Functional Impulsivity and Reinforcement Sensitivity Theory

Luke D. Smillie and Chris J. Jackson
University of Queensland, Australia

ABSTRACT In this article, we attempt to integrate Dickman's (1990) descriptive concept of Functional Impulsivity (FI) with Gray's (1970, 1991) Reinforcement Sensitivity Theory (RST). Specifically, we consider that FI bears great conceptual similarity to Gray's concept of reward-reactivity, which is thought to be caused by the combined effects of a Behavioral Activation System (BAS) and Behavioral Inhibition System (BIS). In our first study, we examine the construct validity and structural correlates of FI. Results indicate that FI is related positively to measures of BAS and Extraversion, negatively to measures of BIS and Neuroticism, and is separate from Psychoticism and typical trait Impulsivity, which Dickman calls *Dysfunctional Impulsivity* (DI). In our second study, we use a go/no-go discrimination task to examine the relationship between FI and response bias under conditions of rewarding and punishing feedback. Results indicate that FI, along with two measures of BAS, predicted the development of a response bias for the rewarded alternative. In comparison, high DI appeared to reflect indifference toward either reward or punishment. We consider how these findings might reconcile the perspectives of Gray and Dickman and help clarify the broader understanding of Impulsivity.

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Luke Smillie and Chris Jackson are at the School of Psychology, The University of Queensland. All correspondence to Luke Smillie, School of Psychology, University of Queensland, Brisbane Q4072, Australia. E-mail: luke@psy.uq.edu.au.

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Impulsivity is widely regarded as having various negative or dysfunctional implications, being associated with rash actions, irresponsibility, a failure to consider the consequences of one's actions, and even as having a key role in criminal behavior (Barratt, 1985; Claes, Vertommen & Braspenning, 2000; Coscina, 1997; Dickman, 1990; Doob, 1990; Eysenck & Gudjonsson, 1989; Levine & Jackson, 2004). For instance, Mathias and Stanford (2003) define Impulsivity as "a tendency towards acting without forethought, making quick cognitive decisions and failing to appreciate circumstances beyond the here-and-now" (p. 355). Similarly, within the broader domains of personality, Impulsivity tends to be aligned with less adaptive traits such as Psychoticism (Eysenck, Barrett, Wilson, & Jackson, 1992; Zuckerman, 1979) or low Conscientiousness (Costa & McCrae, 1992). Considering that there is in fact very little consensus about what actually constitutes Impulsivity (Claes et al., 2000; Miller, Joseph & Tudway, 2004; Parker & Bagby, 1997), it is interesting that the negative view of this trait is so pervasive.

Dickman (1990) directly challenged this traditional view of Impulsivity and developed two scales to measure what he terms Functional Impulsivity (FI) and Dysfunctional Impulsivity (DI). Conceptually, Dickman argued that, while some forms of Impulsivity have negative or *dysfunctional* consequences (e.g., failing to "look before you leap"), other forms have clearly positive or *functional* consequences (e.g., the tendency to "seize the moment"). According to this conceptualization, Dickman suggests that DI reflects the more usual understanding of this trait, capturing reckless or rash behavior with a lack of forethought (e.g., Item 8: *I frequently make appointments without thinking about whether I will be able to keep them*). Conversely, FI is conceptually and statistically distinct from DI (Dickman, 1990, 2000) and concerns rapid responding to situational demands in order to optimize one's circumstances (e.g., Item 15: *I like sports and games in which you have to choose your next move very quickly*). In the broad spaces of personality, FI is most strongly related to Extraversion, while DI is most strongly related to Psychoticism (Chico, 2000; Chico, Tous, Lorenzo-Seva, & Vigil-Colet, 2003). To support the adaptiveness of FI, Dickman demonstrates that high scorers report greater benefits from their behavior than do dysfunctional impulsives (Dickman & Meyer, 1988) and exhibit relatively higher performance on basic cognitive and motor tasks (Dickman, 1990). The important characteristic of FI, which sets it apart from almost all other varieties of Impulsivity, is that the impulsive behavior ultimately serves some positive outcome.

While Dickman's work offers an interesting and potentially useful organizing framework for what has become a complex cluster of Impulsivity traits, the nature and causes of FI, in particular, remain unknown. Not surprisingly, the literature concerning the bases of Impulsivity has been chiefly influenced by the more negative view of this trait and, as such, has only attempted to identify casual substrates relating to maladaptive manifestations of Impulsivity (Coscina, 1997; Dickman, 2000). For example, substantial research has examined the role of dopamine and serotonin as regulators of impulsive behavior. Processes involving serotonin have been linked to aggression (for a review, see Young, Phil, & Ervin, 1988), substance abuse (e.g., Moeller et al., 1994), and antisocial behavior in criminal populations (Dolan & Anderson, 2003). Similarly, dopamine processes have been implicated in a number of theoretical frameworks as a basis for Impulsivity, typically in relation to substance abuse (e.g., Peterson, Wolf, & White, 2003), disorders of disinhibition such as Attention Deficit/Hyperactivity Disorder (ADHD; e.g., Davids, Zhang, Tarazi, & Baldessarini, 2003), and antisocial behavior (Goldman & Fishbein, 2000). However, as has been noted elsewhere (Coscina, 1997), none of this research to date seems to indicate a basis for more functional aspects of Impulsivity.

Recently, Dickman (2000) compared four arousal hypotheses of Impulsivity and found reasonable support for his "attentional-fixity" theory (Dickman, 1993). This posits that Impulsivity is associated with an inability to attend to key features of a decision-making situation, thus explaining the tendency for highly impulsive individuals to act with little forethought. This hypothesis is not dissimilar from other cognitive explanations of Impulsivity (and psychopathy, e.g., Abramowitz, Kosson, & Seidenberg, 2004), and, like all four theories examined by Dickman, was implicitly related only to typical (i.e., dysfunctional) Impulsivity. However, Dickman (2000) noted a modest correlation between FI and measures of energetic arousal and speculated that this may improve the ability of functional impulsives to attend more effectively to the decision-making properties of the task at hand. An alternative interpretation of this data, however, is that FI is related to motivation and emotion processes. As has been noted elsewhere (e.g., Revelle, 1993), Thayer's (1978, 1989) concept of "energetic arousal" is closely linked with positive affect (e.g., Watson & Tellegen, 1985) and behavioral approach (Fowles, 1980; Gray, 1987a). If Dickman's observation was reliable, therefore, it could indicate that FI has some similarity to traits that have been related to positive incentive motivation (e.g., as reviewed by Depue & Collins, 1999).

Functional Impulsivity and Behavioral Activation

Jeffrey Gray's (1970, 1981, 1987a) Reinforcement Sensitivity Theory (RST) is arguably the most influential motivation-based theory of personality. Furthermore, other than Dickman's concept of FI, RST is one of the few personality models that does not demand a strictly negative view of Impulsivity. Gray suggested that Impulsivity is caused by reward motivation, regulated by the Behavioral Activation System (BAS; Fowles, 1980). While, originally, it was thought that the BAS was responsive only to conditioned stimuli (Gray, 1987b), the scope of this system has now been broadened (Gray & McNaughton, 2000), such that the BAS is responsive to all positively valenced stimuli (presentation of reward or termination/omission of punishment). Activation of the BAS by reward is thought to produce an output to the motor cortex and an increase in arousal, enabling the individual to approach the source of reward. BAS-Impulsive individuals are thought to be more reactive to and more strongly motivated by positive incentive stimuli, such that they are disposed toward approaching situations likely to bring reward (and/or relief from punishment). Gray's perspective on Impulsivity has some similarity with mainstream views, such as the involvement of dopaminergic processes (Pickering & Gray, 2001) and the suggestion that Impulsivity has links with psychopathology (Gray, Feldon, Rawlins, Hemsley, & Smith, 1991). However, the concept of reward-reactivity is clearly distinct from more common conceptualizations of Impulsivity. In fact, while the typical view of Impulsivity emphasizes a failure to consider the outcomes of one's actions, the RST view emphasizes the specific direction of behavior towards certain outcomes, namely, rewarding or positive stimuli. In this sense, BAS-mediated Impulsivity is conceptually quite similar to Dickman's notion of FI.

It is pertinent to the subject of this article to note that the kind of Impulsivity related to reactivity of the BAS has never been entirely clear (Diaz & Pickering, 1993; Pickering & Gray, 2001). This is to be expected given the considerable heterogeneity among common definitions of this trait in the literature. In addition, Impulsivity was specified as a potential manifestation of BAS reactivity, but initial research concerning the BAS did not serve the exclusive purpose of deriving an explanation of trait Impulsivity (Gray, Owen, Davis & Tsaltas, 1983). Rather, the BAS was linked to Impulsivity in an ad hoc manner (Diaz & Pickering, 1993), and many have suggested that "Impulsivity" as referred to by Gray (1981) is not the same trait referred to more generally by that name (e.g., Dawe & Loxton, 2004; Depue & Collins, 1999; Quilty & Oakman, 2004; Smillie & Jackson, 2005; Zelenski & Larsen, 1999). Therefore, just as FI lacks a theoretical basis, the motivational processes comprising RST are not clearly delineated at the trait level (Jackson, 2002, 2003). The conceptual similarity and potential theoretical convergence of the views of Gray and Dickman is therefore very interesting.

Functional Impulsivity and Behavioral Inhibition

In addition to the BAS, the other central component of RST is the Behavioral Inhibition System (BIS), which is understood to provide the causal basis of Anxiety. Initially, the BIS was thought to be engaged by conditioned signals of punishment, resulting in the interruption of ongoing behavior and simultaneous direction of attention and arousal toward the potential threat. According to recent revisions of the model (Gray & McNaughton, 2000), it is now specifically seen as being responsive to conflicting goals.[1] An example of such conflict might include the simultaneous goals to approach and avoid an appetitive stimulus previously associated with punishment, such as food paired with electric shock in a classic animal learning experiment. This stimulus would be expected to trigger behavioral inhibition, enabling the animal to assess the situation further and resolve the source of conflict (e.g., either continuing to approach the stimulus or avoiding it altogether). In personality terms, it is posited that BIS-reactive individuals are higher in trait Anxiety and will

1. It is important not to confuse Gray and McNaughton's (2000) use of the word "goal" with the typical cognitive conceptualisation of this term within various domains of psychology (e.g., "goal setting," "goal orientation"). Gray and McNaughton define a "goal" as the conflation of a stimulus and a behavioral response (p. 23).

therefore react more readily to potential sources of conflict, thus disposing them towards cautious behavior and risk assessment.

Interestingly, FI appears to have some conceptual similarity to BIS functioning as well as to the BAS. A critical feature of FI concerns rapid responding to "situational demands" in order to optimize ones' circumstances (Claes et al., 2000; Dickman, 1990). An example of a situational demand is "a car suddenly braking on a crowded freeway" (Claes et al., 2000, p. 28), which may require immediate action by the driver of the following car. Of importance here is the potential for either action or inaction to produce a better or worse result, and, to this extent, the term "situational demands" appears very similar to Gray and McNaughton's concept of goal conflict. In RST, it is the BIS that responds to conflict by *inaction,* thus enabling further assessment of the situation. FI on the other hand seems to concern *rapid action* to seize a window of opportunity. To borrow Claes and colleagues' example of a car suddenly braking on a crowded freeway, this conflict may trigger behavioral inhibition in a BIS-reactive (highly anxious) individual traveling in the car behind, with the result that he or she might not respond in time to avoid a collision. In contrast, a prototypical functionally impulsive individual might not be expected to experience behavioral inhibition, but rather to act spontaneously (e.g., by swerving) in order to avoid a crash. In other words, the opportunistic nature of the functional impulsive suggests that such individuals will be disposed toward less behavioral inhibition. This being the case, FI might be expected to negatively correlate with measures of BIS, in addition to the positive association we have suggested it may have with measures of BAS.

Now, at this point, we should note that the BIS and BAS are thought to be physiologically independent, and, as such, their manifestations, namely, Anxiety and Impulsivity, have been traditionally viewed as orthogonal constructs (Gray, 1981, 1987a; Gray et al., 1983). Therefore, it might be argued from the RST perspective that if FI is related to both the BIS and BAS, then it is a confounded measure. Nevertheless, while the BIS and BAS are thought to be physically independent, their neural and motor output is unlikely to be orthogonal. In fact, Gray and Smith (1969) proposed mutual inhibitory pathways between the BIS and BAS, such that the functioning of one system would attenuate the output of the other. From this, some have proposed (Corr, 2001, 2002; Pickering, 1997) that the BIS and BAS will combine to influence behavior. Specifically, reward-reactivity will be relatively stronger in BAS reactive individuals, but strongest in BAS+/BIS- individuals. Corr (2004) reviews evidence for this "Joint Subsystems Hypothesis," whereby reward-reactivity is related to measures of BAS (positively) and BIS (negatively). Based upon the conceptual similarity of FI to both BIS (+) and BAS (−) processes, it might be suggested that FI reflects Gray's notion of reward-reactivity and could therefore have an underlying basis in the structures of RST. This is a novel suggestion, which the present research will endeavor to evaluate.

To summarize, we suggest that Dickman's (1990) thesis of Impulsivity may offer a useful means to distinguish between two fundamental variations of this trait. Unfortunately, FI, in particular, is in need of further construct validation and theoretical explanation. Based upon the conceptual overlap, we identify between FI and the motivational processes with which RST is concerned and we theorize that FI may represent (or be highly similar to) Gray's notion of reward-reactivity. As such, we hypothesize that FI will be related to measures of BAS (+) and BIS (−) and should also predict behavioral reactions to reward. In Study 1, we investigate bivariate and structural relationships of FI and DI with specific measures of RST and broader scales of personality. In Study 2, we use a go/no-go task to examine the ability of FI and DI, along with purpose-built measures of BAS, to predict response bias during a decision-making task employing schedules of rewarding or punishing feedback. This research aims to clarify both the conceptual and substantive nature of FI and may also help to clarify the kind of Impulsivity to which RST is relevant.

STUDY 1

To date, surprisingly few studies have examined the construct validity of FI and DI or the location of Dickman's dimensions within the factor spaces of personality. Basic correlational studies suggest that FI is most strongly related to Extraversion, while DI appears most strongly related to Psychoticism (Chico, 2000; Chico et al., 2003). This supports the conceptualization of DI as representative of typical trait Impulsivity, which tends to be viewed as a component of Psychoticism (Eysenck et al., 1992). It is also consistent with our suggestion that FI has some similarity with the BAS, which Gray positioned at a 30° rotation from Extraversion (Pickering, Corr, & Gray, 1999) and which is often measured using Extraversion (e.g., Gupta, 1990; Pickering, 2004). Nevertheless, very little research has examined correlates of FI using specific measures of RST. In a comparative psychometric study, Jackson and Smillie (2004) investigated relationships among a number of Impulsivity and BAS scales, including the Dickman Impulsivity Inventory (DII; Dickman, 1990). FI was strongly related to BAS measures but also negatively related to BIS measures. Somewhat similar findings were observed by Gomez, Cooper, McOrmond, and Tatlow (2004), whereby FI was associated positively with the processing of pleasant stimuli (putatively BAS-mediated) but negatively with processing of unpleasant stimuli (putatively BIS-mediated). These findings suggest that there may indeed be some overlap between FI and reward-reactivity (BAS+/ BIS−).

Our first study seeks to build upon the dearth of research into the construct validity and factor structure of FI and DI. Our specific focus will be to examine the overlap of FI with measures of RST and the extent to which it can be considered independent from typical Impulsivity (e.g., DI). We predict that (1) FI will relate positively to measures of BAS and negatively to measures of BIS; and (2) DI will be related to Psychoticism and other trait Impulsivity measures, but will have a less clear relationship with measures of RST. Although these predictions derive from our theoretical position that FI may have a causal basis in RST, a direction of causality is not tested because all measures were taken concurrently.

Method

Participants

A total of 299 undergraduate psychology students, enrolled at the University of Queensland, participated in Study 1. Some completed questionnaires as part of their practical assessment in a psychology course, while others were recruited via a first-year psychology research participation pool. As questionnaires were administered over a period of weeks, sample size varied between scales due to differing attendance, and not all participants completed all scales. The results section indicates sample size resulting from pair-wise deletion of cases, giving well over 100 data points for most analyses conducted. The mean age of the sample was 23.1 years ($SD = 3.16$), and 65% were female.

Questionnaires

Functional and dysfunctional Impulsivity. All participants completed the Dickman Impulsivity Inventory (DII: Dickman, 1990) using a 6-point scale (1 = *completely disagree*, 6 = *completely agree*). While this measure is typically responded to using a True/False format, we had wanted to maximize variance for the purpose of this exploratory study. The FI scale consisted of 11 items concerning opportunistic or directed impulsive behavior (e.g., Item 4: "I would enjoy working at a job that required me to make a lot of split-second decisions"). The DI scale consisted of 12 items concerning reckless or undirected impulsive behavior (e.g., Item 2: "I often get into trouble because I don't think before I act"). Both scales have been found to have adequate internal consistency (alphas $>.80$ are typically reported, e.g., Chico et al., 2003).

Most participants also completed all or some of the following personality questionnaires:

RST measures. The Appetitive Motivation scale (Jackson & Smillie, 2004) is a recently developed 20-item measure of BAS/reward-reactivity. Psychometric and experimental investigation suggests that the measure has good general psychometric properties (Jackson & Smillie, 2004) and predicts behavioral reactions to reward (Smillie & Jackson, 2005). The Sensitivity to Reward and Punishment Questionnaire (SPSRQ; Torrubia, Avila, Molto, & Caseras, 2001) consists of 25 items to index Sensitivity to Reward (BAS) and 25 items to index Sensitivity to Punishment (BIS), and shows good reliability and validity (e.g., Avila, 2001). The BIS/BAS Scales (Carver & White, 1994) is a widely used RST questionnaire, consisting of one 7-item BIS scale (CWBIS) and three 4- to 5-item BAS scales. Due to the low ($<.70$) alphas that are commonly observed for some of the CWBAS scales (e.g., Smillie & Jackson, 2005), we use the sum total of the three scales as is common practice. (In no analysis did this result in a substantive change of interpretation as, overall, the three scales did not diverge in their prediction of relevant criteria.) The Gray-Wilson Personality Questionnaire (GWPQ; Wilson, Gray, & Barrett, 1990) is the earliest purpose-built measure of RST, consisting of six 20-item scales to assess BIS (passive avoidance and extinction), BAS (approach and active avoidance), and Fight/Flight (fight and flight). The GWPQ has consistently poor psychometric properties (Jackson, 2002, 2003), but it continues to hold great theoretical interest due to the fact that the items are direct human analogues of the animal behavior upon which RST was first based.

Three- and five-factor personality measures. The Eysenck Personality Questionnaire Revised (EPQ-R: Eysenck & Eysenck, 1991) is a widely used, broad-focus measure of personality, considered to provide the benchmark measures of Extraversion, Neuroticism, and Psychoticism. It is also of particular relevance to the present study due to the fact that Extraversion is a common proxy measure of the BAS and Neuroticism is a common proxy measure of the BIS (e.g., Gupta, 1990; Pickering, 2004). The Eysenck Personality Profiler (EPP; Eysenck et al., 1992) is a less commonly used measure of Eysenck's model and divides each factor into seven narrow-focus scales, each consisting of 20 items. The NEO-FFS (Costa & McCrae, 1992), and the Big Five Inventory (John, Donahue, & Kentle, 1991) are two widely used inventories for assessing the five factors of Extraversion, Neuroticism, Conscientiousness, Agreeableness, and Openness.

Statistical Analyses

Our first strategy was to identify scales from the questionnaires that correlated significantly with either FI or DI. These correlation patterns were used to identify the overlap in content between Dickman's scales and other personality dimensions. We then used Exploratory Factor Analysis (via Principal Components Analysis) to investigate the alignment of FI and DI within the factor spaces of personality. It was expected that FI would be aligned between BIS (low scores on purpose-built BIS measures and EPQ Neuroticism) and BAS (high scores on purpose-built BAS measures and EPQ Extraversion), while DI would be aligned with typical Impulsivity (high scores on trait Impulsivity measures and EPQ Psychoticism).

Results and Discussion

Preliminary Analyses

Cronbach's alpha, means, and standard deviations are shown for all scales in Table 1, and correlations between Dickman's scales and the other personality scales are shown in Table 2. FI shows high internal consistency (alpha = .85) and was not correlated with DI, $r = .06$, *ns*.

Correlations With Functional Impulsivity

Consistent with our predictions and the findings of Jackson and Smillie (2004), FI correlated with many indices of Gray's BAS. Significant loadings included Appetitive Motivation; Sensitivity to Reward; EPP Impulsiveness; CWBAS; plus EPQ, EPP, and NEO Extraversion. Relationships were also observed with measures that

Table 1
Means, Standard Deviations, and Alphas for Personality Scales

	N	alpha	Mean	*SD*
(a) Dickman's Impulsivity Inventory				
DII Functional	299	.85	41.29	8.13
DII Dysfunctional	299	.83	35.64	10.21
(b) RST Measures				
CWBAS	256	.77	39.67	4.71
CWBIS	256	.82	20.86	3.87
Appetitive Motivation Scale	273	.74	14.61	3.24
Sensitivity to Reward	104	.82	11.08	3.23
Sensitivity to Punishment	104	.73	11.55	4.99
GWPQ Approach	201	.63	18.48	6.06
GWPQ Active Avoidance	202	.45	22.39	5.63
GWPQ Passive Avoidance	187	.64	19.06	5.90
GWPQ Extinction	193	.64	20.55	5.61
GWPQ Fight	197	.76	16.96	6.50
GWPQ Flight	189	.76	18.33	7.79
(c) High bandwidth personality				
EPQ Psychoticism	202	.69	6.59	3.95
EPQ Extraversion	201	.82	15.57	4.69
EPQ Neuroticism	201	.85	14.34	5.83
EPP Psychoticism	127		126.94	29.33
EPP Extraversion	127		131.32	30.61
EPP Neuroticism	127		70.74	33.69
NEO Openness	111	.78	32.31	7.71
NEO Conscientiousness	57	.83	31.65	8.11
NEO Extraversion	119	.86	33.38	7.12
NEO Agreeableness	113	.83	31.35	5.34
NEO Neuroticism	109	.88	24.56	10.53
BFI Openness	175	.78	33.03	6.32
BFI Conscientiousness	175	.81	30.39	5.46
BFI Extraversion	175	.86	27.57	6.49
BFI Agreeableness	174	.77	31.91	5.92
BFI Neuroticism	173	.87	23.39	6.85
(d) Low bandwidth personality (EPP subscales)				
Extraversion				
EPP Activity	127		20.22	8.20
EPP Sociability	127		23.24	9.37
EPP Expressiveness	127		17.99	6.01

(*Continued*)

Table 1
(Continued)

	N	alpha	Mean	*SD*
EPP Assertiveness	127		19.37	7.18
EPP Ambition	126		19.73	7.16
EPP Dogmatic	127		14.90	4.75
EPP Aggression	127		14.07	5.70
Neuroticism				
EPP Low self-esteem	127		15.08	9.82
EPP Unhappiness	126		10.44	8.87
EPP Anxiety	127		15.82	8.46
EPP Dependence	127		7.46	5.55
EPP Hypochondria	127		4.51	4.25
EPP Guilt	126		8.04	5.69
EPP Obsessiveness	127		11.72	6.31
Psychoticism				
EPP Risk taking	126		18.75	7.44
EPP Impulsiveness	127		17.66	8.61
EPP Irresponsibility	126		20.88	6.52
EPP Manipulativeness	127		15.48	5.88
EPP Sensation seeking	201		20.57	7.66
EPP Tough mindedness	127		15.23	7.03
EPP Practical	127		16.40	8.24

*Alpha coefficients were not computed for EPP scales as only total scores were computed during data collection.

Note: DII = Dickman Impulsivity Inventory (Dickman, 1990); CWBIS and CWBAS are described by Carver & White (1994); GWPQ = Gray-Wilson Personality Questionnaire (Wilson et al., 1990); the Appetitive Motivation scale is described in Jackson & Smillie (2004); EPQ = Eysenck Personality Questionnaire Revised (EPQ-R: Eysenck & Eysenck, 1991); EPP = Eysenck Personality Profiler (Eysenck & Wilson, 1992); Sensitivity to Reward and Punishment scales are from the Sensitivity to Reward and Punishment Questionnaire (SPSRQ: Torrubia et al., 2001); NEO = NEO-FFS (NEO-FFS: Costa & McCrae, 1992); BFI = Big Five Inventory (John et al., 1991).

could be expected to associate with BAS activity (e.g., EPP primary scales of Extraversion including Assertiveness, Ambition, Expressiveness, Activity, and Sociability). These patterns are consistent with the notion that FI has some similarity with Gray's (1987a) conceptualization of the BAS. Also consistent with our hypothesis were a number of strong inverse correlations between FI and various benchmark measures of BIS. Specifically, significant (negative)

Table 2
Correlations Between Dickman's Scales of Impulsivity and Other Personality Questionnaires

	Functional	Dysfunctional	*N*
(a) Significant correlations with Functional Impulsivity			
CWBIS	– .47**	.06	104
Sensitivity to punishment	– .43**	– .17	104
EPP Assertiveness	.43**	.22	81
EPP Dependence	– .43**	– .09	81
Appetitive Motivation	.43**	.14	145
EPP Low self-esteem	– .42**	– .17	81
EPP Anxiety	– .41**	– .04	81
BFI Neuroticism	– .41**	.01	148
NEO Extraversion	.39**	.08	81
NEO Neuroticism	– .37**	– .13	104
GWPQ Passive Avoidance	– .37	– .01	163
EPQ Neuroticism	– .36**	.07	169
EPP Ambition	.34**	– .07	80
EPP Neuroticism	– .32**	– .15	104
EPP Sociability	.28*	.22	81
EPP Guilt	– .25*	– .12	80
GWPQ Extinction	– .24**	– .02	164
GWPQ Flight	– .23**	.05	161
(b) Significant correlations with both types of Impulsivity			
EPQ Extraversion	.49**	.29**	168
EPP Extraversion	.48**	.25*	105
BFI Extraversion	.45**	.37*	151
EPP Unhappiness	– .44**	– .26*	80
EPP Activity	.40**	.28*	81
EPP Impulsiveness	.34**	.59**	81
EPP Expressiveness	.34**	.40**	81
CWBAS	.31**	.23*	104
Sensitivity to reward	.25*	.35**	104
EPP Risk taking	.24*	.35**	80
GWPQ Active Avoidance	– .15*	– .16*	172
(c) Significant correlations with Dysfunctional Impulsivity			
EPP Psychoticism	.13	.47**	104
BFI Conscientiousness	.03	– .47**	150

(*Continued*)

Table 2
(Continued)

	Functional	Dysfunctional	*N*
EPP Irresponsibility	.20	.44**	81
EPQ Psychoticism	.16	.43**	169
NEO Conscientiousness	– .08	– .36*	44
NEO Agreeableness	– .16	– .30**	83
EPP Obsessiveness	– .15	– .38**	81
EPP Sensation Seeking	.18	.24*	104
GWPQ Approach	.07	.22**	175

*$p < .05$. **$p < .01$.
Note: Only scales significantly correlated with at least one of Dickman's scales are represented.

loadings included GWPQ passive avoidance and extinction; EPP Anxiety; Sensitivity to Punishment; CWBIS; plus the Neuroticism scales of EPP, EPQ, and the NEO. Moreover, similar relationships were observed with BIS related measures (e.g., EPP primary scales of Unhappiness, Dependence, and Low Self-Esteem). Therefore, FI also has some descriptive similarity with Gray's notion of BIS.

Correlations With Dysfunctional Impulsivity

Correlations generally support Dickman's (1990, 2000) claim that DI reflects typical trait Impulsivity and findings by Chico et al. (2003) that this scale is aligned with Psychoticism. Significant correlations included EPQ and EPP Psychoticism; EPP Sensation Seeking; and both (low) Conscientiousness and (low) Agreeableness from the NEO and Big Five inventories. DI was not associated with any measures of BIS but was significantly correlated with a number of BAS measures (although these tended to be weaker than those between FI and measures of BAS).

Factor Analysis

A factor analysis (via Principal Components Analysis) with varimax rotation was conducted to determine the alignment of FI and DI within orthogonal factor spaces formed from measures of BAS (and Extraversion), BIS (and Neuroticism) and trait Impulsivity (and Psychoticism). Specific scales selected from our battery of measures were DII Functional and Dysfunctional Impulsivity; EPQ Extraversion, Neuroticism, and Psychoticism; SPSRQ Sensitivity to Reward and Sensitivity to Punishment; Appetitive Motivation; CWBIS and CWBAS; and EPP Sensation Seeking (whose definition in the EPP manual is very similar to the notion of typical Impulsivity we have considered in this article). Recalling that not all of our 299 participants completed all measures, listwise deletion resulted in a total of 104 participants who completed all 11 scales (52% female).

The first three components extracted had eigenvalues greater than 1 (3.32, 2.60, 1.30), and together accounted for 65.3% of the total variance. It can be seen from the rotated component matrix presented in Table 3 that the three factors clearly resemble the broad dimensions we had expected. The first factor consists of CWBIS, EPQ Neuroticism, Sensitivity to Punishment, and FI (−) and yields an (unweighted) internal consistency of .80. As indicated by our suggested labels, this factor seems to capture the conceptual dimension of the BIS. The second factor consists of CWBAS, Appetitive Motivation, EPQ Extraversion, FI, and Sensitivity to Reward and yields an (unweighted) internal consistency of .77. It seems likely that the conceptual communality among these scales is synonymous with the BAS. The third factor is composed of EPQ Psychoticism, EPP Sensation Seeking, DI, and Sensitivity to Reward. This factor might reflect typical Impulsivity or some key facet of Psychoticism, and, for this reason, it is unexpected that Sensitivity to Reward was also an important loading variable.[2] The lower (unweighted) internal consistency of this factor (.66) indicates that it is less homogenous, perhaps reflecting the multifaceted and unclear nature of both trait Impulsivity and Psychoticism (Eysenck et al., 1992).

These findings contribute significantly toward the clarification of Impulsivity. First, results provide some support for our hypotheses concerning the structure of FI and DI and the possible bases we have suggested for FI in particular. If factors 1 and 2 from our Principal

2. Note that results of recent factor analytic investigations using the Sensitivity to Reward scale tend to be similar to ours in this respect (Caseras, Avila, & Torrubia, 2003). A possible explanation for this relates to the scale's heterogeneous content, perhaps making it a sufficiently broad-focus measure to encompass both BAS/Reward Responsiveness and Impulsivity/Sensation-Seeking (Torrubia, personal communication).

Table 3
Rotated Factor Loadings From Factor Analysis (via PCA) With Suggested Factor Labels

	Factor		
	I (BIS/N)	II (BAS/E)	III (IMP/P)
Alpha	.80	.77	.66
CWBIS	**.86**	– .03	– .06
EPQ Neuroticism	**.86**	.02	.10
Sensitivity to Punishment	**.83**	– .14	.07
CWBAS	.07	**.84**	.07
Appetitive Motivation	– .06	**.81**	.12
EPQ Extraversion	– .25	**.67**	.29
DII Functional	– **.52**	**.57**	.07
Sensitivity to Reward	.29	**.53**	**.50**
EPQ Psychoticism	– .07	– .10	**.87**
EPP Sensation Seeking	– .13	.32	**.66**
DII Dysfunctional	.17	.18	**.58**

Note: Factor loadings greater than .50 are in **bold** (N = 104).

Components Analysis can be thought of as representing the BIS and BAS respectively, then FI is indeed related to or subsumed within both. This supports findings by Jackson and Smillie (2004) and Gomez et al. (2004), where FI was not only associated with BAS measures but also negatively so with BIS measures. According to our theoretical rationale, this is because FI captures what Gray refers to as reward-reactivity, and as such it may have a causal basis in the BIS and BAS. As advocated by Dickman, it seems that DI is largely separate from FI and related to the more typical conceptualizations of Impulsivity, including Psychoticism. Furthermore, it is interesting to note that no measures of BAS (with the exception of Sensitivity to Reward) were related to the Impulsivity/Psychoticism factor. This supports the increasingly firm boundary that has been drawn between Impulsivity as typically defined and Impulsivity as initially referred to by Gray as a possible manifestation of reward-reactivity (cf. Pickering & Gray, 2001). We are therefore inclined to agree with others (e.g., Depue & Collins, 1999; Pickering, 2004; Zelenski & Larsen, 1999) who have argued for a distinction between reward-reactivity and trait Impulsivity and consider that Dickman's notion of FI and DI may capture this distinction. Further attention to this issue, and its possible implications for Impulsivity research, is given in the general discussion.

STUDY 2

Study 1 provides a broad examination of the relationships between Dickman's (1990) Impulsivity scales and other measures of personality and is the first dedicated attempt to assess the convergence between the personality frameworks provided by Dickman and Gray. While our results indicate that there is some descriptive similarity between FI and reward-reactivity, they do not necessarily imply that FI has a theoretical explanation in the BIS and BAS motivational systems. This is because relationships among psychometric measures are insufficient means to indicate processes at deeper (i.e., biobehavioral) levels of analysis. Clearer support for our hypothesis that FI is a trait manifestation of reward-reactivity requires, at a minimum, experimental demonstration of FI as a predictor of reactions to experimentally manipulated reward. For our second study, therefore, we compare FI with purpose-built RST measures in the prediction of behavioral reactions to reward.

The difficulties in providing an adequate test of predictions from RST are well known (Corr, 2001, 2004; Pickering et al., 1997; Pickering & Gray, 2001). Reward-reactivity relates directly to motivation in the sense that rewarding events encourage preceding behavior. Therefore, some paramorphic quantification of the extent to which behavior is encouraged is needed for operationalizing reward-reactivity. A means to derive such quantification is provided by Signal Detection Theory (SDT; Macmillan & Creelman, 1991; Swets, Tanner, & Birdsall, 1961). In two-alternative, forced-choice, decision-making tasks, SDT analysis enables calculation of two separable aspects of performance; discrimination ability (d') and response bias (β). Discrimination ability conveys information regarding decision accuracy, whereas response bias indicates the choice preference of the decision maker (e.g., a person's propensity to respond "yes" vs. "no"), this latter measure being motivationally based (Macmillan & Creelman, 1991; McNicol, 1972). From RST, the prediction could be made that an individual who is highly reactive to reward will develop a response bias in favor of the more rewarded response alternative, as indicated by lower values of β. While SDT analysis has to date been underutilized in RST research, conceptually similar measures have been successfully used in its place. Examples include measurement of response latency and/or false-alarm rates (responses to non-target stimuli) using go/no-go tasks, disinhibition paradigms, and rapid visual information processing tasks (Avilla & Parcet, 2001; Corr, 2002; Gomez & McLaren, 1997).

A further challenge to research in personality and reinforcement learning is devising appropriate reinforcement stimuli (Corr, 2001; Matthews & Gilliland, 1999), especially in the case of reward (Gupta, 1990). The first problem concerns identifying a reward that is perceived similarly from one individual to another because a person may be highly motivated by rewards (in general) but not perceive a given stimulus (in particular) to be rewarding (Corr, 2001, Gray, 1987b). The second problem then occurs if the effects of a given reward (e.g., money) are to be compared with those of a punishment (e.g., electrical stimulation) under the tenuous assumption that they are of similar intensity. Like many others faced with these problems, we consider that a reasonable solution is to use basic social reinforcement or feedback as rewarding and punishing stimuli. Much research in the RST literature has adopted this method with some success, not least the Gupta group (e.g., see Gupta, 1990, for a review). Furthermore, Pickering (2004) reports that feedback alone appears to be at least as reinforcing as monetary rewards. Accordingly, we use confirmatory ("correct") and disconfirmatory ("incorrect") feedback as reward and punishment.

For this experiment, we employed a go/no-go discrimination task, which is a two-alternative, forced-choice task appropriate for SDT analysis. If FI is a measure of Gray's concept of reward-reactivity and corresponds to joint BIS/BAS motivational influences, then it should predict the development of a preference for a rewarded response. This is because reactions to reward are thought to be mediated by the BAS but manifest most strongly in BAS+/BIS- individuals (Corr, 2002, 2004). Furthermore, we expect FI to predict (in the rewarded group) a shift in response bias over blocks because the systems of RST are fundamentally concerned with learning (as it is the subject's *reaction* to the reinforcing stimulus that is important; Pickering & Gray, 2001). Although the BIS is now thought to be activated by conflict rather than punishment (Gray & McNaughton, 2000), we consider that negative feedback is likely to create some conflict to the extent that it flags a mismatch between response and outcome (as suggested by Corr, 2002). Study 1 indicates that FI has a clear descriptive relationship with psychometric measures of BIS, but our theoretical position views FI as more directly relevant to appetitive motivation than to aversive motivation. Accordingly, we predict that FI will associate with other measures of BAS and predict behavioral reactions to reward rather than punishment. Finally, based upon the findings of Study 1, we expect that DI will not be a good predictor of BAS- or BIS-mediated behavior. This is because it is more strongly related to trait Impulsivity, which is not clearly accommodated by the RST view. Instead, as trait Impulsivity is thought to reflect rash responding and lack of forethought, DI should predict failure to reliably approach reward or avoid punishment/conflict. These predictions will be clarified in the context of our task description in the following section.

Method

Participants and Questionnaires

A total of 122 undergraduate psychology students, enrolled at the University of Queensland, participated in this study in exchange for course credit (mean age = 20.36; *SD* = 4.65; 63% female). Participants completed the Dickman Impulsivity Inventory (DII), the Appetitive Motivation scale (AM), and the CWBAS scale of Carver and White (1994), which have all been described in Study 1. Data for eight participants were discarded due to equipment failure, and a further six were excluded from main analyses due to atypical response patterns resulting in the inability to calculate parameters of SDT (final *N* = 108).

Experimental Task

After completing the questionnaires, participants were seated in individual booths to begin the computer task. The go/no-go task was based upon that used by Gomez and McLaren (1997), which, in turn, was based directly upon the task used by Newman and Kosson, (1986). The task consisted of 24 practice trials with full and balanced feedback followed by three blocks of 32 experimental trials (total = 96)[3] with either rewarding

3. Gomez and McLaren (1997) divided their task into eight blocks of 12 trials. However, as we intended to calculate SDT parameters, it was necessary to include sufficient trials per block to ensure reliable estimates of response bias (Macmillan & Creelman, 1991).

or punishing feedback provided (described below). For each trial, one of 12 two-digit numbers was presented. Six of these were "good" numbers, and six were "bad" numbers. (For the practice block there were only four good/bad numbers in total.) Participants were instructed to respond to good numbers (by pressing the button on a single button button-box) and to ignore bad numbers (i.e., by giving no response). Participants were further instructed that they would have to learn by trial and error in order to discriminate between the good and bad numbers and that they should rely on the feedback provided to assist them in doing so.

Reinforcement Manipulations

During the experimental trials, two schedules of partial feedback were used to manipulate the conditions of reinforcement. Feedback, when it was presented, appeared in 12-point font in the center of the computer screen following each trial. The reward schedule consisted of mostly confirmatory feedback ("That was a correct decision") for making a "go" response, such that $p(\text{feedback}|\text{correct go}) = .80$ and $p(\text{feedback}|\text{incorrect go}) = .25$. The punishment schedule consisted of mostly disconfirmatory feedback ("That was an incorrect decision") for making the same response such that $p(\text{feedback}|\text{correct go}) = .25$ and $p(\text{feedback}|\text{incorrect go}) = .80$. (A fixed expected probability of .10 was chosen for all no-go responses to ensure minimal reward or punishment for this choice alternative.) Feedback manipulations using this probability matrix have been demonstrated to have rewarding and punishing effects on participants, as indicated by self-report ratings (Dalgliesh & Smillie, in press). In this study, approximately half of the participants were randomly assigned to receive the schedule that rewarded "go" responses (final $N = 52$), while the other half were assigned to receive the schedule that punished "go" responses (final $N = 56$).

Statistical Analyses

Formulae for the parameters of SDT are widely available (e.g., Stanislaw & Todorov, 1999), and we used the natural logarithm of beta, $\ln(\beta)$. This distributes values symmetrically around zero, rather than asymmetrically around 1, thus providing an index that is more interpretable and more appropriate for parametric data analyses (McNicol, 1972).

To test the hypothesis that FI (and measures of BAS) would predict behavioral reactions to reward, it was necessary to show that FI interacted with group (reward/punishment) in the prediction of $\ln(\beta)$ and that this conditional relationship developed over the course of the three experimental blocks (thus demonstrating that learning, in the form of a shift in response bias, had taken place). To do so, we utilize the repeated measures GLM procedure in SPSS, where group is the between-subjects variable, experimental block is the within subjects variable, and trait (e.g., FI) is a continuous variable included in the full factorial design. This will enable us to test all main effects, 2-way interactions, and 3-way interactions that could emerge among trait, block, and group. Of most interest will be the linear trend for the 3-way trait × group × block interaction. This effect is identical to that tested via a Moderated Multiple Regression (MMR; Aiken & West, 1991; Cohen, Cohen, Aiken, & West, 2003), where the interaction between group and trait is computed by the cross-product of these variables, and specified as a predictor of $T_{\ln(\beta)}$ – the linear trend in ln(β) over experimental blocks. As such, it can be followed up via conventional "simple slopes" analysis (Jaccard, Turrisi, & Wan, 1990), whereby the regression of $T_{\ln(\beta)}$ upon trait is tested at the two discrete levels of group. According to our hypotheses, we expected that the relationship between FI and $T_{\ln(\beta)}$ would be significant for the rewarded but not for the punished group. Specifically, FI should predict the development of a more lenient response bias under the reward schedule (i.e., a shift in preference toward the "go" response), as indicated by lower scores on $T_{\ln(\beta)}$, but should remain unrelated to change in response bias under the punishment schedule. The same effect was anticipated for the other measures of BAS, namely, AM and CWBAS.

As we consider DI to have no relationship with RST, it was difficult to anticipate exactly how this scale would relate to our criterion. Broadly, we considered that, if DI reflected typical Impulsivity, and therefore the *failure* to consider outcomes of behavior, then DI should not predict reinforcement learning (in terms of $T_{\ln(\beta)}$).

Results and Discussion

Descriptive and Preliminary Statistics

Table 4 reports alpha reliabilities, means, and standard deviations for all scales used, and these are consistent with those observed in Study 1. As a manipulation check, a 2 (group) × 3 (block) mixed ANOVA was conducted with ln(β) as the within-subjects dependent variable (DV). There was a significant main effect of group, $F(1, 106) = 5.15$, $p = .025$, indicating that the rewarded group ($M = -0.55$) had a stronger bias towards the go response than did the punished group ($M = -0.32$). There was no main effect of block, but a significant block × group interaction, $F(2, 212) = 3.25$, $p = .04$. Simple main effects of group for each of the experimental blocks indicated no significant difference in response bias for the two

Table 4
Means, Standard Deviations, Internal Consistency and Intercorrelations

	FI	DI	BAS	AM	Alpha	Mean	*SD*
DII Functional	–				.79	39.35	8.22
DII Dysfunctional	.07	–			.78	35.03	7.85
CWBAS	.33**	– .04	–		.80	38.50	5.23
Appetitive Motivation	.51**	.04	.37**	–	.76	13.96	3.13
ln(β)block1	.16	– .12	.02	– .07	–	– 0.38	0.56
ln(β)block2	– .01	– .01	.02	– .04	–	– 0.40	0.73
ln(β)block3	– .02	.04	.12	.07	–	– 0.51	0.95

*$p < .05$. **$p < .01$.
Note: N = 108.

groups at block 1, $F(1,106) = 1.38$, $p = .24$, or at block 2, $F < 1$ *ns*, but a significant difference at block 3, $F(1,106) = 7.67$, $p = .007$, indicating that, by the final block of the experiment, the rewarded group ($M = -0.77$) had a stronger bias towards the "go" response than the punished group ($M = -0.27$) (see Figure 1). Thus, it appears that the partial feedback manipulation had the desired effect upon response bias. However, the tendency for response bias to be lower than neutral (i.e., zero), for both groups throughout the experiment (overall $M = -0.43$), indicates that, across all blocks and both experimental groups, there was a general preference for the "go" response, $t(107) = 8.52$, $p < .001$. This may reflect a common strategy of participants to respond "go" when uncertain of the correct response (as observed informally by the experimenter).

Functional Impulsivity and Reward Reactivity

A 2 (group) × 3 (block) mixed ANOVA was conducted with ln(β) as the repeated measures DV and FI as a continuous variable included in the full factorial design. There were no significant main effects, and the only 2-way interaction to approach significance was group × FI, $F(1, 108) = 2.86$, $p = .09$. There was, however, a significant 3-way interaction between block, group, and FI, $F(2, 208) = 3.89$, $p = .02$. The significant linear trend for the block × group × FI within-subjects contrast indicates a change in ln(β) over blocks that differs for the rewarded and punished groups and this difference is, in

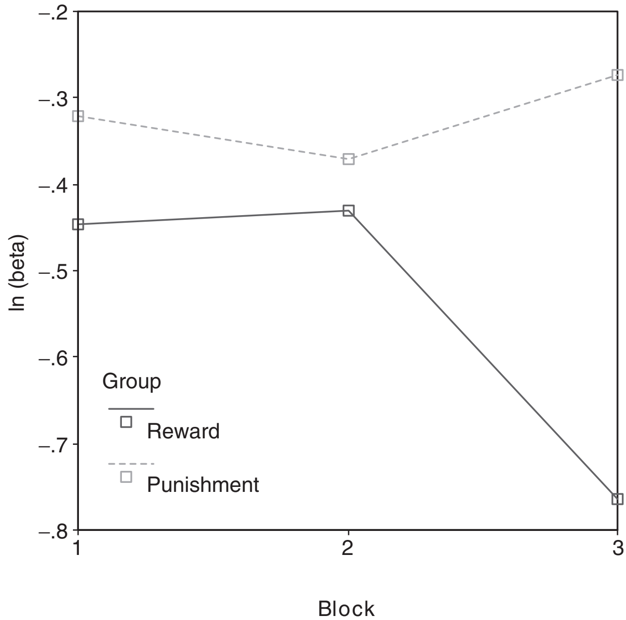
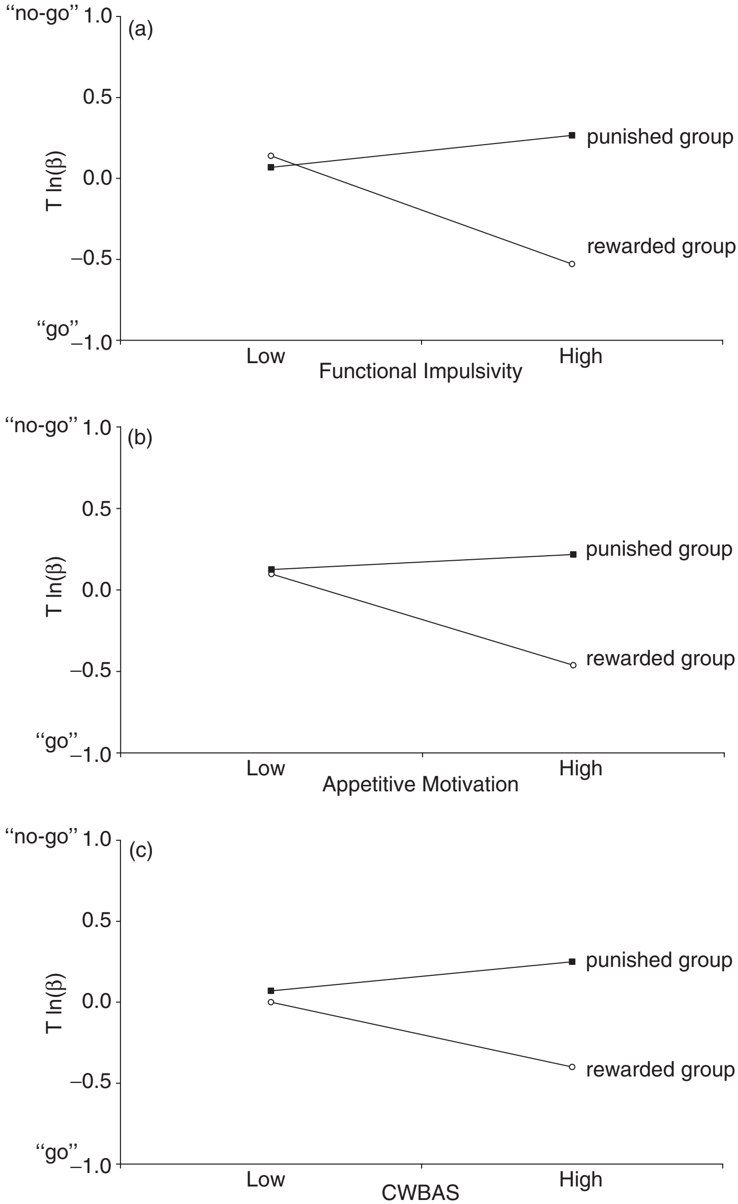


Figure 1
Plot depicting response bias for each experimental group over the three blocks of the go/no-go task. Lower values of ln(β) indicate a tendency towards go.

turn, conditional upon FI score, $F(1, 104) = 5.12$, $p = .02$. To follow up this effect, the relationship between FI and $T_{\ln(\beta)}$ —the linear trend of ln(β) over experimental blocks—was examined at the two discrete levels of group (to permit ease of interpretation, both $T_{\ln(\beta)}$ and FI were standardized prior to analysis). This simple slopes analysis revealed that the relationship between FI and ln(β) was significant in the rewarded group, $B = -0.34$, $t(104) = 2.31$, $p = .02$, but not in the punished group, $B = 0.09$, $t < 1$ *ns*. As such, a 1 *SD* increase in FI was associated with a .34 *SD* shift in response bias (from early to late in the experimental block) toward the "go" response when it was rewarded, but with a negligible (.09 *SD*) shift in response bias when it was punished (see Figure 2a).

Other BAS Measures and Reward Reactivity

For comparative purposes, these analyses were repeated using AM as the personality measure. A 2 (group) × 3 (block) mixed ANOVA was conducted with ln(β) as the DV and AM included in the full factorial design. There were no significant main effects or 2-way interactions, but the 3-way interaction between block, group, and AM was significant, $F(2, 208) = 3.10$, $p = .03$. The linear trend for the



block × group × AM within-subjects contrast approached significance, suggesting a modest change in ln(β) over blocks that differed for the rewarded and punished groups and which was, in turn, conditional upon AM score, $F(1, 104) = 2.89$, $p = .09$. As before, the relationship between AM and $T_{\ln(\beta)}$ was examined at the two discrete levels of group (with $T_{\ln(\beta)}$ and AM standardized prior to analysis). This revealed that the relationship between AM and ln(β) reached borderline significance in the rewarded group, B = – 0.28, $t(104) = 1.98$, $p = .05$, but not in the punished group, B = 0.04, $t < 1$, *ns*. This indicates that a 1 *SD* increase in AM was associated with a .28 *SD* shift in response bias (from early to late in the experimental block) toward the "go" response when it was rewarded, but with a near-zero (.04 *SD*) shift in response bias when the "go" response was punished (see Figure 2b).

As was the case for the FI and AM measures, a 2 (group) × 3 (block) mixed ANOVA was conducted with ln(β) as the DV and CWBAS included in the full design. No main effects or interactions were significant, and the anticipated linear trend for the block × group × CWBAS within-subjects contrast was weak, $F(1, 104) = 2.26$, $p = .12$. Although any follow-up tests should therefore be treated with caution, we proceeded to the analysis of simple slopes as is recommended when specific directional predictions have been made (Jaccard et al., 1990). This indicated that the relationship between CWBAS and $T_{\ln(\beta)}$ (both standardized) approached significance in the rewarded group, B = – 0.20, $t(104) = 1.38$, $p = .08$ (one-tailed), but not in the punished group, B = 0.10, $t < 1$, *ns*. Therefore, a 1 *SD* increase in CWBAS was associated with a .20 *SD* shift in

Figure 2

Plots depicting analysis of simple slopes for the interaction of BAS/Reward-Responsiveness scales with reinforcement in the prediction of the linear trend of response bias over experimental trials. Lower scores indicate a shift in bias towards making a "go" response, higher scores indicate a shift in bias towards making a "no-go" response. In all three figures only the slope representing the rewarded group is significant showing that (a) Functional Impulsivity predicts approach of reward, (b) Appetitive Motivation predicts approach of reward, and (c) CW-BAS has a modest trend towards approaching reward.

Note: As all measures have been standardized, the zero shown on the Y-axis corresponds to the mean value of ln(β) (which throughout the experiment was – 0.43, indicating a general preference for the "go" response).

response bias (from early to late in the experimental block) towards the "go" response when it was rewarded, and with a .10 *SD* shift in response bias away from the "go" response when it was punished (see Figure 2c). We emphasize, however, that these are only weak trends and should be interpreted with caution. Results from separate analyses for each CWBAS subscale (Reward-Responsiveness, Drive and Fun) were not substantively different or statistically stronger than that using the total scale.

Dysfunctional Impulsivity and Reward Reactivity

The final analysis was conducted to determine whether DI would relate to our criteria in the same manner as our BAS/Reward-Reactivity measures. A 2 (group) $\times$ 3 (block) mixed ANOVA was conducted with ln(β) as the DV and DI as a covariate included in the full design. This revealed a significant main effect of group, $F(1, 104) = 6.19$, $p = .02$, which was qualified by a group $\times$ DI interaction, $F(1, 104) = 4.22$, $p = .04$. The absence of a significant 3-way interaction between group, block, and DI indicates that the group $\times$ DI interaction did not vary over experimental blocks. As such, our follow up analysis was conducted using the average value of ln(β) across the three experimental blocks. DI and ln(β) were standardized, and simple slopes analysis revealed that the relationship between them was weak in the rewarded group, $B = 0.18$, $t(104) = 1.32$, $p = .09$ (one-tailed), and nonsignificant in the punished group, $B = -.23$, $t < 1$, *ns*. These slopes are in the opposite direction to those observed for the BAS/reward-responsiveness measures, indicating that a 1 *SD* increase in DI is associated with a .18 *SD increase* (i.e., away from reward) in response bias when it is rewarded, and with a .23 *SD decrease* (i.e., towards punishment) in response bias when it is punished (see Figure 3). As for the CWBAS scale, these effects are weak trends and should be interpreted with caution. However, the pattern depicted in Figure 3 is interesting, as it seems that at high-levels of DI (+1*SD*) individuals do not react differently to reward or punishment in terms of response bias. This could be interpreted in terms of Dickman's view that DI reflects rash responding and a failure to consider the outcomes of one's behavior.

This study extends the psychometric findings of Study 1 and offers further support for the hypothesis that FI reflects reward-reactivity. Specifically, high scores on FI were predictive of a change in re-

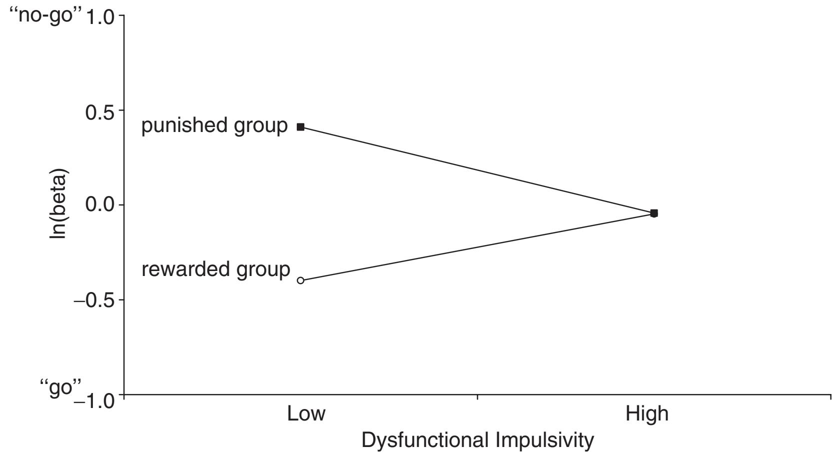


Figure 3

Plot depicting analysis of simple slopes for the interaction of Dysfunctional Impulsivity with reinforcement in the prediction of response bias (averaged over the three experimental blocks). Lower scores indicate a bias towards making a "go" response; higher scores indicate a bias towards making a "no-go" response. Only the slope representing the rewarded group is significant, showing that Dysfunctional Impulsivity predicts *less* approach of reward.

Note: As all measures have been standardized, the zero shown on the Y-axis corresponds to the mean value of ln(β) (which throughout the experiment was – 0.43, indicating a general preference for the "go" response).

sponse bias throughout the "go/no-go" task, such that a preference was developed for the rewarded choice alternative. Pickering and Gray (2001) state that this is what would be expected of a good measure of reward-reactivity, and the pattern of results was found to be similar for two other purpose-built measures of the BAS (although this relationship was weak for the CWBAS scale). DI was not correlated with FI in this study and related quite differently to performance on the "go/no-go" task. Specifically, it appeared that higher DI was associated with less approach of reward, and with less avoidance of punishment (trending only). Furthermore, this relationship was not contingent upon block, suggesting that DI is not associated with reinforcement learning. In sum, these findings demonstrate that FI is a significant predictor of behavioral reactions to reward, converging with two other BAS/reward-reactivity measures in an RST paradigm. The failure for DI to relate in the same way to our criteria appears to further indicate its conceptual unrelatedness to FI, perhaps mirroring the distinction between "trait Impulsivity" and reward-reactivity (Pickering, 2004; Quilty & Oakman, 2004).

GENERAL DISCUSSION

Impulsivity is the common name for a multitude of dimensions reflecting anything from disorganization to positive affect—all grouped within one poorly understood trait cluster. In what has become something of a tradition in this area of personality research, Dickman (1990) attempted to bring improved order to the Impulsivity cluster by suggesting two fundamental varieties of this trait. Dysfunctional Impulsivity (DI) reflects the more common conceptualization in the literature and concerns reckless action and a failure to consider consequences of behavior. Functional Impulsivity (FI), on the other hand, reflects spontaneity directed toward seizing some opportunity and, unlike DI, is thought to have positive outcomes for the individual. While FI seems an interesting and relatively unique view of Impulsivity, its construct validity and potential underlying causes are not clear and, as such, the nature of this trait remains poorly understood. It is therefore interesting to note the conceptual similarity between FI and Gray's (1991) concept of reward-reactivity—another "variety of Impulsivity" which appears quite unique. Reward-reactivity is believed to have a combined basis in low behavioral inhibition (BIS–) and high behavioral activation (BAS+) as detailed in Gray's Reinforcement Sensitivity Theory (RST) of personality (cf. Corr, 2004). We predicted that, if Dickman's concept of FI is synonymous with Gray's concept of reward-reactivity, it should converge with trait measures of the BIS and BAS and predict behavioral reactions to reward.

Two studies were employed to evaluate our broad hypothesis. Study 1 comprised a psychometric exploration of FI and DI, examining their construct validity and structural relationships. Consistent with our predictions, we found that (1) FI is related positively to measures of BAS/Extraversion and negatively to measures of BIS/Neuroticism and that (2) DI is most clearly related to Psychoticism and trait Impulsivity and appears largely unrelated to FI and measures of RST. This pattern of results is very consistent with recent literature (Chico et al., 2003; Gomez et al., 2004; Jackson & Smillie,

2004) and with our theoretical position regarding FI. Study 2 extended and clarified these initial findings by providing an experimental test of our hypotheses. It was found that (1) FI, Appetitive Motivation, and CWBAS (trending) predicted the development of a response bias in favor of reward, while (2) DI predicted a lower tendency to approach reward, and also a lower tendency to avoid punishment (both trending). As far as we know, this is the first use of Dickman's scales in an experimental test of RST, and the pattern of results clearly suggests that FI has some similarity to reward-reactivity while DI does not.

Overall, while not providing a causal test of our hypotheses, these findings give some encouragement to the notion that FI may have an underlying basis in the motivational systems of Gray's RST. To what extent does this theoretical interpretation complement current understanding of FI? Dickman (2000) alone has offered one preliminary suggestion for the basis of this trait, noting a modest correlation between FI and energetic arousal. He speculated that higher energetic arousal might enable functional impulsives to better attend to the task at hand than their dysfunctional counterparts. Dickman's speculation is easily accommodated by the motivational explanation we have offered. Specifically, the BIS and BAS systems, whose activity we suggest may constitute the underlying basis of FI, produce outputs to attentional resources (e.g., Gray, 1987b, p. 263). Nevertheless, Thayer (1989) has explicitly linked energetic arousal to the motivational states arising from reactivity to reward, as specified in RST. Therefore, Dickman's observations may in fact correspond directly to the underlying influences with which our own explanation is concerned. Our perspective does, however, question Dickman's (1990) assertion that FI is nonhesitant and without forethought: In order to respond effectively to situational demands (resolve conflict) and seize some opportunity (approach reward), it seems necessary for consideration of alternative courses of action and their likely consequences. Similarly, Dickman's (2000) own suggestion that functional impulsives may be able to better attend to decision-making properties of a situation appears to hinge directly on the involvement of greater thought about one's actions. We therefore view FI/reward-reactivity as differing quite sharply from most forms of Impulsivity in that it necessarily involves directed behavior and, therefore, the consideration of outcomes.

Next, how do the present findings articulate with current understanding of RST? On the one hand it could be argued from RST that the BIS and BAS are orthogonal systems and, therefore, that measures of these systems should not associate. FI, being related to both BIS and BAS measures, is not easily reconciled with this view of the RST framework. Nevertheless, recent considerations of this issue argue convincingly that independent effects of the BIS and BAS are very unlikely. Instead, the BIS and BAS are thought to jointly influence behavior (e.g., Corr, 2001; Pickering, 1997), such that reward-reactivity results from the combined effect of BIS – /BAS+. In this case, an overlap with both BIS and BAS is exactly what would be expected of a reward-reactivity measure. A second point to note relates to our finding that measures of BAS/reward-reactivity are relatively separate from trait Impulsivity (in terms of both psychometric overlap and divergent prediction of response bias). Again, it is necessary to distinguish the traditional RST view from more recent accounts: In this case, we refer to the fact that Impulsivity has, for some time, been viewed as the trait through which individual differences in reactions to reward are manifest. More recently, the relevance of "Impulsivity" to RST has been questioned, with the suggestion that reward-reactivity and trait Impulsivity are distinct constructs (e.g., Depue & Collins, 1999; Pickering, 2004; Quilty & Oakman, 2004; Smillie & Jackson, 2005; Zelenski & Larsen, 1999). Our findings converge with this more recent literature.

Overall, we consider that Dickman's (1990) distinction between functional and dysfunctional Impulsivity parallels the distinction that can be made between Gray's notion of reward-reactivity and typical conceptualizations of trait Impulsivity. In one sense, these distinctions bring structure to the tangled cluster of Impulsivity traits. On the other hand, the existence of these so-called varieties of Impulsivity is ultimately the source of this confusion, and their distinctiveness is such that one might encourage a wholly separate nomenclature for scales reflecting reactions to reward. That is, measures such as FI, Appetitive Motivation, and CWBAS might best be conceived of as measures of reward-reactivity, and if so, that should be the trait name by which they are known. At the same time, the tendency for such measures to be identified, mistakenly or otherwise, as Impulsivity traits suggests that there may be some mechanism through which reward-reactivity and trait Impulsivity are linked. This is a point to be addressed by future research. One possibility is that measures of reward-reactivity (e.g., FI) and Impulsivity (e.g., DI) have similar underlying bases (e.g., the biological systems of RST) that manifest differently after interacting with surface-level (i.e., social/cognitive) variables. To speculate: BAS+/BIS− output may combine with perceived competence to cause FI (higher perceived competence) or DI (lower perceived competence). Indeed, some items in the FI scale make reference to general competency (e.g., Item 18: "I am good at taking advantage of opportunities"; Item 6: "I can put my thoughts into words very rapidly") suggesting that such an explanation may be tenable.[4] Further consideration of this issue is of prime value for this area of personality research.

Some limitations of the present investigation highlight the need for further critical examination of our theoretical position. First, our efforts to capture the general distinction between reward-reactivity and trait Impulsivity are challenged by the fact that numerous scales reflect a composite of these constructs. This was clearly seen in the case of the Sensitivity to Reward scale (Torrubia et al., 2001), which appears from our factor analytic results to be equally related to BAS/Extraversion and Impulsivity/Psychoticism. Similarly, the failure for the CWBAS scale to reach significance in the prediction of reactions to reward raises concerns about the validity of this measure (as also noted by Smillie & Jackson, 2005, and Smillie, Jackson, & Dalgleish, in press). As reward-reactivity, trait Impulsivity, and BAS functioning have often been treated as psychometrically equivalent, it is difficult to judge the importance of the Impulsivity/reward-reactivity distinction based upon results employing potentially mixed measures. Secondly, our experimental paradigm in Study 2 was specifically designed for testing predictions from RST, and therefore it only offered a single-dissociation test. That is, a clear hypothesis could not be made for our measure of trait-Impulsivity (DI), other than the general supposition that it would not predict approach of reward. Future research should endeavor to provide a double-dissociation test of Impulsivity and reward-reactivity measures, which we would expect to show that Impulsivity predicts Impulsivity criteria and not reward-reactivity criteria, and vice versa for reward-reactivity measures.

In conclusion, psychometric and experimental findings suggest that Dickman's (1990) Functional Impulsivity scale reflects Gray's

4. We thank an anonymous reviewer for this suggestion.

concept of reward-reactivity. Dysfunctional Impulsivity appears to be a conceptually and statistically distinct measure, capturing the typically negative view of this trait. While further research is needed to consolidate our theoretical position, these findings advance theoretical understanding of Functional Impulsivity, and additionally suggest that Dickman's label for this trait may be a misnomer. Specifically, our results support the growing view that reward-reactivity is not a kind of Impulsivity, but something conceptually separate. Future research is needed to evaluate the importance of this distinction.

REFERENCES

Abramowitz, C. S., Kosson, D. S., & Seidenberg, M. (2004). The relationship between childhood Attention Deficit Hyperactivity Disorder and conduct problems and adult psychopathy in male inmates. *Personality and Individual Differences*, **36**, 1031–1047.

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. London: Sage.

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

Avilla, C., & Parcet, M. A. (2001). Personality and inhibitory deficits in the stop-signal task: The mediating role of Gray's anxiety and Impulsivity. *Personality and Individual Differences*, **31**, 975–986.

Barratt, E. S. (1985). Impulsiveness subtraits: Arousal and information processing. In J. T. Spence & C. E. Itard (Eds.), *Motivation, Emotion, and Personality* (pp. 137–146). Amsterdam: Elsevier.

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

Cesaras, X., Avila, C., & Torrubia, R. (2004). The measurement of individual differences in behavioral inhibition and behavioral activation systems: a comparison of personality scales. *Personality and Individual Differences*, **34**, 999–1013.

Chico, E. (2000). Relación entre la impulsividad Functional y disfuncional y los rasgos de persinalidad de Eysenck [The relationship of functional and dysfunctional impulsivity to Eysenck's personality traits]. *Anuaro de psicología*, **31** (1), 64–79.

Chico, E., Tous, J. M., Lorenzo-Seva, U., & Vigil-Colet, A. (2003). Spanish adaptation of Dickman's Impulsivity inventory: Its relationship to Eysenck's personality questionnaire. *Personality and Individual Differences*, **35**, 1883–1892.

Claes, L., Vertommen, H., & Braspenning, N. (2000). Psychometric properties of the Dickman Impulsivity Inventory. *Personality and Individual differences*, **29**, 27–35.

Cohen, J., Cohen, P., Aiken, L. S., & West, S. G. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed). London: Erlbaum.

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**, 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**, 511–532.

Corr, P. J. (2004). Reinforcement Sensitivity Theory and personality. *Neuroscience and Biobehavioral Reviews*, **28**, 317–332.

Coscina, D. V. (1997). The biopsychology of Impulsivity: Focus on brain serotonin. In C. D. Webster & M. A. Jackson (Eds.). *Impulsivity: Theory, assessment and treatment*. London: The Guilford Press.

Costa, P. T. Jr., & McCrae, R. R. (1992). *NEO PI-R professional manual*. Odessa, Florida: Psychological Assessment Resources.

Dalgleish, L. I., & Smillie, L. D. (under review). Decision-making and confidence under partial feedback: Perceptual discrimination and application to personnel selection decisions. Submitted to *Journal of Behavioral Decision Making*.

Davids, E., Zhang, K., Tarazi, F. I., & Baldessarini, R. J. (2003). Animal models of attention-Deficit hyperactivity disorder. *Brain Research Reviews*, **42**, 1–21.

Dawe, S., & Loxton, N. J. (2004). The role of Impulsivity in the development of substance use and eating disorders. *Neuroscience and Biobehavioral Reviews*, **28**, 343–351.

Depue, R. A., & Collins, P. F. (1999). Neurobiology of the structure of personality: Dopamine, facilitation of incentive motivation, and extraversion. *Behavioral and Brain Sciences*, **22**, 491–569.

Diaz, A., & Pickering, A. D. (1993). The relationship between Gray's and Eysenck's personality spaces. *Personality and Individual Differences*, **15**, 297–305.

Dickman, S. J. (1990). Functional and dysfunctional Impulsivity: Personality and cognitive correlates. *Journal of Personality and Social Psychology*, **58**, 95–102.

Dickman, S. J. (1993). Impulsivity and information processing. In W. McCown, M. Shure, & J. Johnson, *The impulsive client: theory, research and treatment*. Washington, DC: APA.

Dickman, S. J. (2000). Impulsivity, arousal and attention. *Personality and Individual Differences*, **28**, 563–581.

Dickman, S. J., & Meyer, D. E. (1988). Impulsivity and speed-accuracy tradeoffs in information processing. *Journal of Personality and Social Psychology*, **54**, 274–290.

Dolan, M. C., & Anderson, I. M. (2003). The relationship between serotonergic function and the Psychopathy Checklist: Screening Version. *Journal of Psychopharmacology*, **17**, 216–222.

Doob, L. (1990). *Hesitation: Impulsivity and reflection*. New York: Greenwood Press.

Eysenck, H. J., Barrett, P., Wilson, G. D., & Jackson, C. J. (1992). Primary trait measurement of the 21 components of the P-E-N System. *The European Journal of Psychological Assessment*, **8**, 109–117.

Eysenck, H. J., & Eysenck, S. B. G. (1991). *The Eysenck Personality Scales*. Hodder & Stoughton: London.

Eysenck, H. J., & Gudjonsson, G. H. (1989). *The causes and cures of criminality*. London: Plenum Press.

Fowles, D. (1980). The three arousal model: Implications of Gray's two-factor learning theory for heart rate, electrodermal activity, and psychopathology. *Psychophysiology*, **17**, 87–104.

Goldman, D., & Fishbein, D. H. (2000). Genetic basis for impulsive and antisocial behaviours: Can their course be altered? In D. H. Fishbein (Ed.), *The science, treatment, and prevention of antisocial behaviors: Application to the criminal justice system* (pp. 9–1–9–18)). Kingston, NJ: Civic Research Institute.

Gomez, R., Cooper, A., McOrmond, R., & Tatlow, S. (2004). Gray's reinforcement sensitivity theory: Comparing the separable and joint subsystems hypothesis in the predictions of pleasant and unpleasant emotional information processing. *Personality and Individual Differences*, **37**, 289–305.

Gomez, R., & McLaren, S. (1997). The effects of reward and punishment on response disinhibition, moods, heart rate and skin conductance level during instrumental learning. *Personality and Individual Differences*, **23**, 305–316.

Gray, J. A. (1970). The psychophysiological basis of introversion-extraversion. *Behavior Research and Therapy*, **8**, 249–266.

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

Gray, J. A. (1987a). The neuropsychology of emotion and personality. In S. M. Stahl, S. D. Iverson, & E. C. Goodman (Eds.), *Cognitive neurochemistry*. Oxford: Oxford University Press.

Gray, J. A. (1987b). *The psychology of fear and stress* (2nd ed). New York: Cambridge University Press.

Gray, J. A. (1991). The neuropsychology of temperament. In J. Strelau & A. Angleitner (Eds.), *Explorations in temperament: International perspectives on theory and measurement*. *Perspectives on individual differences* (pp. 105–128). New York: Plenum Press.

Gray, J. A., Feldon, J., Rawlins, J. N. P., Hemsley, D. R., & Smith, A. D. (1991). The neuropsychology of schizophrenia. *Behavioral and Brain Sciences*, **14**, 1–84.

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

Gray, J. A., Owen, S., Davis, N., & Tsaltas, E. (1983). Psychological and physiological relations between Anxiety and Impulsivity. In M. Zuckerman (Ed.), *The biological basis of sensation seeking, impulsivity and anxiety*. Hillsdale: Erlbaum.

Gray, J. A., & Smith, P. T. (1969). An arousal-decision model for partial reinforcement and discrimination learning. In R. M. Gilbert & N. S. Sutherland (Eds.) *Animal discrimination learning*. London: Academic Press.

Gupta, S. (1990). Impulsivity sociability and reinforcement in verbal operant conditioning: A replication. *Personality and Individual Differences*, **11**, 585–589.

Jaccard, J., Turrisi, R., & Wan, C. K. (1990). *Interaction effects in multiple regression. Sage university paper series on quantitative applications in the social sciences*. Newbury Park, CA: Sage.

Jackson, C. J. (2002). Mapping Gray's model of personality onto the Eysenck Personality Profiler (EPP). *Personality and Individual Differences*, **32**, 495–507.

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

Jackson, C. J., & Smillie, L. D. (2004). Appetitive motivation predicts the majority of personality and an ability measure: a comparison of BAS measures and a re-evaluation of the importance of RST. *Personality and Individual Differences*, **36**, 1627–1636.

John, O. P., Donahue, E. M., & Kentle, R. L. (1991). *The Big Five Inventory: Version 4a and 5*. Technical report, Institute of Personality and Social Research, University of California, Berkeley.

Levine, S. Z., & Jackson, C. J. (2004). Eysenck's theory of crime revisited: Factors or primary scales? *Legal and Criminological Psychology*, **9**, 1–18.

Macmillan, N. A., & Creelman, C. D. (1991). *Detection theory: A users guide*. Cambridge: Cambridge University Press.

Mathias, C. W., & Stanford, M. S. (2003). Impulsiveness and arousal: Heart rate under conditions of rest and challenge in healthy males. *Personality and Individual Differences*, **35**, 355–371.

Matthews, G., & Gilliland, K. (1999). The personality theories of H. J. Eysenck and J. A. Gray: A comparative review. *Personality and Individual Differences*, **26**, 583–626.

McNicol, D. (1972). *A primer of signal detection theory*. London: Allen and Unwin.

Miller, E., Joseph, S., & Tudway, J. (2004). Assessing the component structure of four self-report measures of Impulsivity. *Personality and Individual Differences*, **37**, 349–358.

Moeller, F. G., Steinberg, J. L., Petty, F., Fulton, M., Cherek, D. R., & Kramer, C., et al. (1994). Low CSF 5-HIAA concentrations and sever aggression and impaired impulse control in nonhuman primates. *American Journal of Psychiatry*, **151**, 1485–1491.

Newman, J. P., & Kosson, D. S. (1986). Passive avoidance learning in psychopathic and nonpsychopathic offenders. *Journal of Abnormal Psychology*, **96**, 145–148.

Parker, J. D. A., & Bagby, R. M. (1997). Impulsivity in adults: A critical review of measurement approaches. In C. D. Webster & M. A. Jackson (Eds.) *Impulsivity: Theory, assessment and treatment*. London: The Guilford Press.

Peterson, J. D., Wolf, M. E., & White, F. J. (2003). Impaired DRL 30 performance during amphetamine withdrawal. *Behavioral Brain Research*, **143**, 101–108.

Pickering, A. D. (1997). The conceptual nervous system and personality: From Pavlov to neural networks. *European Psychologist*, **2**, 139–163.

Pickering, A. D. (2004). The neuropsychology of impulsive antisocial sensation seeking personality traits: From dopamine to hippocampal function? In R. M. Stelmack (Ed.), *On the psychobiology of personality: Essays in honor of Marvin Zuckerman* (pp. 455–478). London: Elsevier.

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**, 357–365.

Pickering, A. D., Corr, P. J., Powell, J. H., Kumari, V., Thornton, J. C., & Gray, J. A. (1997). Individual differences in reactions to reinforcing stimuli are neither black nor white: To what extent are they Gray? In Helmuth Nybork (Ed). *The scientific study of human nature* (pp. 36–67). Amsterdam, the Netherlands: Pergamon/Elsevier Science Inc.

Pickering, A. D., & Gray, J. A. (2001). Dopamine, appetitive reinforcement, and the neuropsychology of human learning: An individual differences approach. In A. Eliasz & A. Angleitner (Eds.), *Advances in individual differences research*. Lengerich, Germany: PABST Science Publishers.

Quilty, L. C., & Oakman, J. M. (2004). The assessment of Behavioral Activation—The relationship between Impulsivity and behavior activation. *Personality and Individual Differences*, **37**, 429–442.

Revelle, W. (1993). Individual differences in personality and motivation: "Non-cognitive" determinants of cognitive performance. In A. Baddeley & L. Weiskrantz (Eds.), *Attention: selection, awareness and control: A tribute to Donald Broadbent*. Oxford: Oxford University Press.

Smillie, L. D., & Jackson, C. J. (2005). The Appetitive Motivation Scale and other BAS measures in the prediction of approach and active avoidance. *Personality and Individual Differences*, **38**, 981–994.

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

Stanislaw, H., & Toderov, N. (1999). Calculation of signal detection theory measures. *Behavioral Research Methods, Instruments, and Computers*, **31**, 137–149.

Swets, J. A., Tanner Jr., W. P., & Birdsall, T. G. (1961). Decision processes in perception. *Psychological Review*, **68**, 301–340.

Thayer, R. E. (1978). Toward a psychological theory of multidimensional activation (arousal). *Motivation and Emotion*, **2**, 1–34.

Thayer, R. E. (1989). *The biopsychology of mood and arousal*. New York: Oxford.

Torrubia, R., Avila, C., Molto, J., & Caseras, X. (2001). The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ) as a measure of Gray's anxiety and impulsivity dimensions. *Personality and Individual Differences*, **31**, 837–862.

Watson, D., & Tellegen, A. (1985). Toward a consensual structure of mood. *Psychological Bulletin*, **98**, 219–235.

Wilson, G. D., Gray, J. A., & Barrett, P. T. (1990). A factor analysis of the Gray-Wilson Personality Questionnaire. *Personality and Individual Differences*, **11**, 1037–1045.

Young, S. N., Phil, R. O., & Ervin, F. R. (1988). The effect of altered tryptophan levels on mood and behavior in normal human males. *Clinical Neuropharmacology*, **11** (Suppl. 1), S207–S215.

Zelenski, J. M., & Larsen, R. J. (1999). Susceptibility to affect: a comparison of three personality taxonomies. *Journal of Personality*, **67**, 761–791.

Zuckerman, M. (1979). *Sensation seeking: Beyond the optimal level of arousal*. Hillsdale, NJ: Erlbaum.