Personality and Individual Differences 72 (2015) 79–84

Contents lists available at ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid

Sensitivity to reward and punishment: Associations with diet, alcohol consumption, and smoking

Katy Tapper [a,*], Louise Baker [b], Gabriela Jiga-Boy [b], Geoffrey Haddock [c], Gregory R. Maio [c]

[a] Department of Psychology, City University London, United Kingdom
[b] Department of Psychology, Swansea University, United Kingdom
[c] School of Psychology, Cardiff University, United Kingdom

ARTICLE INFO

Article history:
Received 7 April 2014
Received in revised form 15 August 2014
Accepted 18 August 2014

Keywords:
BIS/BAS
Health
Fat intake
Sugar intake
Alcohol
Smoking
Diet

ABSTRACT

This study examined whether sensitivity to reward predicts a range of potentially health-damaging behaviours. Secondary objectives were to explore the relationship between these behaviours and sensitivity to punishment. Sensitivity to reward and punishment were assessed among 184 individuals using questionnaire measures of Behavioural Approach System (BAS) and Behavioural Inhibition System (BIS) sensitivity. Participants also completed a food frequency questionnaire and measures of alcohol consumption and smoking. Higher BAS sensitivity predicted higher fat intake, higher alcohol consumption, greater likelihood of binge drinking, greater likelihood of being a smoker and, amongst smokers, smoking frequency. Higher BIS sensitivity predicted lower alcohol consumption but higher sugar intake. Thus, sensitivity to reward appears to be a risk factor for lifestyle behaviours that contribute to poor health. Whilst BIS sensitivity seems to offer some protection with respect to alcohol intake, the results suggest that this does not extend to health-related behaviours, in which the negative consequences may be less immediate. Instead, BIS sensitivity predicted higher sugar intake. This is consistent with the view that BIS sensitivity leads to higher anxiety, which individuals may attempt to regulate by indulging in sugary foods.

1. Introduction

The concepts of sensitivity to reward and punishment are drawn from Gray's Reinforcement Sensitivity Theory (RST, see Corr, 2008), which postulates two independent systems that control a person's tendency to approach reward-related stimuli (Behavioural Approach System; BAS) and avoid signals related to punishment (Behavioural Inhibition System; BIS). A more active BAS results in greater sensitivity to reward; a more active BIS leads to greater sensitivity to punishment. Research has suggested that the BAS can be further sub-divided into three different types of reward sensitivity: (a) Reward Drive, relating to persistent pursuit of desired goals, (b) Fun Seeking, relating to behaviours associated with biological reinforcers not requiring planning and restraint, and (c) Reward Responsiveness, relating to positive responses to receiving or anticipating reward (Carver & White, 1994; Corr, 2008). In this research, we investigate how these systems relate to health behaviour.

1.1. Behavioural activation and health behaviours

The BAS is relevant to health because many potentially damaging behaviours, such as eating a diet high in fat and sugar, have a high reward value (Stice, Burger, & Yokum, 2013). For example, Davis and colleagues found a positive relationship between reward sensitivity and body mass index (BMI) amongst normal and overweight individuals, (albeit reversed amongst obese and morbidly obese individuals, Davis & Fox, 2008; Davis et al., 2007). There is also evidence that individuals with higher sensitivity to reward are more responsive to appetising foods and food cues (e.g., Beaver et al., 2006; Rollins, Loken, Savage, & Birch, 2014; Tapper, Pothos, & Lawrence, 2010), have a greater preference for foods high in fat and sugar and are more likely to overeat (Davis et al., 2007). However, there is little research examining how reward sensitivity relates to *actual diet*. This distinction is important, as dietary preferences do not necessarily translate into eating behaviour (Connors, Bisogni, Sobal, & Devine, 2001). A study by Voigt et al. (2009) with undergraduate students showed no relationship between reward sensitivity and diet, though their measure of diet focused on consumption of only eight high calorie foods over the previous seven days so may not have been sensitive enough to uncover any possible association.

* Corresponding author. Address: Department of Psychology, City University London, London EC1R 0JD, United Kingdom.
E-mail address: katy.kapper.1@city.ac.uk (K. Tapper).

http://dx.doi.org/10.1016/j.paid.2014.08.025
0191-8869/

One goal of the present study was to offer an extended consideration of the relationship between diet and behavioural approach and inhibition systems by using a validated food frequency questionnaire (FFQ; Margetts, Cade, & Osmond, 1989) to estimate sugar and fat intake. Consistent with previous research, we expected that there would be positive correlations between BAS scores and (a) total fat intake and (b) total sugar intake. Because research suggests that the Reward Drive component of BAS most strongly predicts response to food cues (Beaver et al., 2006; Tapper et al., 2010), associations with both total BAS and Reward Drive were examined.

Smoking and alcohol consumption also represent health-damaging behaviours with high reward value (Everitt & Robbins, 2005). Studies show that higher reward sensitivity, particularly in relation to Fun Seeking, is associated with higher alcohol intake and more frequent binge drinking (Feil & Hasking, 2008; Franken & Muris, 2006; Loxton & Dawe, 2001; O'Connor, Stewart, & Watt, 2009; Voigt et al., 2009). Similarly, studies show that Fun Seeking is associated with a greater likelihood of being a smoker (O'Connor et al., 2009) and more frequent use of cigarettes, cigars or chewing tobacco (Voigt et al., 2009). However, most studies showing a relationship between Fun Seeking and alcohol use or smoking have employed undergraduates, who are not representative of the general population.

Thus, another goal of the present study was to extend previous research by employing a community sample of participants to explore the relationship between BAS and consumption of alcohol and cigarettes. It was predicted that higher levels of total BAS, and higher levels of Fun Seeking in particular, would be associated with (a) higher alcohol intake, (b), a greater likelihood of binge drinking, (c), a greater likelihood of being a smoker, and (d) (amongst smokers) smoking frequency. These predictions, together with those previously outlined in relation to saturated fat and added sugar, relate to the main hypothesis of the research – that higher levels of reward sensitivity will be associated with more health-damaging behaviours.

1.2. Behavioural inhibition and health behaviours

The relationship between sensitivity to punishment and health behaviours is less clear. Recent revisions to RST (see Corr, 2008) suggest that, instead of inhibiting behaviour, the BIS draws attention to the potential dangers of a situation and functions as a conflict resolution system. As a result, a more active BIS may lead to higher anxiety. This may, in turn, leads individuals to try to reduce anxiety by indulging in behaviours such as overeating, smoking and drinking (see Hasking, 2006). In support of this, Voigt et al. (2009) found that undergraduate students with a more active BIS reported more drug use and a worse diet. Conversely, others have suggested that a more active BIS may act as a protective factor due to avoidance of potentially risky situations or aversive consequences (e.g., hangovers). In support of this, Franken and Muris (2006) found weak negative correlations between measures of BIS and both quantity of alcohol consumed and frequency of binge drinking amongst undergraduates. Similarly, Knyazev, Slobodskaya, Kharchenko, and Wilson (2004) found that a more active BIS protected against substance abuse amongst female (but not male) youths. An additional possibility is that a more active BIS increases anxiety in response to health information, which may motivate health-related behaviours (Norman, Boer, & Seydel, 2005).

The present study conducted exploratory analyses of the relationship between BIS and health behaviours. To the extent that a more active BIS would lead individuals to indulge in more unhealthy behaviours, one would expect a positive relationship between the two. We tested this hypothesis by examining associations between BIS and (a) total fat intake, (b) total sugar intake, (c) alcohol consumption, (d) likelihood of binge drinking, and (e) smoking frequency. However, as outlined above, it is possible that in some instances BIS may actually predict more *healthy* behaviours, because individuals with a more active BIS may experience more anxiety about health-related outcomes, which they may seek to reduce by engaging in more healthy behaviours. Such a relationship should only apply to variables that the individual is concerned about (e.g., that have been targeted in health promotion campaigns). Thus, an effect should be most apparent in relation to saturated fat and added sugar. Such an effect may also lead to a negative relationship between BIS and (c) alcohol consumption, (d) likelihood of binge drinking (e) likelihood of being a smoker, and (f) smoking frequency.

2. Method

2.1. Participants and procedure

Participants were 184 individuals (100 women; 92% White; M_{age} = 33 years, range 18–65) recruited in South Wales, UK via posters, flyers, press releases and online advertisements. 31% of the sample was educated to degree level or higher and mean BMI (based on self-report) was 25.19 (range = 14.10–42.60). Participants took part individually or in small groups. They completed measures of BIS/BAS, diet, BMI, alcohol use, smoking and demographics. Questionnaires relating to a separate study were interspersed between the measures. Participants were given £10 for participating.

2.2. Measures

2.2.1. BIS/BAS

Sensitivity to reward and punishment were assessed using the BIS/BAS scale, which has good psychometric properties (Carver & White, 1994). In the current study, Cronbach alphas were 0.80 (BIS), 0.79 (BAS), 0.80 (Reward Drive) and 0.71 (Fun Seeking).

2.2.2. Diet

Diet was assessed using a validated food frequency questionnaire (FFQ; Margetts et al., 1989) in which respondents record the frequency with which they consumed 63 food items over the previous month. The FFQ has good test–retest reliability (Armitage & Conner, 1999), good convergent validity with 10-day weighed records (Thompson & Margetts, 1993) and with 24-h dietary records (Margetts et al., 1989).

To compute daily intake of relevant macronutrients, we first calculated average levels of total fat, total sugar, saturated fat, and added sugar per gram of each of the 63 foods, based on data provided by the British Foods Standards Agency (2002, 2008). Each participant's daily intake of each food was then computed by multiplying frequency of consumption by average portion size. Average portion sizes were based on Bingham and Day (1987) and the British Foods Standards Agency (2008). Finally, for each food item, the amount of the relevant macronutrient per gram was multiplied by average daily portion size for each participant. These were then summed across the 63 foods to provide daily total intakes, in grams, of each of the four macronutrients, for each participant.

2.2.3. BMI

To compute BMI, participants reported their weight and height (at the end of the FFQ).

2.2.4. Alcohol use

Alcohol consumption was measured using a questionnaire developed by Cox (2003). It contains items asking about frequency of consumption and number of units consumed for both *usual* consumption and for days when the respondent consumed larger-than-usual quantities. The questionnaire was scored by multiplying frequency by number of units to obtain the number of units consumed per week from usual drinking. To compute additional units consumed from larger-than-usual episodes, the usual number of units consumed was first subtracted from the larger-than-usual number of units. This gave the number of additional units consumed on these occasions. This number was then multiplied by the larger-than-usual frequency to obtain a figure for the additional number of units consumed per week from 'more-than-usual' drinking. The two figures were then summed to obtain the overall number of units consumed per week.

In line with British government recommendations (http://www.drinkaware.co.uk/understand-your-drinking/is-your-drinking-a-problem/binge-drinking), binge drinking was defined as eight or more units per day for men, and six or more for women. Where quantities consumed for either usual or larger-than-usual consumption met these criteria they were coded as an episode of binge drinking.

2.2.5. Smoking

Participants indicated whether they smoked cigarettes and, if yes, the number they usually smoked, either per day, per week, or per month.

2.2.6. Demographics

A questionnaire asked participants about gender, age, education level and ethnic origin.

3. Results

3.1. Data screening and correlation analysis

Seven participants had missing data for one or more items on the BIS/BAS. These were replaced with a mean score computed from the remaining items on the subscale for that participant. Eight outliers (scores >3.5 SDs from the mean) were excluded from the total fat (1 woman), total sugar (1 woman, 2 men), saturated fat (1 woman), and added sugar (1 woman, 2 men) variables. There were missing data for alcohol consumption for 1 woman. Table 1 shows zero-order correlations between predictor and criterion variables as well as means and standard deviations.

Independent t-tests were used to examine gender differences in predictor and criterion variables. These showed significantly higher intakes of total fat, saturated fat, and alcohol amongst men compared to women, $t(181) = 3.77$, $p < .001$, $t(181) = 3.36$, $p < .001$, and $t(179) = 2.98$, $p < .005$, respectively. For predictor variables, women scored significantly higher than men on BIS, $t(182) = 4.24$, $p < .001$. Associations with age showed significant negative correlations between age and added sugar ($r = -.19$, $p = .01$), BAS ($r = -.27$, $p < .001$), alcohol consumption ($r = -.23$, $p < .001$), Reward Drive ($r = -.25$, $p < .001$), and Fun Seeking ($r = -.21$, $p < .005$).

Hierarchical regression models were used to test our main hypotheses that higher BAS would predict higher sugar and fat intake and higher Fun Seeking would predict more smoking and alcohol consumption. These models were also used to explore the relationship between BIS and health behaviours. Since analyses were restricted to effects that were predicted, slightly different predictors were used for different outcome variables. Predictors were mean centred and, given associations with age and gender (see above), these were entered into step 1 of all regression models.

3.2. Diet

For total fat and total sugar, BAS and BIS were entered at step 2. As shown in Table 2, these variables accounted for an additional 5% and 4% of variance in total fat and total sugar intake respectively. For total fat, the only significant predictor was BAS. Consistent with our hypothesis that higher reward sensitivity is associated with more unhealthy behaviours, BAS showed a positive association with total fat intake. Including BAS on its own at step 2 confirmed that it accounted for 5% of the variance in total fat, ($\Delta R^2 = 0.05$, $p < .01$, $\beta = .22$, $p < .01$). Using Reward Drive in place of BAS in this model did not result in a better fit ($\Delta R^2 = 0.04$, $p < .01$, $\beta = .20$, $p < .01$). For total sugar intake, BIS showed a significant positive relationship with intake. This is consistent with the hypothesis that higher punishment sensitivity is associated with more unhealthy behaviours. BAS showed a trend toward significance for total sugar intake ($p = .09$).

To examine the clinical significance of these results, high versus low scores on predictors were defined as the top and bottom 15% of scores (see Table 1). According to the regression models, the difference in total fat intake between a person with high

Table 1
Descriptive statistics and correlations for predictor and criterion variables.

	Predictors				Criterion variables					
	Total BAS	Reward Drive	Fun Seeking	BIS	Total fat n = 183	Total sugar n = 181	Saturated fat n = 183	Added sugar n = 181	Alcohol[a] n = 181	Cigarettes n = 46
Total BAS		.81**	.74**	−.05	.25**	.13	.25**	.11	.21**	.31*
Reward Drive			.37**	−.22**	.24**	.09	.24**	.05	.08	.30*
Fun Seeking				−.10	.15*	.03	.14	.02	.38**	.16
BIS					−.18*	.15*	−.17*	.12	−.15*	−.06
Mean	38.60	10.29	11.86	20.93	77.63[b]	85.55[b]	31.09[b]	50.21[b]	15.54[c]	75.60[d]
SD	5.32	2.60	2.35	3.99	34.45	36.36	14.80	29.43	23.12	49.25
Low scores[e]	21–33	4–7	6–9	7–16						
High scores[f]	44–50	12–16	14–16	25–28						

* $p < 0.05$.
** $p < 0.01$.
[a] Due to a skewed distribution, Spearman's rho was computed.
[b] g/day.
[c] Units/week.
[d] Number/week amongst smokers.
[e] Defined as the lowest 15% of the sample.
[f] Defined as the highest 15% of the sample.

versus low BAS (i.e., a difference of 11 points on the BAS scale) would be at least 15 g per day (the equivalent of about a tablespoon of vegetable oil) whilst the difference in total sugar intake between a person with high versus low BIS (i.e., a difference of 9 points) would be at least 13 g per day (approximately three teaspoons of white sugar).

For saturated fat and added sugar, BIS was also entered at step 2. The addition of these variables did not improve the fit of either model (both $ps > .11$).

3.3. Alcohol

For quantity of alcohol consumed, only participants who consumed more than one unit per week were included in the analyses ($n = 138$); these data were log transformed to normalise a positively skewed distribution. Given the correlation analyses (Table 1) and results of previous research (Feil & Hasking, 2008; Franken & Muris, 2006; O'Connor et al., 2009; Voigt et al., 2009), Fun Seeking was used as a predictor instead of BAS and, given the negative correlation between Fun Seeking and BIS (Table 1), these were entered into separate models.

As shown in Table 3, Fun Seeking significantly improved the fit of the model after gender and age, accounting for 12% of the variance – further supporting the hypothesis that higher reward sensitivity is associated with more unhealthy behaviours. BIS was entered at step 2 in a separate model. This showed that higher BIS predicted significantly lower alcohol consumption. This supports the view that higher punishment sensitivity is associated with more healthy behaviours. BIS explained 4% of variance over and above age and gender.

According to the regression models, the difference in alcohol consumption between a person with high versus low Fun Seeking would be at least 0.40 units per week. In contrast, the difference between a person with high versus low BIS would be at least 0.27 units per week.

Hierarchical logistic regression was used to assess the presence versus absence of binge drinking. In the first analysis, Fun Seeking was entered at step 2 and significantly improved the fit of the model (see Table 4), supporting the hypothesis that higher reward sensitivity is associated with more unhealthy behaviours. In a separate model, BIS was entered at step 2, but this resulted in no significant improvement in fit, χ^2 (1) = 1.31, ns.

Table 2
Hierarchical linear regression models predicting total fat and total sugar intake from BAS and BIS.

	Total fat			Total sugar		
	B	SE B	β	B	SE B	β
Step 1						
Constant	76.90	6.31		89.11	7.04	
Gender	20.59	4.98	.30***	−1.44	5.54	−.02
Age	−0.26	0.17	−.11	−0.08	0.19	−.03
R^2		.09			.00	
Step 2						
Constant	73.16	6.33		85.07	7.19	
BAS	1.42	0.47	.22**	.90	0.53	.13[a]
BIS	−0.84	0.64	−.10	1.45	0.71	.16*
R^2		.14			.04	
ΔR^2		.05**			.04*	

[a] $p < .10$.
* $p < .05$.
** $p < .01$.
*** $p < .001$.
men = 1, women = 0.

Table 3
Hierarchical linear regression models predicting units of alcohol consumed per week from Fun Seeking and (separately) BIS.

	Alcohol consumption		
	B	SE B	β
Step 1			
Constant	1.13	0.09	
Gender	0.21	0.08	.24**
Age	−0.00	0.00	−.13
R^2		0.06*	
Step 2			
Constant	1.01	0.09	
Fun Seeking	0.08	0.02	.36***
R^2		0.18	
ΔR^2		0.12***	
Step 2			
Constant	1.14	0.09	
BIS	−0.03	0.01	−.21*
R^2		0.10	
ΔR^2		0.04*	

* $p < .05$.
** $p < .01$.
*** $p < .001$.
men = 1, women = 0.

3.4. Smoking

For number of cigarettes per week, hierarchical linear regression was employed and only smokers were included in the analysis ($n = 46$). BAS and BIS were entered at step 2. This resulted in a significant improvement in fit; the only significant individual predictor was BAS (see Table 5). Entering BAS into the model on its own showed that it accounted for 14% of the variance over and above gender and age ($\Delta R^2 = 0.14$, $p < .05$, $\beta = .38$, $p < .05$). This again supports the hypothesis that higher reward sensitivity is associated with more unhealthy behaviours. Using Reward Drive and Fun Seeking in place of BAS in this model did not improve its fit ($\Delta R^2 = 0.11$, $p < .05$, $\beta = .35$, $p < .05$ and $\Delta R^2 = 0.04$, ns, $\beta = .19$, ns respectively). According to the model, the difference in number of cigarettes smoked between a person with high versus low BAS would be at least 36 per week.

Hierarchical logistic regression was used to predict smoking status. For the first model, Fun Seeking was entered at step 2 and significantly improved the fit (see Table 4), again supporting the hypothesis that higher reward sensitivity is associated with more unhealthy behaviour. In a separate model, BAS and BIS were entered at step 2, but this did not result in a significant improvement in fit, χ^2 (2) = 3.95, ns.

4. Discussion

The results showed that a more active BAS was associated with higher total fat intake (and a trend toward higher total sugar intake). This is consistent with research that has shown reward sensitivity to be associated with a higher BMI amongst normal and overweight individuals and a greater preference for fatty foods (Davis & Fox, 2008; Davis et al., 2007), but is the first to show a relationship between reward sensitivity and self-reported food consumption. Of interest, additional analyses examining interactions with gender in step 2 of our regression models were not presented here because none of the interactions were significant. The results therefore applied to men as well as women, despite research suggesting that women may be more responsive to food cues (Frank et al., 2010). The difference between someone with high compared to low BAS was estimated to correspond to a difference of at least 15 g of total fat intake

Table 4
Hierarchical logistic regression models predicting binge drinking and smoking status from Fun Seeking.

	Binge drinking					Smoking				
	B	SE B	95% CI for odds ratio			B	SE B	95% CI for odds ratio		
			Lower	Odds ratio	Upper			Lower	Odds ratio	Upper
Step 1										
Constant	2.64	0.46				−0.73	0.44			
Gender	0.92*	0.38	1.21	2.51	5.25	0.20	0.01	0.62	1.22	2.40
Age	−.08***	0.01	0.90	0.93	0.95	−0.01	0.01	0.97	0.99	1.01
R^2 (Cox & Snell)		.20					.01			
R^2 (Nagelkerke)		.27					.01			
X^2 Model (2)		40.43***					1.02			
Step 2										
Constant	2.61	0.49				−1.21	0.48			
Fun Seeking	0.34***	0.08	1.20	1.41	1.67	0.38***	0.09	1.22	1.46	1.75
R^2 (Cox & Snell)		.28					.11			
R^2 (Nagelkerke)		.38					.16			
X^2 Block (1)		19.23***					20.24***			

* $p < .05$.
*** $p < .001$.
men = 1, women = 0.

per day. Extrapolated, this represents an annual weight gain of approximately 15 lb.

In line with previous studies, predominantly conducted with undergraduates (Franken & Muris, 2006; O'Connor et al., 2009; Voigt et al., 2009; see also Feil & Hasking, 2008), our analysis of a community sample revealed that the Fun Seeking component of BAS was associated with both higher alcohol consumption and a greater likelihood of binge drinking. Additionally, the results showed that a more active BAS was associated with an increased likelihood of being a smoker and, amongst smokers, greater smoking frequency, estimated as an additional 36 cigarettes per week for those with high compared to low BAS. Extrapolated, this represents a reduced life expectancy of two weeks every year. However, whilst the Fun Seeking component of BAS was most influential in terms of smoking status, overall BAS and Reward Drive were the most important predictors of smoking frequency. These findings support previous research (O'Connor et al., 2009; Voigt et al., 2009), but also suggest that different personality traits are influential with respect to smoking status versus frequency. Given that Fun Seeking is thought to relate more to behaviours that are close to biological reinforcers (Corr, 2008), it seems likely that the rewards associated with smoking status are social in nature, whilst those associated with smoking frequency are derived from the act of smoking itself.

Table 5
Hierarchical linear regression models predicting number of cigarettes per week from BAS and BIS.

	Smoking (n = 46)		
	B	SE B	β
Step 1			
Constant	46.30	20.18	
Gender	10.04	14.47	.10
Age	0.80	0.57	.21
R^2		.05	
Step 2			
Constant	27.19	20.38	
BAS	3.62	1.32	.42**
BIS	1.60	2.00	.13
R^2		0.20	
ΔR^2		0.15*	

* $p < .05$.
** $p < .01$.
men = 1, women = 0.

The current study also conducted exploratory analyses examining the relationship between BIS and health-related behaviours. The results showed that for both men and women, a more active BIS was associated with lower alcohol consumption. However, a more active BIS was not associated with lower intake of saturated fat and added sugar, a reduced likelihood of binge drinking and being a smoker or, amongst smokers, smoking frequency. The absence of effects for these other health-related behaviours suggests that the significant association between BIS and alcohol consumption may be due to factors unrelated to long-term health consequences. For example, it may be that those with a more active BIS are more concerned about the immediate consequences of alcohol consumption. Further research would be needed to establish this. Nevertheless, the present data suggest that, in general, BIS does not function as a protective factor when it comes to health-related behaviours with long-term outcomes. Instead, the results showed a positive relationship between BIS and total sugar intake, consistent with the idea that those with higher BIS may indulge in more 'comfort eating,' possibly as a result of higher levels of anxiety (see Hasking, 2006). That this association occurred for sugar but not fat may be due to the higher reward value of sugar (Stice et al., 2013).

It is important to acknowledge the limitations of the present study. Whilst the study used a community sample of men and women rather than students or all women, it was nonetheless restricted to adults, contained a higher proportion of women compared to men and tended to be better educated than average (http://wales.gov.uk/docs/statistics/2013/130424-key-education-statistics-2013-en.pdf). The research was also restricted to distal predictors of health behaviours. Research has suggested that these may interact with more proximal predictors, such as coping strategy, to influence behaviours (Corr, 2008; Hasking, 2006). It would be useful to examine this in future studies as well as employ measures of BIS and BAS that take account of recent theoretical revisions to RST (Corr, 2008; Corr & McNaughton, 2008). Such research could eventually lead to the development of more individually tailored health advice and intervention.

Acknowledgements

This research was supported by a grant from the Economic and Social Research Council, (UK) awarded to Tapper, Maio, Haddock and Lewis, grant number RES-062-23-1529.

References

Armitage, C. J., & Conner, M. (1999). The theory of planned behaviour: Assessment of predictive validity and ''perceived control''. *British Journal of Social Psychology, 38*, 35–54.

Beaver, J. D., Lawrence, A. D., van Ditzhuijzen, J., Davis, M. H., Woods, A., & Calder, A. J. (2006). Individual differences in reward drive predict neural responses to images of food. *The Journal of Neuroscience, 26*, 5160–5166.

Bingham, S., & Day, K. (1987). Average portion weights of foods consumed by a randomly selected British population sample. *Human Nutrition: Applied Nutrition, 41A*, 258–264.

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

Connors, M., Bisogni, C. A., Sobal, J., & Devine, C. M. (2001). Managing values in personal food systems. *Appetite, 36*, 189–200.

Corr, P. J. (2008). Reinforcement sensitivity theory (RST): Introduction. In P. J. Corr (Ed.), *The reinforcement sensitivity theory of personality* (pp. 1–43). Cambridge: Cambridge University Press.

Corr, P. J., & McNaughton, N. (2008). Reinforcement sensitivity theory and personality. In P. J. Corr (Ed.), *The reinforcement sensitivity theory of personality* (pp. 155–187). Cambridge: Cambridge University Press.

Cox, W. (2003). *Alcohol use questionnaire*. Bangor, Wales, UK: Bangor University.

Davis, C., & Fox, J. (2008). Sensitivity to reward and body mass index (BMI): Evidence for a non-linear relationship. *Appetite, 50*, 43–49.

Davis, C., Patte, K., Levitan, R., Reid, C., Tweed, S., & Curis, C. (2007). From motivation to behaviour: A model of reward sensitivity, overeating, and food preferences in the risk profile for obesity. *Appetite, 48*, 12–19.

Everitt, B. J., & Robbins, T. W. (2005). Neural systems of reinforcement for drug addiction: From actions to habits to compulsion. *Nature Neuroscience, 8*, 1481–1489.

Feil, J., & Hasking, P. (2008). The relationship between personality, coping strategies and alcohol use. *Addiction Research and Theory, 16*, 526–537.

Foods Standards Agency (2002). *McCance and Widdowson's the composition of foods* (6th summary ed.). Cambridge: Royal Society of Chemistry.

Foods Standards Agency (2008). *Manual of nutrition* (11th ed.). London: TSO.

Frank, S., Laharnar, N., Kullmann, S., Veit, R., Canova, C., Li Hegner, Y., et al. (2010). Processing of food pictures: Influence of hunger, gender and calorie content. *Brain Research, 1350*, 159–166.

Franken, I. H. A., & Muris, P. (2006). Personality characteristics and college students' substance use. *Personality and Individual Differences, 40*, 1497–1503.

Hasking, P. A. (2006). Reinforcement sensitivity, coping, disordered eating and drinking behaviour in adolescents. *Personality and Individual Differences, 40*, 677–688.

Knyazev, G. G., Slobodskaya, H. R., Kharchenko, I. I., & Wilson, G. D. (2004). Personality and substance use in Russian youths: The predictive and moderating role of behavioral activation and gender. *Personality and Individual Differences, 37*, 827–843.

Loxton, N. J., & Dawe, S. (2001). Alcohol abuse and dysfunctional eating in adolescent girls: The influence of individual differences in sensitivity to reward and punishment. *International Journal of Eating Disorders, 29*, 455–462.

Margetts, B., Cade, J., & Osmond, C. (1989). Comparison of a food frequency questionnaire with a diet record. *International Journal of Epidemiology, 18*, 868.

Norman, P., Boer, H., & Seydel, E. R. (2005). Protection motivation theory. In M. Conner, & P. Norman (Eds.), *Predicting Health Behaviour* (pp. 81–126.). Maidenhead: Open University Press.

O'Connor, R. M., Stewart, S. H., & Watt, M. C. (2009). Distinguishing BAS risk for university students' drinking, smoking, and gambling behaviors. *Personality and Individual Differences, 46*, 514–519.

Rollins, B. Y., Loken, E., Savage, J. S., & Birch, L. L. (2014). Measurement of food reinforcement in preschool children. Associations with food intake, BMI and reward sensitivity. *Appetite, 72*, 21–27.

Stice, E., Burger, K., & Yokum, S. (2013). Relative ability of fat and sugar tastes to activate reward, gustatory, and somatosensory regions. *The American Journal of Clinical Nutrition, 98*, 1377–1384.

Tapper, K., Pothos, E. M., & Lawrence, A. D. (2010). Feast your eyes: Hunger and trait reward drive predict attentional bias for food cues. *Emotion, 10*, 949–954.

Thompson, R. L., & Margetts, B. M. (1993). Comparison of a food frequency questionnaire with a 10-day weighed record in cigarette smokers. *International Journal of Epidemiology, 22*, 824–833.

Voigt, D. C., Dillard, J. P., Braddock, K. H., Anderson, J. W., Sopory, P., & Stephenson, M. T. (2009). Carver and White's (1994) BIS/BAS scales and their relationship to risky health behaviours. *Personality and Individual Differences, 47*, 89–93.