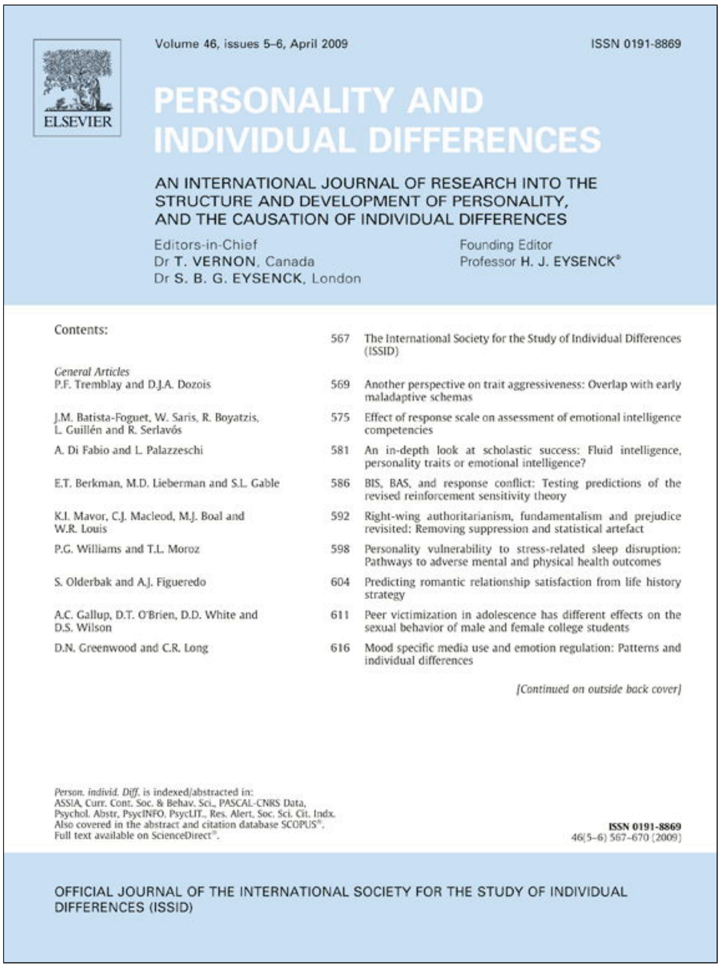

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Contents:

567 The International Society for the Study of Individual Differences (ISSID)

General Articles

P.F. Tremblay and D.J.A. Dozois — 569 Another perspective on trait aggressiveness: Overlap with early maladaptive schemas

J.M. Batista-Foguet, W. Saris, R. Boyatzis, L. Guillén and R. Serlavós — 575 Effect of response scale on assessment of emotional intelligence competencies

A. Di Fabio and L. Palazzeschi — 581 An in-depth look at scholastic success: Fluid intelligence, personality traits or emotional intelligence?

E.T. Berkman, M.D. Lieberman and S.L. Gable — 586 BIS, BAS, and response conflict: Testing predictions of the revised reinforcement sensitivity theory

K.I. Mavor, C.J. Macleod, M.J. Boal and W.R. Louis — 592 Right-wing authoritarianism, fundamentalism and prejudice revisited: Removing suppression and statistical artefact

P.G. Williams and T.L. Moroz — 598 Personality vulnerability to stress-related sleep disruption: Pathways to adverse mental and physical health outcomes

S. Olderbak and A.J. Figueredo — 604 Predicting romantic relationship satisfaction from life history strategy

A.C. Gallup, D.T. O'Brien, D.D. White and D.S. Wilson — 611 Peer victimization in adolescence has different effects on the sexual behavior of male and female college students

D.N. Greenwood and C.R. Long — 616 Mood specific media use and emotion regulation: Patterns and individual differences

[Continued on outside back cover]

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BIS, BAS, and response conflict: Testing predictions of the revised reinforcement sensitivity theory

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ABSTRACT

Gray's (1970) reinforcement sensitivity theory (RST) was recently updated (Gray & McNaughton, 2000), but the changes have not received extensive empirical validation. The study tests three novel predictions of the revised RST. First, the behavioral activation system (BAS) is expected to be sensitive to both conditioned and unconditioned incentives. Second, the behavioral inhibition system (BIS) is expected to be sensitive to conflicting incentives such as between unconditioned and conditioned stimuli, and not to avoidance responses or aversive stimuli alone. Third, during approach-avoidance conflicts only, BAS is expected to moderate BIS responses to conflict such that individuals with high BAS show the strongest effect of BIS. In order to test these hypotheses, we developed a novel incentive task that crosses approach/avoidance conditioned responses to appetitive/aversive unconditioned stimuli. Conflict between unconditioned and conditioned stimuli occurred on the approach-aversive and avoid-appetitive trials. Results confirm the predictions and provide support for the revised RST.

1. Introduction

One view on motivation is that there are two fundamental types of behavior – one to *approach* positive outcomes, and another to *avoid* negative outcomes. One of the first scientists to describe behavior along this approach-avoidance dimension was Schneirla (1959), who based his conclusions about human motivation on models involving invertebrate and vertebrate animals. Later, based on work with rodents, Gray (1970, 1987) postulated specific brain areas involved in approach and avoidance. According to Gray's *Reinforcement Sensitivity Theory* (RST), the approach system served as a *behavioral activation system* (BAS) that activated behavior toward incentives. The avoidance system consisted of a *behavioral inhibition system* (BIS), relating to avoidance of conditioned aversive stimuli, and a *fight-flight system* (FFS) relating to avoidance of unconditioned aversive stimuli, both through withdrawal and freezing behaviors. In humans, stable individual differences in BIS and BAS relate to anxiety and impulsivity, respectively (Gray, 1981; Pickering, Corr, & Gray, 1999).

RST has been recently revised to account for inconsistencies in studies of the original theory (e.g. Corr, 2001, 2008; Jackson, 2003). In the revised reinforcement sensitivity theory (rRST), sensitivity to all punishments – conditioned or unconditioned – is shifted to the FFFS. In the new RST, BIS becomes a conflict detection system that acts as a gatekeeper between environmental stimuli and the other two systems. Specifically, BIS maintains vigilance for conflict in the environment, directs attention to conflicting stimuli when detected, and resolves conflict by inhibiting ongoing action and biasing action toward the FFFS to facilitate defensive behavior (Gray & McNaughton, 2000; McNaughton & Gray, 2002). The role of BAS in facilitating approach behavior remains relatively unchanged, but has been broadened to also include approach toward unconditioned as well as conditioned incentives.

These changes yield several novel predictions about how BIS and BAS regulate behavior. First, because BAS is sensitive to conditioned incentives, individuals with higher trait BAS might show improved behavioral responses to stimuli linked to a desired outcome even if those stimuli are hedonically aversive (e.g. unconditioned negative stimuli that have been associated with incentives). Second, BIS is expected to be active only when there is conflict or uncertainty, such as in "approach-avoidance" situations. In these situations, individuals with higher trait BIS might show improved behavioral responses relative to those with lower BIS because they detect conflict more quickly and thus allocate resources more efficiently toward resolving it. Finally, in light of empirical findings that BIS and BAS interact under situations with mixed incentives (e.g. Corr, 2002), these predictions further suggest that responses to conflicting incentives might be influenced by high BIS and high BAS together more than either one

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alone. Because the rRST has not yet been tested extensively (for review, see Smillie, Pickering, & Jackson, 2006b), the purpose of the present study was to provide an initial investigation into these new aspects of the theory.

An appropriate test of these predictions requires a situation with mixed incentives. This can be achieved by presenting participants with stimuli that are themselves pleasant or unpleasant (*hedonic* variation), and also independently act as a means to attain rewards or avoid punishments (*instrumental* variation). Examining how participants respond to these situations and particularly when there is conflict (e.g. approaching an aversive stimulus to attain an instrumental reward) allows us to test hypotheses about the revised RST.

To meet these specific demands, we created the *Nochmani* task in which participants read a fake *National Geographic*-style article about a newly-discovered tribe of people, the Nochmani. Through the article, participants learn that the Nochmani are similar to Westerners in their enjoyment of sweets and their distaste for fungii, but are dissimilar in their fondness for eating insects and disgust when eating meats. On the subsequent task, Western participants respond whether to "eat" or "not eat" various foods from the perspective of the Nochmani. Thus, we created approach-avoidance conflicts (e.g. indicating "eat" to a disgusting-looking food) and also separated hedonic (unconditioned) from instrumental (conditioned) responses.

We tested three hypotheses using this task. First, we expected individuals with high trait BAS activation (compared to low) to be more responsive to instrumental rewards, even when the stimuli that had been associated with incentives were hedonically unpleasant (e.g. correctly answering "eat" to a picture of an insect). Second, we expected individuals with high trait BIS activation (compared to low) to be better able to deal with approach-avoidance conflicts, and not to avoidance responses or aversive stimuli on their own (as predicted by the original RST). And finally, because BIS is expected to relate to approach-avoidance conflicts and BAS is expected to relate to instrumental rewards, on trials where aversive stimuli are paired with conditioned incentives we expected a BIS-by-BAS interaction such that BAS enhances the relationship between BIS and faster correct responses.

2. Method

2.1. Participants

Participants were 96 (61 female) undergraduates recruited from the UCLA psychology subject pool (*M* age = 19.6, range = 18–27). Since the task depends on unconditioned appetitive and aversive reactions to certain foods, participants were screened to enjoy eating meats and desserts, and to be disgusted by eating insects and fungi. Participants gave informed consent. All procedures described herein were approved by the UCLA Institutional Review Board.

2.2. Design

The task used three within-subject factors, each with two levels: hedonic value (appetitive/aversive) × instrumental action (approach/avoidance) × perspective (American/Nochmani). The 'hedonic value' factor indicated whether the participant's unconditioned response to the stimulus was appetitive (for meats and desserts) or aversive (for fungus and insects). The 'instrumental action' factor indicated whether an approach ("eat") or avoidance ("don't eat") action was required for a correct response; we assumed that our participants were intrinsically motivated to respond correctly. 'Perspective' indicated whether the participant was to "respond on behalf of the typical American (Nochmani) person." The Nochmani trials allowed for a full crossing of the hedonic value and instrumental action factors using four stimulus sets: insects (approach-aversive), fungi (avoid-aversive), desserts (approach-appetitive), and meats (avoid-appetitive). The American conditions served as a baseline. Because the participants were American and the instructions in these conditions were to respond as an American would, the hedonic value and instrumental action for the American trials were always congruent (i.e. appetitive-approach or avoid-aversive).

2.3. Materials

Trait behavioral activation and inhibition was measured using the Behavioral inhibition/Behavioral Activation Scales (BIS/BAS; Carver & White, 1994). The BAS scale has three subscales: the BAS-drive subscale measures persistent pursuit of goals (e.g. "I go out of my way to get things I want"), $\alpha = .82$; the BAS-fun seeking subscale measures desire for new rewards (e.g. "I crave excitement and new sensations"), $\alpha = .72$; and the BAS-reward responsiveness subscale relates to positive responses to reward (e.g. "When I get something I want, I feel excited and energized"), $\alpha = .68$. The reliability for the overall BAS scale was .68. The BIS scale is thought to be unidimensional, and taps sensitivity to negative events (e.g. "Criticism or scolding hurts me quite a bit"), $\alpha = .65$. Mood at the time of experiment was assessed as a covariate using the Positive Activation/Negative Activation Schedules (PANAS; Watson, Clark, & Tellegen, 1988). In the state form of the PANAS, participants rated how they "currently feel right now" to each of twenty emotion terms grouped into positive affect (PA; e.g. elated, happy; $\alpha = .92$) and negative affect (NA; e.g. troubled, upset; $\alpha = .65$).

The pictures of food used in the task belonged to one of four categories: fungi, desserts, meats, or insects. There were 40 pictures in each class for a total of 160 color pictures. Pictures were pre-rated on the internet ($N = 696$) on a 7-point scale of hedonic valence (-3 = Extremely aversive, 0 = Neutral, 3 = Extremely appetitive) and found to differ significantly from one another, $F_{(3, 692)} = 5{,}959.2$, $p < 0.001$. Planned *t*-tests indicated that the appetitive images were rated as significantly more appetitive than the aversive images (*M* diff = 3.93, $t_{695} = 98.55$, $p < 0.001$). Among the aversive images, the insects were rated as slightly more aversive than the fungi (*M* diff = 0.26, $t_{695} = 14.04$, $p < 0.001$), and the cakes were rated as slightly more appetitive than the meats (*M* diff = 0.41, $t_{695} = 9.92$, $p < 0.001$). The images were standardized on brightness and contrast, and fixed at a resolution of 500 by 375 to maintain a 4-to-3 width-to-height ratio.

2.4. Procedure

Following consent, participants completed the BIS/BAS and PANAS scales, then read the realistic but fake article about the Nochmani. Participants were told to read the article carefully because they subsequently would be completing a memory task about the Nochmani. Although the subjects were led to believe that the task involved memory, success in the forthcoming task depended only on participants remembering two unusual characteristics of the Nochmani – that they enjoyed eating insects, and were disgusted by eating meat. The Nochmani otherwise share Western tastes in food as they enjoy eating desserts and are disgusted by eating fungi.

Next, participants completed a computerized response time task. They were shown a series of trials that each displayed a single picture of a dessert, meat, fungus, or insect. Participants were asked to respond as quickly as possible via keypress whether Nochmani (or Americans) would "eat" or "not eat" the food. Each trial lasted 2000 ms, and participants could respond at any point during that time. Trials occurred within 32 blocks of 10 trials each with 6 s of resting fixation between blocks and 4 s of instructions per block, yielding a total of 320 trials in 16 min. All the trials within each block were from the same perspective (e.g. Nochmani) and were 80% "target" trials from one hedonic value-instrumental action pairing (e.g. approach-appetitive) and 20% "distractor" trials of the opposite action (i.e. avoid-appetitive or avoid-aversive). The logic of using blocks composed predominantly of a single target trial type with a few distractors grew out of pretesting which indicated that participants were unable to respond correctly at greater-than-chance levels to completely mixed blocks in the Nochmani condition (i.e. a random assortment of all trial types), suggesting these to be excessively difficult. In the current design, participants were able to achieve a high rate of accuracy. The 20% of the trials that serve as distracters ensure that participants must still attend to each trial to determine the correct response. The eight block types (2 [appetive/aversive] × 2 [approach/avoid] × 2 [Nochmani/American]) were evenly and randomly distributed throughout the experiment. The dependent measures were response time (average block reaction time in milliseconds after image onset, excluding distracters) and accuracy.

The key blocks for the present analyses are those in which participants experience a conflict that must be resolved in order to respond correctly. The conflict is a result of a mismatch between the inherent hedonic valence of the stimulus (appetitive/aversive) and the motivational direction of a correct (instrumental) response (approach/avoid). Specifically, these trials occur when responding from the Nochmani perspective to images of insects (approach-aversive) and meat (avoid-appetitive). Those same images from the American perspective have no-conflict, since Americans generally eat meat (appetive-approach) and do not eat insects (avoid-aversive).

3. Results

3.1. BIS/BAS and affect

Table 1 shows the correlations among BIS, the BAS subscales, PA, and NA. BIS and BAS were not significantly correlated. Nonetheless, to ensure independent effects, unless otherwise noted each of the subsequent analyses involving any of the BAS subscales controlled for BIS, and the analyses involving BIS controlled for the BAS average.

State affect was measured as a covariate because it is known to relate to BIS and BAS. The BAS subscales tended to be positively but non-significantly correlated with PA, and negatively correlated with NA. The Reward Responsiveness subscale was significantly negatively correlated with NA ($r = -.27$, $p < .01$). BIS was negatively correlated with PA ($r = -.25$, $p < .01$), and positively non-significantly correlated with NA. All analyses described below involving BIS and the BAS subscales control for PA and NA. However, the results remain unchanged when PA and NA are excluded from the analyses.

Table 1
Zero-order correlations among BIS/BAS and PA/NA.

Variable	1	2	3	4	5	6
1. BIS	–	−.13	−.12	.06	−.25**	.06
2. BAS-drive		–	.45***	.50***	.18*	−.14
3. BAS-fun seeking			–	.36***	.18*	−.16*
4. BAS-reward responsiveness				–	.11	−.27**
5. Positive affectivity (PA)					–	.02
6. Negative affectivity (NA)						–

Note: $N = 96$.
* $p < .1$.
** $p < .01$.
*** $p < .001$.

3.2. Accuracy

The average accuracy across participants was 98.2%, and no participant was less than 95% accurate. There were too few errors to compare accuracy across conditions. Hence, inaccurate trials were discarded from all further analyses.

3.3. Response time

Given the lack of variance on accuracy, response time latency was used as the primary dependent measure. Average response time for each subject in each trial type was computed using only the target trials in each block, yielding eight within-subjects response time averages for each participant. Tests of skewness and kurtosis were non-significant for each of the trial types (all *ps* > .1), suggesting that the average response times were approximately normally distributed.

There was a main effect of perspective on response time such that participants were faster to respond as Americans than Nochmani (M diff = 108 ms, $t_{95} = 14.42$, $p < 0.001$). There was also a valence effect such that participants were faster to respond to aversive than appetitive stimuli (M diff = 24 ms, $t_{95} = 5.2$, $p < 0.001$). Finally, participants were slightly faster to respond "eat" than "don't eat" (M diff = 11 ms, $t_{95} = 2.60$, $p < .02$). The cell means are presented in Fig. 1.

3.4. BAS and reward

The first novel prediction that we tested was that BAS should be sensitive to both unconditioned and conditioned rewards. The present experimental paradigm contains a mixture of unconditioned (because the stimuli are intrinsically hedonic) and conditioned stimuli (because each trial is an opportunity to respond correctly and thus succeed in the task). According to the rRST, trait BAS should predict faster correct (i.e. instrumental) responses across all trials regardless of whether the hedonic valence of the stimulus is appetitive or aversive. A repeated-measures ANOVA

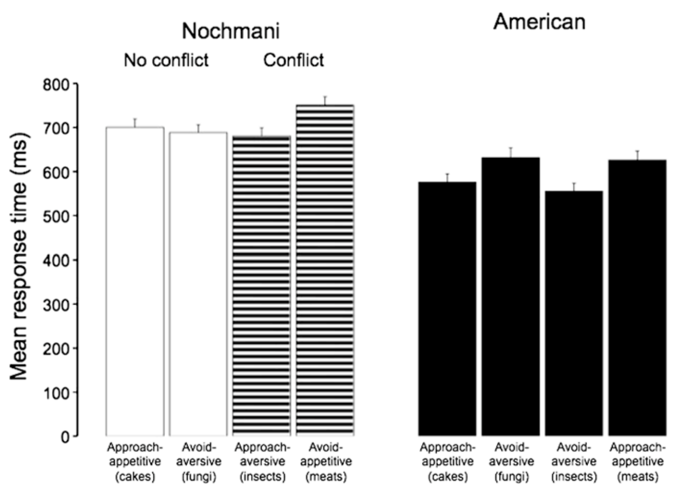

Fig. 1. Mean response time (±2 SEs) for each cell in milliseconds. Open bars indicate *Nochmani* perspective; closed bars indicate *American* perspective; striped bars indicate conflict.

predicting response time across all conditions from BIS and the three BAS subscales was used to test this prediction. The BAS-drive subscale, controlling for all others, was the only predictor of faster correct responses across all conditions ($F_{4,92} = 3.06$, $p < .02$). To further explore this result, we used partial correlations to predict response time in each condition from BAS-D controlling for BIS: American ($r_{93} = -.30$, $p < .01$), Nochmani ($r_{93} = -.19$, $p < .06$), appetitive ($r_{93} = -.25$, $p < .02$), aversive ($r_{93} = -.28$, $p < .01$), approach ($r_{93} = -.26$, $p < .01$), and avoidance ($r_{93} = -.28$, $p < .01$). Neither BIS nor the other BAS subscales (reward responsivity and fun seeking) was associated with response times in any of the conditions (all *ps* > .1). Thus, the Drive subscale of BAS demonstrates specificity in its relationship with conditioned rewards, even when the actual stimulus to which participants responded was hedonically aversive.

Though Carver and White's (1994) BAS scales were based on the original RST, the Drive subscale was developed to be a measure of "persistent pursuit of desired goals" (p. 322), broadly construed. Subsequent work suggesting that the Drive subscale relates specifically to pursuit of conditioned and unconditioned incentives more than the other two subscales (e.g. Franken, 2002). The theoretical intent and evidence from previous work, taken together with the present results, suggests that the Drive subscale continues to be a valid measure of BAS in the rRST.

3.5. BIS and response conflict

The next theoretical question examined the relationship between trait BIS and behavioral responses to conflicting incentives. To examine whether BIS was selectively associated with responses during conflict, we ran a repeated-measures ANOVA with one factor (conflict: conflict/no-conflict), four covariates (BIS, BAS-D, BAS-RR, BAS-F), and the four interactions between the trait BIS/BAS measures and conflict. The interaction between BIS and conflict was significant ($F_{1,87} = 5.02$, $p < .05$), indicating that trait BIS was differentially associated with response time in the Nochmani conflict and no-conflict conditions, controlling for all other covariates. To further explore this result, a *conflict penalty* score was created for each participant reflecting the difference in response time between the conflict and no-conflict conditions (i.e. approach-aversive and avoid-appetitive minus approach-appetitive and avoid-aversive; $M = 24$ ms, different from 0, $p < .01$). Trait BIS, controlling for BAS, was negatively correlated with the conflict penalty score, indicating that individuals with higher levels of trait BIS had smaller conflict penalties ($r_{93} = -.22$, $p < .04$; Fig. 2). As shown in Fig. 2, some participants with high trait BIS scores had negative conflict penalty scores, indicating that they actually responded *more quickly* to conflict than to non-conflict trials. The interaction between BIS and the parallel scores from the American perspective was not significant ($p > .1$).

Finally, a three-way interaction between perspective (Nochmani/American), conflict (conflict/no-conflict), and BIS confirmed that the difference in correlation between BIS and conflict compared to no-conflict trials was different between the Nochmani and American conditions ($F_{1,87} = 11.97$, $p < .01$). This result is expected because correct responses on the American trials are always consistent with participants' hedonic motivation toward the stimulus, so they do not produce conflict. It is particularly noteworthy that BIS did not correlate with avoidance responses or aversive stimuli alone, but only when they were in conflict with an approach response or appetitive stimulus. Additionally, because the stimuli are identical in the American and Nochmani conditions with only the perspective changing (and thus an increase in conflict), the null result in the American condition provides further support for the notion that the BIS effect in the Nochmani trials is driven by conflict and not by the stimulus set *per se*.

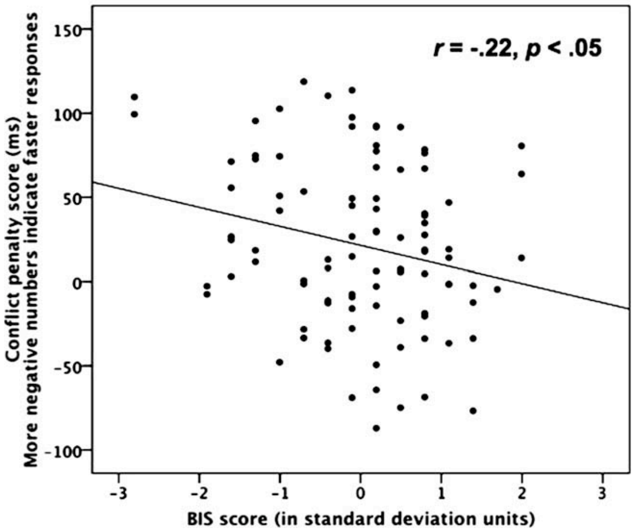

Fig. 2. Conflict penalty scores are negatively correlated with BIS. The conflict penalty for each subject is the mean response time on non-conflict trials subtracted from the mean response time on conflict trials. More negative conflict penalty scores indicate faster responses to conflict compared to non-conflict trials.

3.6. BIS-by-BAS interaction during response conflict

Finally, the rRST predicts that BIS and BAS interact in some cases to contribute to successful goal pursuit. We reasoned that if BAS mediates responses to desired goals and if BIS mediates responses during conflict, then BIS and BAS would interact during conflict when one of the conflicting response options was associated with a desired instrumental outcome (i.e. a correct response). To test this prediction, we computed an ANOVA for each of the BAS subscales with conflict as a repeated-measures factor and BIS, BAS, and their interaction as covariates. The three-way interaction of conflict, BIS, and BAS was significant for the BAS-drive subscale ($F_{1,92} = 4.94$, $p < .03$), but not the other subscales (*ps* > .1). The only other significant term in this model was conflict by BIS interaction, $F_{1,92} = 6.21$, $p < .02$. This finding suggests that BIS is associated with faster responses during conflict, and especially for those also high in BAS-drive. Fig. 3 illustrates the BIS-by-BAS-D interaction by

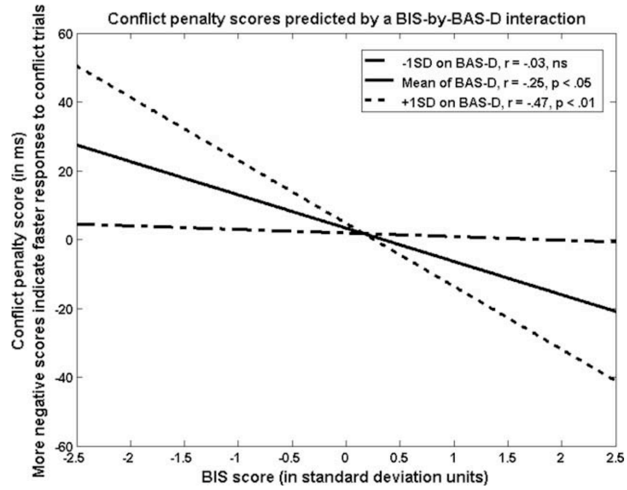

Fig. 3. The BIS-by-BAS-drive interaction predicting response times during conflict. The negative association between BIS and conflict scores was strongest for those high on BAS (1 SD above the mean, $r = -.47$, $p < .01$) and weakest for those low on BAS (1 SD below the mean, $r = -.03$, *ns*).

plotting the relationship between BIS and conflict penalty scores at various levels of BAS-D. The simple slope of BIS on the congruent-incongruent difference at −1 SD of BAS was −0.03 ($t_{93} = -.18$, *ns*), at the mean of BAS was −0.25 ($t_{93} = -2.49$, $p < .02$), and at +1 SD of BAS was −0.47 ($t_{93} = -3.51$, $p < .01$). The association between BIS and conflict penalty score was negated for individuals with low levels of trait BAS-D and increased significantly for those with moderate to high levels of BAS-D.

4. Discussion

In the time since the revisions to Reinforcement Sensitivity Theory (Gray & McNaughton, 2000; McNaughton & Gray, 2002), the new model has received little empirical attention, especially with human subjects (Smillie et al., 2006b). The present study provides new direct tests of several key aspects of the revised theory using a novel task that was specifically designed for this purpose.

First, the behavioral activation system is expected to act as a general reward system that is sensitive to both conditioned and unconditioned stimuli. Individuals with higher levels of trait BAS were faster to respond correctly to all trial types, regardless of whether the stimulus itself was hedonically appetitive or aversive. The fact that BAS (specifically the Drive subscale) correlated with faster responses to aversive stimuli that are conditioned rewards converges with related studies showing BAS sensitivity relates to reward learning and is distinct from impulsiveness (Smillie, Dalgleish, & Jackson, 2007; Smillie, Jackson, & Dalgleish, 2006a).

Second, the behavioral inhibition system is expected to be sensitive to conflict among response options. Individuals with higher levels of trait BIS were faster to respond in cases where there was approach-avoidance conflict. Importantly, BIS was not related to aversive stimuli in the absence of conflict. This finding adds to a growing consensus that BIS sensitivity relates more to conflict detection and inhibition than to aversiveness *per se* (Avila, 2001; Blanchard, Hynd, Minke, Minemoto, & Blanchard, 2001; Smillie et al., 2006a, 2006b).

And third, the BIS and BAS are expected to interact during goal pursuit. We found that the relation of BIS to faster responses during conflict was moderated by BAS-drive. The correlation between BIS and faster correct responses was even stronger for individuals who also had higher BAS-drive. This is consistent with the roles of the two systems in the rRST. As we demonstrated, BAS relates to faster correct responses in general, presumably because responding correctly acts as a conditioned reward. And BIS relates to faster responses under conflict. So it follows that individuals with high levels of trait BIS and BAS would respond most quickly during conflict trials where one of the response options is also a correct response. A more complete test of this hypothesis would also include a response conflict condition in the absence of a conditioned correct response (i.e. two conflicting but both incorrect responses). We would predict responses in these conditions would relate to BIS but not BAS.

4.1. Measuring the rRST with Carver and White's (1994) BIS/BAS scales

The BIS and BAS scales were intended to measure behavioral inhibition and activation, respectively, in Gray's original RST. Since the revision the precise mapping of these measures onto the new constructs is unclear. Considering that the theoretical change of the BAS is minor, and in light of the data presented, it is possible that at least the Drive subscale still relates to BAS in the rRST. However, the standing of the BIS scale in terms of the rRST is more murky. The scale was designed to measure the inhibition system in the original RST, which is now spread across the BIS and FFFS in the rRST. And it has been suggested that the BIS scale is likely to relate to FFFS because the items focus on sensitivity to punishment and do not mention inhibition (Smillie et al., 2006b).

Our data are at odds with these claims and suggest that Carver & White's BIS scale relates to behavior in the way expected of the BIS in the new RST. One explanation is that the old and new conceptions of the BIS are highly overlapping, and the BIS scale taps into parts of both. This explanation is supported by the face validity of the scale in measuring approach-avoidance conflicts (e.g. "I worry about making mistakes"), and by a recent factor analysis of the scale in light of the revised RST. Heym, Ferguson, and Lawrence (2008) demonstrate a two-factor solution of the BIS scale that divides the items into "FFFS-Fear" and "BIS-anxiety" subscales that correspond to FFFS and BIS, respectively, in the revised RST. Because the subscales are highly correlated ($r \sim .50$) and more than half of the seven items load on the BIS-anxiety subscale, the original BIS scale might still be a reliable measure of the revised BIS construct.

Another explanation for why the BIS scale predicts sensitivity to conflict involved the hierarchical structure of the task (Elliot, 2006). In this view, each stimulus is represented psychologically at two levels: a lower, hedonic value (appetitive or aversive) that is intrinsic to the stimulus, and a higher, instrumental value (approach or avoid) that varies depending on the task condition. For example, images of insects are always hedonically aversive to our participants, but during the Nochmani perspective they are to be approached and during the American perspective these same stimuli are to be avoided. Each hierarchy level represents a different form of "threat" to which BIS might be sensitive. At the lower level, the threat is possible exposure to the aversive stimulus itself (e.g. a spider). At the higher level, the threat is the potential for an incorrect response. Critically, threat of an incorrect response is greater during conflict trials because the participants' natural (unconditioned) response conflicts with the correct (conditioned) response. Thus, conflict is confounded with "threat," but only threat at the higher level. We can conclude that Carver & White's BIS scale is sensitive either to conflict or to the threat of an incorrect response, but our task was not designed to separate these possibilities. Further work will be needed to examine the specific role of the BIS/BAS scales in the new RST.

5. Conclusion

The present study verified three predictions made by the revised reinforcement sensitivity theory (RST) about the relation of BIS and BAS sensitivity to behavioral responses. First, BAS predicted faster responses to stimuli that were either hedonically rewarding or instrumental to a goal. Second, BIS related to faster responses under conflict, and not to aversive stimuli alone. And third, BAS and BIS interacted such that the effect of BIS on faster responses under conflict was amplified for those with high BAS, and reduced for those with low BAS. Each of these results would not have been predicted by the old RST. These results are among the first to empirically demonstrate the functional implications of the revised RST.

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References

Avila, C. (2001). Distinguishing BIS-mediated and BAS-mediated disinihibition mechanisms: A comparison of disinihibition models of Gray (1981, 1987) and of Patterson and Newman (1993). *Journal of Personality and Social Psychology, 80*(2), 311–324.

Blanchard, D. C., Hynd, A. L., Minke, K. A., Minemoto, T., & Blanchard, R. J. (2001). Human defensive behaviors to threat scenarios show parallels to fear- and anxiety-related defense patterns of non-human mammals. *Neuroscience & Biobehavioral Reviews. Special Issue: Defensive behavior and the biology of emotion, 25*(7–8), 761–770.

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of Personality and Social Psychology, 67*(2), 319–333.

Corr, P. J. (2001). Testing problems in J. A. Gray's personality theory: A commentary on Matthews and Gilliland (1999). *Personality and Individual Differences, 30*(2), 333–352.

Corr, P. J. (2002). J. A. Gray's reinforcement sensitivity theory: Tests of the joint subsystems hypothesis of anxiety and impulsivity. *Personality and Individual Differences, 33*(4), 511–532.

Corr, P. J. (2008). *The reinforcement sensitivity theory of personality*. Cambridge: Cambridge University Press.

Elliot, A. H. (2006). The hierarchical model of approach-avoidance motivation. *Motivation & Emotion, 30*, 111–116.

Franken, I. H. A. (2002). Behavioral approach system (BAS) sensitivity predicts alcohol craving. *Personality and Individual Differences, 32*(2), 349–355.

Gray, J. A. (1970). The psychophysiological basis of introversion–extraversion. *Behaviour Research & Therapy, 8*(3), 249–266.

Gray, J. A. (1981). A critique of Eysenck's theory of personality. In H. J. Eysenck (Ed.), *A model of personality* (pp. 246–276). New York: Springer.

Gray, J. A. (1987). *The psychology of fear and stress*. Cambridge, England: Cambridge University Press.

Gray, J. A., & McNaughton, N. (2000). *The neuropsychology of anxiety*. Oxford, England: Oxford University Press.

Heym, N., Ferguson, E., & Lawrence, C. (2008). An evaluation of the relationship between Gray's revised RST and Eysenck's PEN: Distinguishing BIS and FFFS in Carver and White's BIS/BAS scales. *Personality and Individual Differences, 45*, 709–715.

Jackson, C. J. (2003). Gray's reinforcement sensitivity theory: A psychometric critique. *Personality and Individual Differences, 34*(3), 533–544.

McNaughton, N., & Gray, J. A. (2002). "The neuropsychology of anxiety" as it really is: A response to O' Mara (2001). *Neuropsychological Rehabilitation, 12*(4), 363–367.

Pickering, A. D., Corr, P. J., & Gray, J. A. (1999). Interactions and reinforcement sensitivity theory: A theoretical analysis of Rusting and Larsen (1997). *Personality and Individual Differences, 26*(2), 357–365.

Schneirla, T. C. (1959). An evolutionary and developmental theory of biphasic processes underlying approach and withdrawal. In M. R. Jones (Ed.), *Nebraska symposium on motivation* (pp. 1–42). Oxford, England: University of Nebraska Press.

Smillie, L. D., Dalgleish, L. I., & Jackson, C. J. (2007). Distinguishing between learning and motivation in behavioral tests of the reinforcement sensitivity theory of personality. *Personality and Social Psychology Bulletin, 33*(4), 476–489.

Smillie, L. D., Jackson, C. J., & Dalgleish, L. I. (2006a). Conceptual distinctions among Carver and White's (1994) BAS scales: A reward-reactivity versus trait impulsivity perspective. *Personality and Individual Differences, 40*(5), 1039–1050.

Smillie, L. D., Pickering, A. D., & Jackson, C. J. (2006b). The new reinforcement sensitivity theory: Implications for personality measurement. *Personality and Social Psychology Review, 10*(4), 320–335.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063–1070.