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# J. A. Gray's reinforcement sensitivity theory and frustrative nonreward: a theoretical note on expectancies in reactions to rewarding stimuli

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**Abstract**

This theoretical note highlights the potential importance of considering reward expectancies in the context of individual differences in reward sensitivity. Based on a theoretical analysis of J. A. Gray's reinforcement sensitivity theory (RST) of personality, and consistent with the general principles of RST, it is hypothesized that the empirical relationship between individual differences in reward sensitivity and actual reactions to (experimenter-defined) reward is moderated by reward expectancies. However, contrary to the specific predictions of RST, it is argued that actual reward of a lower value than expected reward leads to a state of frustrative nonreward primarily in reward sensitive (e.g. impulsive) individuals (it may, as a secondary effect, be enhanced in punishment sensitive, anxious individuals); in contrast, RST contents that frustrative nonreward is mediated primarily by punishment sensitivity (anxiety), and is unrelated to reward sensitivity (e.g. impulsivity). Frustrative nonreward can produce complex, and difficult to interpret, personality × reward effects in typical human laboratory experiments; such results often appear in opposition to the theoretical foundations of RST. It is argued that closer attention to the operational definitions of (experimenter-defined) reward, as well as participants' reward expectancies, may lead to greater experimental precision in RST studies. Some directions for future research are outlined. © 2002 Elsevier Science Ltd. All rights reserved.

*Keywords:* Reward; Punishment; Sensitivity; Expectancies; Impulsivity; Anxiety; Frustrative nonreward

This article outlines a theoretical clarification of an important, though neglected, aspect of J. A. Gray's reinforcement sensitivity theory (RST) of personality (Gray, 1970, 1981, 1987, 1991), in

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which *expectancies* of reward are hypothesized to moderate the relationship between individual differences in reward sensitivity and *actual* reactions to (experimenter-defined) rewarding stimuli. However, the precise pattern of these hypothesized effects is different from that postulated by the standard version of RST.

Gray's RST was proposed as an alternative biological account of H. J. Eysenck's (1967) taxonomic model of personality, the most recent version of which is expressed in the Eysenck Personality Scales (EPS; Eysenck & Eysenck, 1991: Extraversion, E; Neuroticism, N; & Psychoticism, P). Gray's theory consists of two major systems of emotion that underlie motivated behaviour, the *behavioural approach system* (BAS) and the *behavioural inhibition system* (BIS).

The BAS (Gray, 1987) mediates reactions to appetitive stimuli (i.e. reward and the termination/omission of punishment), and corresponds to the personality factor of impulsivity, which ranges from E+/N+ (high impulsivity) to E−/N− (low impulsivity) (the high pole of impulsivity is rotated 30 degrees from Extraversion; Pickering, Corr, & Gray, 1999). The BIS (Gray, 1976, 1982) mediates reactions to aversive stimuli (i.e. punishment and omission/termination of reward), and corresponds to the personality factor of anxiety, which ranges from E−/N+ (high trait anxiety) to E+/N− (low trait anxiety) (the high pole of anxiety is rotated by 30 degrees from Neuroticism; Pickering et al., 1999). Recently, important changes have been made to Gray's original BIS/BAS theory (Gray & McNaughton, 2000); although substantial, these changes do not affect the basic arguments presented in this article.

Gray's theory predicts that hyper-active BAS individuals should be most sensitive to signals of reward, relative to hypo-active BAS individuals; and hyper-active BIS individuals should be most sensitive to signals of punishment, relative to hypo-active BIS individuals. Impulsivity is often used to measure reward sensitivity; trait anxiety, punishment sensitivity (Corr, 2001).

A critical problem in RST is the relationship between individual differences in (BAS) reward sensitivity and *actual* reactions to (experimenter-defined) rewarding stimuli. A common assumption amongst RST researchers is that this relationship is a positive monotonic function. However, there are theoretical reasons to suggest that, under certain experimental conditions, this relationship may be a negative monotonic function. At best, the research literature on reward sensitivity and reactivity is mixed (e.g. Pickering, Corr, Powell, Kumari, Thornton, & Gray, 1997).

This article focuses on reward sensitivity and reactivity, but a comparable argument may be made for punishment sensitivity and reactivity (where a lower than expected level of punishment may lead to relief of nonpunishment in trait anxious individuals).

## 1. BAS and the comparator

Now the Gray and Smith (1969) arousal-decision model of reward and punishment assigns an important role to reward/punishment comparators, which compare *actual* reinforcement with *expected* reinforcement. This model asserts that only actual reward equal to, or greater than, expected reward serves as an adequate input to the BAS; and only actual punishment equal or, or greater than, expected punishment serves as an adequate input to the BIS. Actual punishment lower than expected punishment (i.e. relief of nonpunishment) is seen as an adequate input to the

BAS, leading to appetitively motivated behaviour; and actual reward lower than expected reward (i.e. frustrative nonreward) is seen as an adequate input to the BIS, leading to aversively-motivated behaviour. However, surprisingly little research has been directed to the question of frustrative nonreward in human beings. There are reasons for assuming that frustrative nonreward is mediated by the BAS, not by the BIS.

## 2. Expectancies of reward

Gray's theory claims that frustrative nonreward is mediated by the BIS, as it represents a signal of nonreward (an adequate input into the BIS; hence the *fear=frustration hypothesis*, see Gray, 1987). Therefore, individual differences in reward (BAS) sensitivity should not be related to this, or any other, form of BIS-mediated behaviour. However, a moment's reflection indicates that the BAS must be involved to the extent that it is sensitive to reward and influences expectancies determined by the reward comparator: under certain conditions, hyper-active BAS individuals will be the first to detect nonreward (i.e. a lower than expected frequency or level of reward) and, therefore, the first to set in train the series of events that lead to the final state of frustrative nonreward.

The comparative neglect of frustrative nonreward in human studies, and the assumption that it is exclusively BIS-related, would seem to be largely the result of inappropriate extrapolation from typical experimental animal paradigms to typical experimental human paradigms. The non-equivalence of these paradigms would give rise to a non-equivalence of predictions and experimental data, and thus to an apparent failure of animal models to predict reactions to rewarding stimuli in human beings.

In a typical animal laboratory experiment, reward and nonreward can be precisely operationalised: animals are first trained to expect a given quantity of reward, and then reward is omitted/terminated, and the effect of nonreward on behaviour is observed. For example, a rat may be reinforced on a continuous schedule of reinforcement and then shifted to a partial or extinction schedule, and the effects of frustration are measured in terms of reduced emission of behaviour (following a continuous schedule) or resistance to extinction (i.e. the partial reinforcement extinction effect, PREE) following an intermittent schedule (these effects are thought to reflect the induction of frustration that set-up the discriminative stimuli that maintains behaviour; Amsel, 1962). In this situation, nonreward would appear to induce a state of frustration, similar to psychological stress, that motivates the animals in much the same way as an aversive stimuli (Gray, 1987).

The crucial point that separates animal and human studies is that animals have a given reward expectancy (determined by training) before frustrating stimuli are introduced. It is, therefore, not surprising that few individual differences remain in reward expectancies, even if these existed prior to training by virtue of BAS-sensitivity differences (the use of inbred rat strains may be expected further to reduce individual differences in BAS sensitivity). Therefore, it is reasonable to argue that the omission/termination of reward is mediated by (BIS) punishment- sensitivity: all animals are trained to expect a given quantity of reward, and then all animals are exposed to the same quantity of nonreward. In these circumstances, the BAS would play little part in mediating frustrative nonreward; and it would be valid to associate frustration with fear (the fact that anxiolytics reduce the effects of frustrative nonreward attests to the involvement of the BIS; e.g. Morales, Torres, Megias, Candido, & Maldonado, 1992).

But frustrative nonreward in human beings differs in important respects from the typical animal experiment. First, there are considerable individual differences in BAS sensitivity (i.e. personality). Were it possible to train human beings to criterion performance (i.e. leading to the elimination of individual differences in reward comparator values), then frustrative nonreward effects, comparable to the typical rat experiment, should be expected: a shift from a favourable to a less favourable reward schedule should lead to frustrative nonreward which, in turn, should be mediated by individual differences in BIS sensitivity. This ideal experimental situation has not been achieved; and there are good reasons to believe that, in typical human laboratory environments, it is unachievable (ethically impermissible control over the environment may be needed to achieve this end).

The typical human experiment resembles the following animal experimental design. The first group of rats is run to expect a high level of reward (corresponding to high reward expectancy, hyper-active BAS individuals), the second group to expect a low level of reward (corresponding to low reward expectancy, hypo-active BAS individuals). Now, under these conditions, which of the two groups of rats would be expected to show the highest level of frustrative nonreward upon termination, or reduction in magnitude, of reward? Presumably, the group run to high reward expectancies (corresponding to hyper-active BAS individuals), that would have suffered the greater disappointment by being switched to a less favourable reward schedule. Amsel and Surridge (1964) reported that frustrative nonreward is greater the higher the animal's expectancy of reward; and as Gray (1987, p. 178) stated: "The most reasonable interpretation of this result, given the other evidence that non-reward is aversive, is that zero reward for rats used to a large reward is more punishing than zero reward for rats used to a small reward."

## 3. Reward sensitivity and expectancies

There is evidence that impulsivity is related to reward expectancies, rather than simply to BAS sensitivity. For example, behavioural impulsivity is associated with both (1) intolerance to the delay of reward, in both rats (e.g. Evenden, 1998) and hyperactive boys (e.g. Schweitzer & Sulzer-Azaroff, 1995), and (2) a high rate of temporal discounting (Ostaszewski, 1996), which has been shown to be related to negative emotions such as aggression and violence (Evenden & Ryan, 1996).

The match/mismatch of expected and actual reward should determine the direction and strength of BAS-sensitivity and behaviour under (experimenter-defined) rewarding conditions. Only when actual reward matches or exceeds expected reward should we expect positive associations with measures of BAS sensitivity (e.g. impulsivity); when expectancies exceed actual reward then a state of frustrative nonreward should be expected. Therefore, reward sensitivity and reactivity may be positively or negatively correlated, depending on the match/mismatch of actual/expected stimuli. In typical human laboratory experiments, rewarding stimuli are comparatively weak in strength, therefore it is not surprising that few studies show clear-cut positive associations between measures of BAS-sensitivity (e.g. impulsivity) and actual reactions to reward.

In contrast to RST, the present analysis predicts frustrative nonreward to be highest in BAS-sensitive (e.g. impulsive) participants; as a secondary effect, it should be enhanced in BIS-sensitive participants. More precisely, it is hypothesised that frustrative nonreward is *caused* by BAS-related reward expectancy/sensitivity, but *mediated* by the BIS. Experimentally, this analysis and the standard model of RST make different predictions: (1) this analysis predicts a main effect of BAS-sensitivity (e.g. impulsivity), and a BAS × BIS-sensitivity interaction (i.e. frustrative nonreward should be greatest in BAS+/BIS+ individuals); and (2) the standard RST model predicts a main effect of BIS-sensitivity (e.g. anxiety), with no effect of BAS-sensitivity.

This theoretical position suggests that in future work it will be necessary not only to relate specific personality measures of reinforcement sensitivity to specific motivational systems (i.e. impulsivity to the BAS), but also to assess prevailing reward/punishment comparator values for all participants in a given experimental situation. That is, two separate components of aversive/appetitive motivation need to be delineated: (1) general (trait) BIS/BAS sensitivities (e.g. trait anxiety and impulsivity); and (2) specific measures of (state) expectancies of reward and punishment (Corr, 2001). It should be possible to measure reinforcement expectancies before the delivery of actual reward/punishment, and then, at the end of the experiment, to compare these expectancies with either (1) the value of reinforcement delivered (e.g. amount of money won/lost), or (2) subjective ratings of the extent to which actual stimuli (e.g. pleasant/unpleasant slides) matched or exceeded what was expected. In this regard, behavioural analysis of the effects of sensitivity to delay, amount, and probability of reinforcement, conceptualised in terms of the matching law of reinforcement (Davison & McCarthy, 1988), may throw light upon individual differences in reactions to reward.

## 4. Impulsivity and frustrative nonreward

There are a number of implications of the foregoing discussion. Assuming that impulsivity and BAS sensitivity are positively related, frustrative nonreward in high impulsivity individuals, along with intolerance to delayed reward, may produce an inability to modulate behaviour in accordance with current punishment/nonreward schedules once the BAS has taken control of the motivational system (Gorenstein & Newman, 1980). The Gray–Smith (1969) arousal-decision model of reward and punishment argues that "...when an animal is in an approach–avoidance conflict it is typically observed that with continued exposure to the situation approach behaviour comes to dominate over passive or vice versa" (Gray, 1987, p. 268). It is reasonable to suppose that BAS-sensitive impulsive people reach this point of BAS dominance much sooner than non-impulsive people, and therefore, would find it much more difficult to modulate behaviour to reflect prevailing and changing reinforcement schedules. In addition, Amsel's (1962, 1994) model of frustrative nonreward points to an increment in general arousal following the omission/termination of expected reward (Dudley & Papini, 1997). It is, therefore, possible that inappropriate BAS-dominant behaviour in impulsive individuals may be further strengthened by this increased arousal. These factors may help to elucidate why individuals who have, putatively, a hyper-active BAS are so often associated with negative emotions (e.g. attention-deficit/hyperactive children and aggressive criminals). The association of impulsivity and antisocial behaviour could be the result of this vulnerability to frustration: only when environmental stimuli match or exceed their expectations should we expect impulsivity to be positively associated with reward mediated appropriate behaviour.

In conclusion, future RST studies should consider the inclusion of a number of design features. First, expectations of reward should be taken before the actual delivery of reward. Second, subjective reports should be taken from participants at the end of the reinforcement manipulations to assess the degree to which actual reward matched, exceeded, or fell short of, expectations of reward. Third, different levels of reward, ranging from low (putatively frustrating) to high (pleasurable) reward should be employed to examine the levels at which manipulations become rewarding for different levels of BAS sensitivity. In addition, it would also be desirable to develop psychometrically sound self-report measures of frustrative nonreward in order to characterise the psychological nature of this psychological state in human beings (in this regard, it will be important to establish whether the *fear = frustration hypothesis* also holds true in human beings).

## References

Amsel, A. (1962). Frustrative nonreward in partial reinforcement and discrimination learning: Some recent history and a theoretical extension. *Psychological Review*, *69*, 306–328.

Amsel, A. (1994). Precis of frustrative theory: An analysis of dispositional learning and memory. *Psychonomic Bulletin and Review*, *1*, 280–296.

Amsel, A., & Surridge, C. T. (1964). The influence of magnitude of reward on the aversive properties of anticipatory frustration. *Canadian Journal of Psychology*, *18*, 321–327.

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.

Davison, M., & McCarthy, D. (1988). *The matching law: a research review*. Hillsdale, NJ: Erlbaum.

Dudley, R. T., & Papini, M. R. (1997). Amsel's frustration effect: Pavlovian replication with control for frequency and distribution of reward. *Physiology and Behaviour*, *61*, 627–629.

Evenden, J. L. (1998). The pharmacology of impulsive behaviour in rats III: The effects of amphetamine, haloperidol, imipramine, chlordiazepoxide and ethanol on a paced fixed consecutive number schedule. *Psychopharmacology*, *138*, 295–304.

Evenden, J. L., & Ryan, C. M. (1996). The pharmacology of impulsive behaviour in rats: The effects of drugs on response choice with varying delays of reinforcement. *Psychopharmacology*, *128*, 161–170.

Eysenck, H. J. (1967). *The biological basis of personality*. Springfield: Thomas.

Eysenck, H. J., & Eysenck, S. B. G. (1991). *Manual of the Eysenck personality scales*. London: Hodder and Stoughton.

Gorenstein, E. E., & Newman, J. P. (1980). Disinhibitory psychopathology: A new perspective and a model for research. *Psychological Review*, *87*, 301–315.

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

Gray, J. A. (1976). The behavioural inhibition system: A possible substrate for anxiety. In M. P. Feldman, & A. M. Broadhurst (Eds.), *Theoretical and experimental bases of behaviour modification* (pp. 3–41). London: Wiley.

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-Verlag.

Gray, J. A. (1982). *The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system*. Oxford: Oxford University Press.

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

Gray, J. A. (1991). Neural systems of motivation, emotion and affect. In J. Madden (Ed.), *Neurobiology of learning, emotion and affect* (pp. 273–306). New York: Raven Press.

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

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* (pp. 243–272). London: Academic Press.

Morales, A., Torres, M. D., Megias, J. L., Candido, A., & Maldonado, A. (1992). Effect of diazepam on successive negative contrast in one-way avoidance learning. *Pharmacology, Biochemistry and Behaviour*, *43*, 153–157.

Ostaszewski, P. (1996). The relation between temperament and rate of temporal discounting. *European Journal of Personality*, *10*, 161–172.

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 H. Nyborg (Ed.), *The scientific study of human nature: Tribute to Hans J. Eysenck at eighty* (pp. 36–67). London: Elsevier Sciences.

Schweitzer, J. B., & Sulzer-Azaroff, B. (1995). Self-control in boys with attention-deficit hyperactivity disorder: Effects of added stimulation and time *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *36*, 671–686.