DIFFERENTIAL EFFECTS OF REWARD AND PUNISHMENT CUES ON RESPONSE SPEED IN ANXIOUS AND IMPULSIVE INDIVIDUALS

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Summary—Four groups of subjects—neurotic extraverts, stable extraverts, neurotic introverts, and stable introverts—were instructed to trace a circle template as slowly as possible. The tracing task was performed under one of three conditions: Condition Rw entailed the presence of reward cues, Condition Pn entailed the presence of punishment cues, and Condition G (while involving the presence of goal stimulus) entailed neither type of conditioned stimulus. As predicted, high impulsive (neurotic extravert) subjects exhibited inappropriately rapid tracing speeds (i.e. behaved impulsively) to a greater extent than did low impulsive (stable introvert) subjects in Condition Rw. Although, as expected, high anxious (neurotic introvert) subjects manifested the fastest tracing speeds among the four subject groups in the presence of punishment cues (i.e. in Condition Pn), they did not trace significantly faster than low anxious (stable extravert) subjects. Finally, replicating earlier research in which the presence of a salient goal stimulus was sufficient to engender rapid responding, high impulsive subjects traced significantly faster than did low impulsives in Condition G. These results are discussed in the context of a model of impulsive behavior that is primarily a synthesis of Eysenck's (1967) personality theory and Gray's (Elements of a two-process theory of learning, 1975) three arousal model. This synthesis maps the extraversion dimension onto the relative strengths of Gray's behavioral activation and inhibition systems, and identifies the neuroticism dimension with Gray's nonspecific arousal system.

In 1985, Bachorowski and Newman, as part of a larger program of research dealing with the relationships among various indices of impulsivity, examined the degree to which the trait of impulsivity is related to motor speed. Ss in their experiment were provided with the template of a circle, and first were asked to trace this circle under neutral conditions (i.e. no instructions were given regarding tracing speed). Ss then were asked to trace the circle again, this time 'as slowly as possible'. Although not differing in speed on the neutral tracing, impulsive Ss traced significantly faster than did nonimpulsives on the second, inhibition, tracing. This outcome clearly is in accord with the notion that rapid responding is a characteristic associated with impulsivity (e.g. Barratt & Patton, 1983; Milich & Kramer, 1984).

However, subsequent attempts to replicate these results were not entirely successful (see Bachorowski, 1986): impulsive Ss did not consistently manifest the most rapid tracing speeds. In fact, it appeared on occasion that trait anxiety exerted a stronger influence on tracing speed than did impulsivity. Whereas under some circumstances impulsives did indeed trace fastest, under others, somewhat surprisingly, anxious Ss traced fastest and thus—by exhibiting inappropriately rapid response speeds—appeared behaviorally impulsive.

To reconcile these conflicting observations, we constructed a theoretical formulation that is primarily a synthesis of Eysenck's (1967) personality theory and Gray's (1975, 1987; Gray & Smith, 1969) neuropsychological model (for a more detailed description of this perspective on impulsive behavior, see Wallace, Bachorowski & Newman, 1990). In brief, Eysenck (1967) proposed that personality can be characterized with reference to two orthogonal dimensions: extraversion (E) and neuroticism (N). Extraverts tend to be outgoing, sociable, active, and optimistic, whereas introverts (extraverts' polar opposites) tend to be quiet, unsociable, passive, and careful.

N, on the other hand, reflects emotionality, or the degree to which persons are reactive to environmental stimuli: neurotic individuals tend to be more emotionally unstable or reactive than are stable individuals. Furthermore, neuroticism magnifies propensities derived from E (Eysenck...
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& Eysenck, 1978): neurotic extraverts tend to be more extraverted, and neurotic introverts tend to be more introverted, than are their stable counterparts.

Gray's three arousal model (see also Fowles, 1980) consists of a set of interacting arousal systems. The behavioral activation system (BAS) is sensitive to stimuli associated with reinforcing events (Rew-CSs), and its level of activity increases when such stimuli are detected. It is responsible for the initiation of goal-directed behavior, including both approach and active avoidance responses.

The behavioral inhibition (BIS) is sensitive to cues for punishment (Pun-CSs), as well as to unexpected or novel stimuli, and, like the BAS, the detection of stimuli to which it is sensitive engenders an increase in its activity level. BIS activity normally results in the interruption of ongoing BAS-mediated goal-directed behavior; this response interruption tends to occur whenever Pun-CSs or unexpected stimuli are detected in an organism's environment.

The third system—the nonspecific arousal system (NAS)—is responsive to excitatory inputs from the BAS and the BIS, such that an increase in the activity of either behavioral system results in heightened NAS activity. Consequently, when stimuli that are inputs to either the BAS or the BIS are detected in an organism's environment, an increase in NAS activity results. Of especial relevance to the subsequent discussion, the NAS has excitatory connections affecting responses mediated by the behavioral systems: as the activity level of the NAS increases, the speed and vigor of subsequently occurring responses also tends to increase.

As alluded to above, our formulation maps Gray's three arousal model onto E and N. We view E as reflecting the relative strengths of the two behavioral systems (see also Gray, 1981; Gray, Owen, Davis & Tsaltas, 1983). In particular, the BAS of extraverts is stronger than the BIS, whereas for introverts the BIS is stronger than the BAS; extraverts are BAS-dominant and introverts are BIS-dominant. Consequently, extraverts and introverts differ with respect to relative stimulus sensitivities (Gupta & Shukla, 1989; Derryberry, 1987). Extraverts are preferentially sensitive to stimuli that serve as inputs to the BAS, such as Rew-CSs. Introverts, on the other hand, are preferentially sensitive to inputs to the BIS, such as Pun-CSs. Introverts, on the other hand, are preferentially sensitive to BIS inputs, such as Pun-CSs.

Furthermore, because response initiation is a function of the BAS, extraverts are 'geared to respond' (Brebner & Cooper, 1974, p. 273), and readily initiate goal-directed behavior (Derryberry, 1987). Introverts, on the other hand, by virtue of being BIS-dominant are prone to engage in functions associated with behavioral inhibition (e.g. response interruption). Thus, E is a dimension not only of relative stimulus sensitivities, but also of differences in characteristic response tendencies.

N, in our view, reflects the reactivity of the NAS, with a neurotic individual possessing a more reactive NAS than does a stable individual. Thus, neurotic individuals are predisposed to experience rapid increases in the activity level of the NAS: given stimulation of similar intensity, neurotic individuals tend to experience a greater and more rapid increment in NAS activity than do their stable counterparts, and in consequence their subsequent responses tend to be faster and more forceful.

Because neuroticism magnifies propensities derived from E (Eysenck & Eysenck, 1978), neurotic extraverts are highly reactive, especially to BAS inputs such as Rew-CSs, whereas neurotic introverts are highly reactive, especially to BIS inputs such as Pun-CSs. Moreover, neurotic extraverts are even more inclined to initiate responses or engage in goal-directed behavior than are stable extraverts, and neurotic introverts are prone to be even more cautious and withdrawn than are stable introverts. Consequently, we identify the combination of neuroticism and extraversion with impulsivity and that of neuroticism and introversion with anxiety (Eysenck, 1967; Eysenck & Eysenck, 1985; Gray, 1981; Gray et al., 1983).

The present theoretical perspective highlights the importance of considering situational, as well as individual difference, variables when engaged in the experimental observation of impulsive

*In this manuscript, we do not argue that our conceptualizations of impulsivity and anxiety are the only viable alternatives. Other measures of anxiety and impulsivity have been used effectively by other researchers, and these various instruments may reflect somewhat different constructs (Barratt & Patton, 1983). However, as will be discussed subsequently, the conceptualizations that we employ have proven useful for enhancing our understanding of certain laboratory phenomena involving impulsive and anxious Ss.
behavior. For example, because extraverts are BAS-dominant, they tend to be quite sensitive to Rew-CSs. Moreover, the BAS activity resulting from the presence of such stimuli is translated into heightened activity of the NAS, which is most reactive in neurotic individuals. Thus, because the increase in NAS activity associated with a given level of behavioral system activity is greatest in neurotic individuals, and because heightened NAS activity is associated with increased response speed, impulsive individuals (neurotic extraverts) would be expected to manifest rapid responding in the presence of Rew-CSs.

On the other hand, neurotic introverts under some circumstances might be expected to manifest rapid response speed in the presence of Pun-CSs (Wallace et al., 1990). Introverts, by virtue of being BIS-dominant, tend to be quite sensitive to threats of punishment. In neurotic introverts, this propensity is magnified by the high reactivity of the NAS. Thus, given that response speed is related to the level of NAS activity, increased response speed in anxious individuals (neurotic introverts) might tend to occur in the presence of Pun-CSs.

This formulation, then, suggests that in some situations impulsive individuals (neurotic extraverts) might be expected to exhibit inappropriately rapid response speeds, whereas under other conditions, anxious individuals (neurotic introverts) might respond rapidly and thus appear behaviorally impulsive.

Bachorowski and Newman (1990) utilized this theoretical perspective to explicate the factors responsible for the seemingly inconsistent observations in their circle tracing studies (Bachorowski, 1986; Bachorowski & Newman, 1985). To test their hypotheses regarding these factors, an additional tracing experiment was performed. This design entailed two conditions. In the goal condition, the point on the circle at which Ss were to stop tracing was clearly indicated with a hatchmark and the word STOP; in the no-goal condition the circle had no such markings. All Ss performed a neutral tracing, followed by an inhibition tracing.

In the goal condition, the labelled hatchmark served as a salient goal for the tracing response. Bachorowski and Newman (1990) proposed that this goal would function as an input to the BAS, because such a goal may be conceived as a stimulus for BAS-mediated approach behavior. It was proposed that impulsive Ss (neurotic extraverts) would experience the greatest increment in NAS activity in response to this stimulus, due to the combination of their BAS dominance and the high reactivity of the NAS to behavioral system activity. Given that response speed is related to the activity level of the NAS, it was predicted that neurotic extraverts would trace faster than other Ss during the inhibition tracing of the goal condition.

In the no-goal condition, the lack of a clear behavioral goal was thought to engender uncertainty regarding the experimental task. Anxious Ss (neurotic introverts) were expected to experience the greatest increment in NAS activity in response to this aversive situational uncertainty (which was believed to function as a BIS stimulus input) due to their BIS dominance and their highly reactive NAS. Therefore, as a consequence of this heightened NAS activity, neurotic introverts were predicted to trace faster than other Ss during the inhibition tracing of the no-goal condition.

In fact, neurotic extraverts did trace significantly faster than stable introverts in the goal condition, with neurotic introverts and stable extraverts exhibiting intermediate tracing speeds. Similarly, in the no-goal condition neurotic introverts traced significantly faster than did stable extraverts, with the remaining two groups again exhibiting intermediate tracing speeds.

These results are in accord with the suggestion that inconsistencies among the Bachorowski and Newman circle tracing experiments might have been due to situational factors (e.g. a salient behavioral goal, situational uncertainty) that resulted in differential NAS activation in impulsive and anxious Ss. Specifically, under some conditions impulsive Ss may have experienced the greatest increment in NAS activity, and thus exhibited the fastest tracing speeds, whereas under others, the increase in NAS activity may have been greatest for anxious Ss, who then traced fastest and appeared behaviorally impulsive.

It should be noted, however, that Gray's model, which is an integral component of our theoretical perspective, emphasizes Rew- and Pun-CSs as inputs to the behavioral systems. Whereas the results obtained by Bachorowski and Newman (1990) were consistent with hypotheses that were derived in part from Gray's model, it might be suggested that this experiment did not employ Rew-CSs or Pun-CSs. That is, a labelled hatchmark and the lack thereof are not prototypical reward or punishment cues. Therefore, the present experiment was designed to
increase the generality of the results obtained by Bachorowski and Newman (1990) by utilizing stimuli that explicitly were associated with reward and punishment.

As in the Bachorowski and Newman (1990) study, we employed a circle tracing task, and, as in that experiment, the point at which to stop tracing was clearly indicated on the circle template. However, Ss in each of the three conditions performed three inhibition tracings (designated Tracing 1, Tracing 2 and Tracing 3) and no neutral tracing: all Ss were asked to trace a circle three times, as slowly as possible.

Furthermore, in the reward condition (Condition Rw), Ss were informed that they would be given the opportunity to generate a random number between 0 and 9 following each tracing, and if their total was 15 or more, they would win $3. Punishment condition (Condition Pn) Ss were similarly informed regarding the generation of random numbers following each tracing, but these Ss were told that they would be given three dollars at the start of the task. If their total was 15 or more, they would lose the $3.

However, the computer used to generate the numbers was programmed to display the numeral 7 following Tracing 1 and the numeral 5 following Tracing 2: following Tracing 1 Ss in Conditions Rw and Pn had nearly half of the critical quantity 15, and prior to Tracing 3 they had a total of 12. Thus, Ss in Condition Rw were led to believe that the probability of achieving a total of 15 or more, and thus of winning the $3, was quite high. On the other hand, this manipulation was designed to lead Ss in Condition Pn to believe it to be quite probable that they would lose the $3 by accumulating a total of 15 or more. In this experiment, then, the Rew–CSs and Pun–CSs were the displays presented on the computer monitor, which were associated with the perceived high probabilities of winning $3 (in Condition Rw) or of losing $3 (in Condition Pn).

In the goal-only condition (Condition G), Ss performed the three inhibition tracings, but they did not generate numbers and no mention was made of a monetary contingency.

In our research on impulsivity and anxiety, the primary predictions typically take the form of planned comparisons between high impulsive (neurotic extravert) and low impulsive (stable introvert) Ss, and between high anxious (neurotic introvert) and low anxious (stable extravert) Ss. Because these pairs of groups differ on both E and N, disparities involving impulsivity are expected to be greatest between neurotic extraverts and stable introverts, whereas those involving anxiety are expected to be greatest between neurotic introverts and stable extraverts.

We proposed that (BAS-dominant) extraverts in Condition Rw—due to the presence of Rew–CSs—would be especially prone to experience an increase in BAS activity. This BAS activity, in turn, would be magnified in neurotic extraverts (by virtue of their high NAS reactivity to behavioral system activity) into a substantial increase in NAS activity. Therefore, because we expected that under these conditions NAS activity would be greatest in neurotic extraverts, and given that response speed is related to the activity level of the NAS, we hypothesized that these Ss would exhibit the fastest tracing speeds. In this experiment our index of tracing speed was the amount of time Ss required to trace once around the circle template. Hence, in Condition Rw our specific prediction was that neurotic extraverts would take less time to trace the circle than would stable introverts.

In Condition G, neurotic extraverts again were expected to trace fastest, due to the presence of a salient approach stimulus (the labelled hatchmark that marked the point at which to stop tracing). As discussed previously, such a stimulus acts as an input to the BAS, and thus engenders heightened BAS and NAS activity, especially in neurotic extraverts. Hence, as in Condition Rw, the tracing times of neurotic extraverts were predicted to be less than those of stable introverts.

Finally, it was hypothesized that neurotic introverts would display the fastest tracing speeds among Ss in Condition Pn. By virtue of their BIS dominance, introverts were expected to experience a greater increment in BIS activity than would extraverts in response to the presence of Pun–CSs. Furthermore, this propensity was anticipated to translate into heightened NAS activity, and thus faster tracing speeds, especially among neurotic introverts (due to their high NAS reactivity to activity of either behavioral system). Therefore, paralleling the predictions in Conditions Rw and G, in Condition Pn the tracing times of neurotic introverts were predicted to be less than those of stable extraverts.
Subjects

Two hundred and two male undergraduates, who were enrolled in an introductory psychology course at the University of Wisconsin–Madison, and who received extra credit points for their participation, served as Ss in this experiment. Ss were assigned consecutively to either Condition Rw, Condition Pn, or Condition G. Only after testing were they categorized with respect to E and N.

Procedure

Ss participated individually in the experimental task. An experimenter met each S at a waiting room and, after the S read and signed an informed consent form, he was asked to complete the Eysenck Personality Questionnaire (EPQ; Eysenck & Eysenck, 1975). This instrument includes scales for E and N, which were used to classify Ss in the present experiment.

After completing the EPQ, each S was escorted to the testing room, and was seated at a table on which were positioned a computer monitor, a button box used in the generation of the numbers (in Conditions Rw and Pn), and a stack of three circle templates. The experimenter then read aloud the task instructions.

The instructions read to Ss in Condition Rw were as follows:

This experiment is a study of motor behavior. We want you to trace this circle as slowly as possible, while staying within the double lines. We will have you do this three times.

We believe this to be interesting and potentially important research. However, we realize that college students may find this task somewhat dull. Therefore, to make the procedure more interesting, and because other experiments that we are currently running involve the possibility of winning money, we are going to give you the opportunity to play a kind of number game while you participate in the experiment.

Specifically, we will give you the opportunity to win $3. (The experimenter places $3 on the table.) After each tracing, I will start the computer, which will generate random numbers between 0 and 9, and display them on the video monitor. Whenever you like, press this button and hold it down momentarily. The computer then will display the last number that it generated. If your total for three plays is 15 or more, you will win the $3.

Start at the word ‘GO’ and trace clockwise to the word ‘STOP’, and remember to trace the circle as slowly as possible.

The instructions given Ss in Condition Pn were identical to those for Condition Rw, with the exception of the third paragraph, which read:

Specifically, we will give you $3 at the beginning of the task. (The experimenter places $3 on the table.) After each tracing, I will start the computer, which will generate random numbers between 0 and 9, and display them on the video monitor. Whenever you like, press this button and hold it down momentarily. The computer then will display the last number that it generated. If your total for three plays is 15 or more, you will lose the $3.

Ss in Condition G were read only the first and last paragraphs given in the Condition Rw and Pn instructions.

The template that Ss traced consisted of two concentric circles, of 9" dia (22.9 cm) and 10" dia (25.4 cm). Hatchmarks transected both circles at the 12 o'clock position, indicating the point at which to begin and stop tracing. On the right side of the hatchmark on the outermost circle the word ‘GO’ appeared in green letters, and on the left side appeared the word ‘STOP’ in red letters.

While the S was tracing, the experimenter sat quietly to the S’s right and monitored the time by means of a stopwatch. Ss were required to trace continuously: if a S paused during the task, even momentarily, he was asked to continue tracing.
After completing Tracing 1, Ss in Conditions Rw and Pn generated their first number. This number (7), as well as the S’s total (also 7), remained visible on the computer monitor until the second number (5) was generated following Tracing 2. This second number, as well as the total (12), remained on the screen during Tracing 3.

Following Tracing 3, Ss in Conditions Rw and Pn generated their final number. Because the results of this final generation could not affect performance on the experimental task, the computer was programmed to generate random numbers between 0 and 6 following the third tracing. Thus, for Ss in Conditions Rw and Pn, the probability of gaining $3 was, in fact, 0.5.

RESULTS

Ss were categorized on E and N based on their scores for the corresponding EPQ scales. The cutoff point for E was 15.5, and that for N was 11.5. Ss scoring below the E scale cutoff point were designated introverts; those scoring above this value were designated extraverts. Similarly, those scoring below the N scale cutoff point were designated stable; those scoring above this value were designated neurotic.

We first performed a repeated measures analysis of variance (ANOVA), using E, N, and condition as between-Ss factors. The repeated measures factor—tracing—consisted of Ss tracing times for Tracings 1, 2, and 3.

Three effects attained statistical significance. First, a main effect for N was evident, $F(1, 178) = 4.72, P < 0.05$. This effect was due to the tendency of neurotic Ss to trace faster than stable Ss (see Table 1).

Second, the Tracing x E interaction was significant, $F(2, 356) = 4.06, P < 0.05$. Inspection of Table 1 indicates that introverts increased their tracing times (i.e. responded progressively more slowly) over successive tracings to a greater extent than did extraverts.

Third, a significant Tracing x E x N interaction was observed, $F(2, 356) = 3.49, P < 0.05$. Whereas stable and neurotic introverts evidenced a similar pattern of increasing tracing times over successive tracings, neurotic extraverts slowed less than did their stable counterparts as the experiment progressed (see Table 1).

Before reporting the results of the planned comparisons on which our predictions were based, it should be noted that we did not employ the mean of each S’s three tracing times as our primary dependent variable. We anticipated that as successive numbers were generated, the perceived probability of winning (in Condition Rw) or losing (in Condition Pn) would increase. Furthermore, as the experiment progressed, the amount of exposure to these stimuli would increase. Hence, the potency as Rew–CSs (in Condition Rw) or Pun–CSs (in Condition Pn) of the displays on the computer monitor would be expected to increase throughout the experiment, and their effects on tracing speed should be maximal during Tracing 3. In fact, because numbers were generated following each tracing, during Tracing 1 these stimuli were not even present. Therefore, we utilized tracing time on Tracing 3 as our primary dependent measure.

Because the mean tracing times used to test our hypotheses involved both between-Ss and repeated measures factors, we pooled the corresponding error terms, and utilized this pooled error when computing the planned comparisons (Kirk, 1968). In addition, because the degrees of freedom associated with the between-Ss and repeated measures error terms differed, we adopted the conservative approach of using the smaller of those terms in these analyses. This procedure also was utilized in the computation of supplemental comparison reported below.

Table 1. Mean tracing times in seconds of neurotic extraverts (NE), stable extraverts (SE), neurotic introverts (NI), and stable introverts (SI) in each condition

<table>
<thead>
<tr>
<th>Group</th>
<th>Condition</th>
<th>Rw</th>
<th>G</th>
<th>Pn</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NE</td>
<td>SE</td>
<td>NI</td>
<td>SI</td>
</tr>
<tr>
<td>1</td>
<td>77</td>
<td>120</td>
<td>124</td>
<td>128</td>
</tr>
<tr>
<td>2</td>
<td>81</td>
<td>164</td>
<td>149</td>
<td>160</td>
</tr>
<tr>
<td>3</td>
<td>83</td>
<td>188</td>
<td>169</td>
<td>211</td>
</tr>
<tr>
<td>n*</td>
<td>17</td>
<td>21</td>
<td>16</td>
<td>11</td>
</tr>
</tbody>
</table>

*Numbers of Ss in each cell.
In Condition Rw, neurotic extraverts manifested the fastest tracing speeds, and their tracing time was significantly less than that of stable introverts, $t(190) = 2.30, P < 0.025$. In Condition G neurotic extraverts again traced fastest, and their tracing time was significantly less than that of stable introverts, $t(190) = 2.17, P < 0.05$. Thus, the data provided support for two of our three hypotheses. However, our hypothesis regarding Condition Pn was not corroborated: the disparity between the tracing time of neurotic introverts and that of stable extraverts was not reliably different from zero, $t(190) < 1$.

As noted above, our primary predictions involved tracing times on Tracing 3. However, comparisons identical to those reported above, but utilizing tracing times for Tracing 1 and for Tracing 2, also were performed. None of these subsidiary comparisons attained statistical significance.

Although not the subject of specific predictions, three sets of supplemental analyses were performed in addition to those reported above. First, we compared the tracing times of neurotic extraverts in Conditions Rw and G, and compared those of neurotic introverts in Conditions Pn and G. These analyses were performed to determine (1) whether the presence of Rew-CSs in Condition Rw caused neurotic extraverts to trace faster than they did in Condition G (in which such stimuli were not present), and (2) whether the presence of Pun-CSs in Condition Pn caused neurotic introverts to trace faster than they did in Condition G. Although the disparity between the tracing times of neurotic extraverts in Conditions Rw and G was not reliably different from zero, $t(190) < 1$, tracing times of neurotic introverts in Condition Pn tended to be less than were those of neurotic introverts in Condition G, $t(190) = 1.93, P < 0.06$.

Second, although psychoticism (P)—the third personality dimension represented in the EPQ—does not figure explicitly in our theoretical framework, Eysenck and Eysenck (1985) have emphasized the importance of including all three primary dimensions of personality (i.e., E, N, and P) in analyses of behavioral data. Therefore, we performed an ANOVA that was identical in all respects but one to that which was described above, this exception being the inclusion of P as an additional between-Ss factor. Ss were categorized as either low or high P, using a cutoff point of 3.5.

In addition to the three significant effects involving E and N that were observed in the initial ANOVA, a significant main effect for P was evident, $F(1, 178) = 5.54, P < 0.05$. To clarify the nature of this effect, we present the tracing times for high and low P Ss in each condition (see Table 2). Inspection of these data indicate that high P Ss traced more slowly than did low P Ss.

Finally, we analyzed our data in light of an alternative to our conceptualization of E and N, recently proposed by Larsen and Ketelaar (1990). Like ours, their interpretation involves a synthesis of Eysenck's (1967) personality theory and Gray's neuropsychological model (1975, 1987; Gray & Smith, 1969). Briefly, these researchers identified E with the strength of the BAS and N with the strength of the BIS; thus, E might reflect sensitivity to Rew-CSs and N might reflect sensitivity to Pun-CSs. We reasoned that if this is the case, the tracing speeds of extraverts might be expected to differ from those of introverts in Condition Rw (which entailed Rew-CSs), and the tracing speeds of neurotic Ss might be expected to differ from those of stable Ss in Condition Pn (which entailed Pun-CSs).

To evaluate the degree to which the present data conform to this hypothesis, we performed two additional analyses. The first compared the tracing times of extraverts and introverts in Condition Rw; the second compared the tracing times of neurotic and stable Ss in Condition Pn. For both these comparisons, $t(196) < 1$. Hence, extraverts and introverts did not reliably differ in Condition Rw, and neurotic and stable Ss did not reliably differ in Condition Pn.

Table 2. Mean third tracing times in seconds of low (Lo P) and high (Hi P) scorers on the EPQ Psychoticism Scale in each condition

<table>
<thead>
<tr>
<th>Condition</th>
<th>Rw</th>
<th>G</th>
<th>Pn</th>
</tr>
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<tbody>
<tr>
<td>Group</td>
<td>Lo P</td>
<td>Hi P</td>
<td>Lo P</td>
</tr>
<tr>
<td>Lo P</td>
<td>124</td>
<td>199</td>
<td>199</td>
</tr>
<tr>
<td>Hi P</td>
<td>34</td>
<td>31</td>
<td>30</td>
</tr>
</tbody>
</table>

*Numbers of Ss in each cell.
As predicted in Condition Rw, neurotic extraverts exhibited the fastest tracing speeds, taking significantly less time to trace the third circle than did stable introverts. This outcome is consistent with our present perspective on impulsive behavior (Wallace et al., 1990), which assumes that (1) extraverts will tend to respond to BAS stimulus inputs with greater increments in BAS and NAS activity than will introverts; (2) because neurotic extraverts possess an NAS that is highly reactive to behavioral system activity, this responsivity to BAS inputs will be magnified into even greater increases in NAS activity in these individuals, and (3) given that heightened NAS activity is associated with increased response speed, it is to be expected that neurotic extraverts will tend to respond rapidly—often inappropriately so—in the presence of BAS stimulus inputs such as Rew-CSs.

The results in Condition G also conformed to our predictions. Again, of the four S groups neurotic extraverts traced most rapidly, and these Ss exhibited tracing times that were significantly less than those of stable introverts. We ascribe this faster tracing to the presence of a BAS stimulus input—the labelled hatchmark that served as a salient goal for the tracing response—which we conceive as engendering heightened BAS and NAS activity in extraverts, and especially in neurotic extraverts. Moreover, although the circle templates that were used in the present experiment differed somewhat in size and configuration from those used by Bachorowski and Newman (1990), the data from Condition G are highly similar to those from the goal condition of Bachorowski and Newman's experiment (which also utilized a salient approach stimulus as an input to the BAS).

We note here that, although neurotic extraverts did display faster tracing speeds in Condition Rw than in Condition G, comparison of the tracing times of neurotic extraverts in these two conditions produced a nonsignificant result. Thus, the presence of Rew-CSs in addition to a salient goal stimulus (Condition Rw) did not yield a reliable increment in the tracing speeds of neurotic extraverts over and above that which was evident in the presence of a goal stimulus alone (Condition G).

As discussed previously, the present theoretical formulation emphasizes the importance of considering situational, as well as individual difference, variables when studying impulsive behavior. This point is especially relevant to the results of the Condition Pn analysis. Specifically, although (consistent with our hypothesis) neurotic introverts manifested the fastest tracing speeds of the four groups in Condition Pn, contrary to our prediction their tracing times were not significantly less than those of stable extraverts.

One possible explanation for this non-result involves the fact that Condition Pn explicitly included both BIS and BAS stimulus inputs. BIS inputs were present, in the form of the numbers on the computer monitor, which indicated that the probability of losing the $3 was rather high. As described above, such stimuli are expected to have the greatest impact on the NAS activity levels of neurotic introverts.

On the other hand, two types of BAS stimulus inputs—which should have a greater impact on extraverts than on introverts—also were present in this condition. First, as was the case in the other two conditions of this experiment, the point on the circle at which Ss were to stop tracing was clearly indicated with a hatchmark and the word STOP. As noted above, this labelled hatchmark was sufficient to engender rapid tracing in the Bachorowski and Newman (1990) study, as well as in Condition G of the present experiment. Therefore, extraverts in Condition Pn also might be expected to evidence rapid tracing speeds in response to this BAS input.

Second, it should be recalled that in both Conditions Rw and Pn, prior to Tracing 1 the experimenter placed $3 on the table at which the S was seated, and this money remained there throughout the experiment. It is quite plausible that such a stimulus functions as an input to the BAS, and thus engenders heightened BAS and NAS activity, especially in extraverts.

Therefore, because the Ss designated as the comparison group for the neurotic introverts in this condition were (stable) extraverts, it perhaps is not surprising that they displayed an increment in tracing speed in Condition Pn. It appears at least plausible, then, that the lack of confirmation of our prediction for Condition Pn may not have been due to the failure of neurotic introverts to react as expected to the Pun-CSs, but rather to the response of the stable extraverts to the presence of BAS stimulus inputs in the experimental situation. Some support for the suggestion that neurotic
introverts did, in fact, respond as expected to the Pun-CSs is afforded by the comparison of tracing times of neurotic introverts in Conditions Pn and G: Neurotic introverts tended to trace faster in the presence of Pun-CSs than they did in the absence of these stimuli ($P < 0.06$).

Returning briefly to the results of the planned comparisons in Conditions Rw and G, an alternative hypothesis might be advanced: rather than reflecting heightened NAS activity, the faster tracing speeds of neurotic extravers could be simply a reflection of poorer compliance with the instruction to trace as slowly as possible. That is, if the possibility of negative evaluation by the experimenter is of lesser motivational significance for impulsives than for other Ss, neurotic extravers may have been less likely to comply with the instruction to trace slowly.

The results of the present experiment certainly do not permit refutation of this hypothesis. Nevertheless, we view this explanation as somewhat less than satisfying, at least in part because it does not appear applicable to the inappropriately rapid tracing speeds of neurotic introverts (Bachorowski & Newman, 1990). Rather than being little motivated by the possibility of negative evaluation, one would expect anxious individuals to be more sensitive than other Ss to evaluation anxiety. Hence, such Ss might tend to place a premium on compliance with experimental instructions, and make a concerted effort to trace as slowly as possible.

Furthermore, if the primary determinant of response speed in the present study was the degree of noncompliance with experimental instructions, one would expect neurotic extravers to manifest the most rapid tracing speeds in all three conditions. Again, in accord with our prediction, in Condition Pn neurotic introverts, not neurotic extravers, exhibited the most rapid tracing speeds.

Therefore, although we cannot rule out the possibility that variations in compliance with experimental instructions affected the results of the present experiment, we believe it to be more parsimonious, as well as consistent with past and present observations, to view inappropriately rapid response speeds in both neurotic extravers and neurotic introverts as indicative of heightened NAS activity.

Nevertheless, we do believe that factors other than the level of NAS activity play an important role in the circle tracing paradigm. We conceive, however, that such factors are more relevant to the explanation of the performance of neurotic introverts than do that to neurotic extravers. As alluded to previously, BIS activity engenders not only heightened NAS activity, but also an increased probability of the interruption of ongoing goal-directed behavior. Moreover, whereas increased response speed resulting from heightened BAS and NAS activity is compatible with BAS-mediated approach behavior, BIS-mediated response interruption is incompatible with the translation of increased BIS activity into an inappropriate increase in response speed.

We suggest that requiring Ss to trace continuously is critical to observing inappropriately rapid tracing speeds in the presence of Pun-CSs. As in previous circle tracing experiments, Ss were not allowed to engage in BIS-mediated response interruption; they were not allowed to discontinue the tracing response. As Gray (1987) observes, in the presence of threats of punishment (Pun-CSs), "...the probability of approach behavior goes down, while the vigor of approach behavior, if it nevertheless occurs [italics added], increases" (p. 246). Given the constraint that the tracing response must occur, those in whom Pun-CSs engender the highest levels of NAS activity (i.e. neurotic introverts) will tend to manifest the most rapid response speeds.

Turning briefly to the results of the ANOVAs, we note that the effects involving E and N are consistent with our theoretical perspective, and may be interpreted in light of the present model of impulsive behavior. First, the main effect observed for N, which was due to the tendency of neurotic Ss to trace faster than stable Ss, is in accord with our conceptualization of neuroticism. Examination of Table 1 indicates that this effect was most pronounced in Conditions Rw and Pn. In these conditions, both neurotic extravers and neurotic introverts exhibited faster tracing speeds than did stable extravers and stable introverts.

If, as we propose, N reflects NAS reactivity, then neurotic individuals should tend to manifest a general reactivity to environmental stimuli. In other words, a highly reactive NAS magnifies the reaction to both BAS and BIS stimulus inputs. Therefore, neurotic introverts and neurotic extravers should be more reactive than their stable counterparts to both Rew- and Pun-CSs. Again, the observed main effect for N is in accord with this formulation.

We interpret the significant Tracing x E interaction (which reflected the tendency of introverts to decrease their tracing speeds on successive tracings to a greater extent than did extravers) as
arising from introverts' characteristic stimulus sensitivities. As mentioned previously, the BIS is sensitive not only to Pun–CSs, but also to novel stimulus contexts. Initially, the experimental setting and task quite probably were unfamiliar or novel to most subjects; this unfamiliarity would have been maximal during Tracing 1. However, as the experiment progressed, this aspect of unfamiliarity or novelty naturally would have decreased. In consequence, a decrease in BIS and NAS activity also would have occurred. Because BIS stimulus inputs have a greater impact on introverts than on extraverts, it is to be expected that as the intensity of these stimuli decrease, the BIS and NAS activity (and thus the response speeds) of introverts will decrease more markedly than will those of extraverts.

Parenthetically, it might be mentioned that—following the logic of previous arguments—stimuli that engender BIS activity should have an even greater impact on the NAS activity of neurotic introverts than of stable introverts. In fact, the fastest tracing time observed across all groups, conditions, and tracings was manifested by neurotic introverts in Tracing 1 of Condition Pn (see Table I), when these Ss not only were threatened with monetary loss, but also when the novelty of the situation was maximal.

In contrast to the previously discussed observations, we found it somewhat surprising that, rather than appearing behaviorally impulsive, high P Ss traced slower than did low P Ss. Furthermore, this disparity was especially pronounced in Conditions Rw and Pn (those conditions that entailed monetary contingencies), which could be taken as an indication that high P Ss are less susceptible to incentive manipulations than are their low P counterparts. Low P, however, often is identified with impulse control (Eysenck & Eysenck, 1985); thus, high P Ss might have been expected to manifest inappropriately rapid responding to a greater extent than would low P Ss. Again, the opposite result was obtained in this experiment. At present we have no ready explanation for this intriguing observation.

Finally, we consider the comparison of extraverts and introverts in Condition Rw, and of neurotic and stable Ss in Condition Pn. We had anticipated that if, as Larsen and Ketelaar (1990) proposed, E is associated with the BAS, reflecting sensitivity to Rew–CSs, and N is associated with the BIS, reflecting sensitivity to Pun–CSs, then the tracing times of extraverts and introverts might have been expected to differ in Condition Rw, and the tracing times of neurotic and stable Ss might have been expected to differ in Condition Pn. In fact, the present data provide no support for these hypotheses: no reliable difference was evident either between the tracing times of extraverts and introverts in Condition Rw, or between those of neurotic and stable Ss in Condition Pn.

We recognize that Larsen and Ketelaar's (1990) formulation dealt primarily with the prediction of positive and negative affective responses, not motor speed. Hence, we do not propose that the comparisons reported above necessarily constitute a challenge to their theory. These results are presented solely as indications that Larson and Ketelaar's perspective on E and N does not appear to offer a viable alternative interpretation of the present data.

In conclusion, although the Condition Pn planned comparison provides little support for our conceptualizations of E and N in terms of Gray's three arousal model, this non-result is explicable on a post hoc basis within this framework. Future research into the impulsive behavior of anxious (neurotic introvert) Ss will entail experimental designs that more adequately take into account the propensities of the comparison group (stable extraverts). In particular, it will be necessary to construct situations that entail BIS stimulus inputs, while minimizing the concurrent activation of the BAS.

On the other hand, the results from Conditions Rw and G are consistent with, and provide support for, the present theoretical synthesis. Furthermore, this experiment provides both a replication and an extension of previous observations (Bachorowski & Newman, 1990) regarding the facilitatory effects of BAS stimulus inputs on the response speeds of impulsive (neurotic extravert) Ss.

Finally, the observations reported here highlight the utility of considering situational, as well as individual difference, variables when engaging in the experimental examination of impulsive behavior.

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