared. Of the 207 participants, four participants refused to participate in the speech task. In addition, 40 more were unable to complete the speech task because the study was stopped after 2 h had elapsed, which was the time period that participants had agreed to when they had consented to participate in the research project. Thus, a total of 163 participants (79%) completed the speech task and received an audience rating of anxiety. Notably, because participants were randomly selected for the speech task, the missing data from the vast majority of participants who did not complete the speech task can be considered missing completely at random. Accordingly, consistent with best practices, maximum likelihood estimation was used to estimate missing data (Enders, 2010).

3. Results

Internal consistency for the self-report measures ranged from .78 to .96 (see Table 1). Due to the correlational nature of the hypotheses, the negative bias scoring procedure applied by Mathews et al. (1989) was used, and negative bias scores were created for the three cognitive bias variables that contained both positive and negative scores (beliefs, expectancies, incidental free recall task). These scores were computed by subtracting positive scores from negative scores so that a single negative bias index score could be used in the SEM models. Table 1 presents the correlations among the observed variables.

SEM with maximum likelihood estimation was used to assess the fit of the hypothesized model (Fig. 1). This model contained four latent variables—BIS–FFFS, BAS, cognitive bias, and social anxiety. Item parcels from the SPSRQ were used to create latent variables for BIS–FFFS and BAS; however, since multiple measures of bias and anxiety were available, total scores were used as indicators for these latent variables (Fig. 1). Because there is no single gold standard fit index for all SEM models, Kline (2005) has recommended the statistical analysis of memory bias (Mansell & Clark, 1999).

![Table 1](https://example.com/table1.png)

Table 1

<table>
<thead>
<tr>
<th>Measures</th>
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<tbody>
<tr>
<td>1. BIS–FFFS</td>
<td>.85</td>
<td>−.11</td>
<td>.57</td>
<td>.49</td>
<td>.42</td>
<td>.54</td>
<td>.63</td>
<td>.58</td>
<td>.49</td>
<td>.57</td>
<td>.28</td>
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<td>2. BAS</td>
<td>.78</td>
<td>−.23</td>
<td>−.28</td>
<td>−.08</td>
<td>−.15</td>
<td>−.15</td>
<td>−.10</td>
<td>−.13</td>
<td>−.28</td>
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<td>3. Belief bias</td>
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<td>.74</td>
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<td>4. Expectancy bias</td>
<td>−.38</td>
<td>.62</td>
<td>.35</td>
<td>.43</td>
<td>.54</td>
<td>.67</td>
<td>.37</td>
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<td>5. Memory bias</td>
<td>−.42</td>
<td>.37</td>
<td>−.37</td>
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<td>6. Perceived Threat</td>
<td>−.51</td>
<td>.51</td>
<td>.54</td>
<td>.62</td>
<td>.31</td>
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<td>7. Social Phobia Scale</td>
<td>.93</td>
<td>.58</td>
<td>.51</td>
<td>.54</td>
<td>.23</td>
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<td>8. Beck Anxiety Inventory</td>
<td>.95</td>
<td>.68</td>
<td>.67</td>
<td>.26</td>
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<td>9. Negative Affect</td>
<td>.88</td>
<td>.81</td>
<td>.26</td>
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<td>10. State-Trait Anxiety Inventory</td>
<td>.96</td>
<td>.32</td>
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<td>11. Audience-rated anxiety</td>
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Note: Internal consistency reliability is reported in italics on the diagonal for all measures with more than one item.

**p < .01.

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that researchers always report the chi-square statistic, the Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI), and the standardized root mean residual (SRMR) when reporting SEM results. Generally speaking, models that exhibit close (or acceptable) fit to the data should have CFI values \( \geq 0.95 \) (to \( 0.90 \)), RMSEA values \( \leq 0.06 \) (to \( 0.08 \)), and SRMR values \( \leq 0.08 \) (to \( 0.10 \); Kline, 2005).

The hypothesized model is shown in Fig. 1 with the standardized maximum likelihood estimates. As can be seen in Table 2, the fit indices for the hypothesized model suggested good to adequate fit [chi-square = 173.82 (100), \( p < .001 \); RMSEA = 0.060; CFI = 0.954; SRMR = 0.064]. The hypothesized model was then compared with an independent main effects model constructed to test the competing hypothesis that BIS–FFFS, BAS, and cognitive bias exhibit direct effects upon social anxiety independently of one another. As expected, the independent main effects model showed poor fit [chi-square = 284.213 (101), \( p < .001 \); RMSEA = 0.094; CFI = 0.887; SRMR = 0.194] and was rejected in favor of the better-fitting hypothesized model.

The hypothesized model was then compared to a partial-mediation model in which direct paths from BIS–FFFS to social anxiety and from BAS to social anxiety were added. As in the hypothesized model, both BIS–FFFS (\( \beta = 0.69, p < .001 \)) and BAS (\( \beta = -0.19, p < .001 \)) had significant direct effects on cognitive bias; however, the paths from BIS–FFFS (\( \beta = 0.13, \text{ns} \)) and BAS (\( \beta = -0.03, \text{ns} \)) to social anxiety were not significant (i.e., \( p > .05 \)). In addition, while the fit statistics for the hypothesized model and the partial mediation model were nearly identical (Table 2), a chi-square difference test \( \chi^2 = 2.72 \) (2, ns) indicated that adding direct paths from BIS–FFFS and BAS to social anxiety did not significantly improve the overall fit of the model. Consequently, the partial-mediation model was also rejected in favor of the hypothesized model.

A final comparison was made between the hypothesized model and a model in which the path from BAS to cognitive bias was constrained to be zero. This model was constructed to determine if estimating the direct path from BAS to cognitive bias significantly improved the overall fit of the model. As can be seen in Table 2, the fit statistics for the constrained BAS model were slightly worse than the fit statistics for the hypothesized model, although they still indicated acceptable fit to the data. However, a chi-square difference test indicated that the hypothesized model showed

Fig. 1. Hypothesized model with standardized maximum likelihood estimates. Error and disturbance terms are not shown for clarity of presentation. SP1–SP4 = Sensitivity to Punishment parcels 1–4. SR1–SR4 = Sensitivity to Reward parcels 1–4.

<table>
<thead>
<tr>
<th>Model</th>
<th>Chi-square</th>
<th>( p )-Value</th>
<th>df</th>
<th>RMSEA</th>
<th>SRMR</th>
<th>CFI</th>
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<tr>
<td>Hypothesized Structural Model</td>
<td>173.82</td>
<td>(&lt; .001 )</td>
<td>100</td>
<td>0.060</td>
<td>0.064</td>
<td>0.954</td>
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<tr>
<td>Independent Main Effects</td>
<td>284.22</td>
<td>(&lt; .001 )</td>
<td>101</td>
<td>0.094</td>
<td>0.194</td>
<td>0.887</td>
</tr>
<tr>
<td>Partial Mediation Structural Model</td>
<td>171.40</td>
<td>(&lt; .001 )</td>
<td>98</td>
<td>0.060</td>
<td>0.063</td>
<td>0.955</td>
</tr>
<tr>
<td>BAS Constrained Structural Model</td>
<td>182.89</td>
<td>(&lt; .001 )</td>
<td>101</td>
<td>0.063</td>
<td>0.073</td>
<td>0.949</td>
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</tbody>
</table>

Note: RMSEA = Root Mean Square Error of Approximation; SRMR = Standardized Root Mean Square Residual; CFI = Comparative Fit Index.
significantly better fit to the data [$\chi^2 = 9.07$ (1), $p < .005$]. Accordingly, the constrained BAS model was also rejected in favor of the hypothesized model.

As can be seen in Fig. 1, both BIS–FFFS ($b = .71$, $p < .001$) and BAS ($b = -.20$, $p < .001$) had significant direct effects on cognitive bias, combining to account for 58% of the variance in this latent variable. In turn, cognitive bias had a significant direct effect upon social anxiety ($b = .86$, $p < .001$), accounting for 74% of the variance in this latent variable. Finally, consistent with Kimbrel’s (2008) prediction, both BIS–FFFS ($b = .61$, $p < .001$) and BAS ($b = -.17$, $p = .01$) had significant indirect effects on social anxiety via cognitive bias.

4. Discussion

Overall, our findings are consistent with the hypothesis that cognitive biases for negative and threatening social information mediate the effects of BIS–FFFS and BAS on social anxiety. Specifically, both BIS–FFFS and BAS were found to have significant indirect effects on social anxiety via cognitive bias. While additional research is needed to replicate and expand upon these findings, the results suggest that BIS–FFFS and BAS may be the personality/neurobiological basis for both social anxiety and the cognitive biases associated with this condition. Thus, the present research directly extends the seminal work of Eysenck (1997) concerning the relationship between trait anxiety and cognitive bias to Gray’s rNST. The present research also adds to the literature concerning the relationship between BIS–FFFS and social anxiety by demonstrating a relationship between BIS–FFFS and state social anxiety within the context of a realistic and relevant social situation. An additional strength of the study was its inclusion of audience ratings of anxiety as an indicator on the state social anxiety latent variable.

Our findings may also be of broader interest because they suggest that biased information processing may be the mechanism through which personality influences behavioral and emotional responses to threatening situations. Indeed, one of the most interesting findings comes from examination of the path coefficients in the partial mediation model. As in the hypothesized model, both BIS–FFFS ($b = .69$, $p < .05$) and BAS ($b = -.19$, $p < .05$) had significant direct effects on cognitive bias; however, the paths from BIS–FFFS ($b = .13$, ns) and BAS ($b = -.03$, ns) to social anxiety were not significant, which suggests that Gray’s personality constructs of BIS–FFFS and BAS may actually be more strongly related to the cognitive biases that underlie social anxiety rather than social anxiety itself.

The findings also demonstrate that at least some forms of cognitive bias (i.e., memory bias, belief bias, expectancy bias, perception of threat) load onto a more general cognitive bias factor. This finding is important because it is highly consistent with Gray and McNaughton’s (2000) position that there is a major biasing system in the brain (i.e., the BIS) that underlies many forms of cognitive bias. Further support for this position comes from the finding that BIS–FFFS was the personality trait most strongly associated with negative cognitive bias in both the SEM and correlational analyses. For example, whereas the correlation between BAS and negative memory bias was non-significant ($r = -.08$, ns), BIS–FFFS demonstrated a strong positive correlation with this variable ($r = .42$, $p < .01$). While this pattern of results could simply be a reflection of the more general pattern of stronger relationships between BIS–FFFS and bias, it is also consistent with the idea that the BIS is the primary neural/personality basis for the memory biases associated with social phobia (Gray & McNaughton, 2000; Kimbrel, 2008).

It is also noteworthy that the current study successfully demonstrated a relationship between social anxiety and an explicit memory bias for threatening social information. Given that most of the previous studies that have found a memory bias among socially-anxious participants have also employed a social-threat manipulation (e.g., Breck & Smith, 1983; Mansell & Clark, 1999), the findings from the present study are consistent with previous research and Hirsch and Clark’s (2004) observation that memory biases are most likely to occur among socially-anxious participants following a social threat manipulation. The findings are also consistent with the hypothesis that potentially threatening social situations produce the most pronounced information-processing biases because these types of situations engage the BIS–FFFS and force it into control mode (Gray & McNaughton, 2000; Kimbrel, 2008).

4.1. Limitations and future directions

The current study had several notable limitations. First, it used a student sample, which limits generalizability. It was also cross-sectional and correlational in nature, which limits us from making causal inferences. In addition, the absence of a control group for the social threat manipulation prevents direct examination of the effect of social threat on cognitive bias. Future studies might consider extending the findings from the present research by adding a control group that is not exposed to social threat, using a different type of cognitive bias task (e.g., facial recognition task), or replicating the findings with a clinical sample. Future studies could also benefit from multi-method assessment of BIS–FFFS and BAS. For instance, in addition to self-reports, neuroimaging and/or behavioral tasks could be used to enhance study designs. Finally, additional research examining the relationship between BIS–FFFS, BAS, other forms of cognitive bias (e.g., rumination), and other types of psychological disorders is needed.

5. Conclusion

The results from the present research provide support for Kimbrel’s (2008) mediated model of social anxiety. As predicted, higher BIS–FFFS and lower BAS had significant indirect effects on social anxiety via cognitive bias. While additional research in this area is needed, our findings suggest that cognitive biases for negative and threatening social information may be the mechanism through which BIS–FFFS and BAS exert their influence upon social anxiety.

References

Social Interaction Anxiety Scale (SIAS) and the Social Phobia Scale (SPS).


