A Trait Conceptualization of Reward-Reactivity

Psychometric Properties of the Appetitive Motivation Scale (AMS)

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Abstract. The Appetitive Motivation Scale (AMS; Jackson & Smillie, 2004) represents a recent attempt to conceptualize individual differences in the functioning of Gray's (1981) Behavioral Activation/Approach System (BAS). In this paper we subject the AMS to psychometric scrutiny via factor analysis, item response theory (IRT) analysis, and concurrent construct validation. In Study 1 (N = 1,366 university students, 53% male), results from factor analysis (FA) and IRT led to the removal of several problematic items from the scale. The revised AMS was shown to have improved unidimensional structure and item properties. In Study 2 (N = 122 university students, 20% male), correlational data and factor analysis indicated that the revised AMS was: (1) highly related to the original scale along with various BAS-related measures, and (2) more strongly related to a *reward-reactivity* factor than an *impulsivity* factor, relative to other putative BAS measures. We conclude that the improved AMS is a promising tool for future research.

Keywords: BAS, Appetitive Motivation Scale, RST, Gray, item response theory

Jeffrey Gray's (1970, 1981, 1991) reinforcement sensitivity theory of personality (RST; see Corr, 2008) is widely regarded as the proverbial "head" of a family of theories which form the standard model for the biological explanation of personality (Depue, 2006; Revelle, 2008). This theoretical influence is wielded despite a relative lack of decisive empirical support[1]; this being the contentious subject of many reviews over the last decade (Corr, 2001; Mathews & Gilliland, 1999; Pickering et al., 1997; Smillie, Pickering, & Jackson, 2006). The focus of our 2006 review concerned difficulties surrounding trait operationalization of RST constructs. We see this as a key agenda for RST research, and an unfortunate cost of Gray's rigorous bottom-up approach; by focusing first on potential underlying *causes* of personality, RST lacked – and, we believe, continues to lack – an adequate measurement system.

For one aspect of Gray's model, the Behavioral Activation/Approach System (BAS), ambiguities regarding trait representation have been particularly limiting. The concept of the BAS is based primarily on the reward mechanism suggested by Olds and Olds' (1965) classic animal learning experiments, which showed that rats spontaneously bar-press (for considerable time periods) to stimulate the medial forebrain and related regions via implanted electrodes. Gray (1973) suggested that phenotypic variation in the functioning of this reward mechanism, now widely agreed to have its basis in the mesolimbic dopamine system (Bozarth, 1991; Depue, 2006; Pickering & Gray, 1999), may underlie individual differences in trait impulsivity. Striking recent evidence for this proposal includes the observation that rats which have been outbred for impulsive behavior (premature responding to a reward cue) differ significantly in terms of intravenous cocaine self-administration and predrug exposure dopamine function (Dalley et al., 2007). Linking BAS variation with trait impulsivity in humans, however, has been considerably more difficult. To begin with, the concept of impulsivity is fragmented and heterogeneous (Arce & Santesteban, 2006; Evenden, 1999), as revealed by the multitude of psychometric and behavioral measures which conceive of impulsivity in fundamentally different ways. Furthermore, there is growing evidence at multiple levels of analysis which casts doubt on any direct link between this cluster of impulsivity traits and indices of BAS function (Depue & Collins, 1999; Jackson, 2005; Jackson, in press; Quilty & Oakman, 2004; Smillie, Dalgleish, & Jackson, 2007). These data suggest, for instance, that measures of impulsivity do not predict dopaminergic activity or behavioral effects of reward, and that they dissociate from purpose-built "BAS scales" when subjected to factor analysis[2].

1 In terms of human data; the support for RST based upon animal models is extensive (e.g., Gray & McNaughton, 2000).
2 There are, however, notable exceptions to this body of evidence (e.g., Martin & Potts, 2004).

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Several purpose-built measures of trait reward-reactivity have been put forward in a more focused attempt to capture BAS-related personality variance, but these measures tend also to be conceptually mixed. For example, in the most widely-used RST self-report instrument, the BIS/BAS scales (Carver & White, 1994), the BAS is measured by three related factors (Reward Responsiveness, Drive, and Fun Seeking). This tripartite factor structure has been widely replicated (Cogswell, Alloy, van Dulmen, & Fresco, 2006; Cooper, Gomez, & Aucote, 2007), and the factors consistently diverge in terms of concurrent and predictive validity (Carver, 2004; Smillie, Jackson, & Dalgleish, 2006). The Sensitivity to Reward scale (SR) is an alternative measure designed by Torrubia, Avila, Molto, and Caseras (2001) to provide a unidimensional measure of the BAS. Confirmatory and exploratory factor analyses of this measure have not, however, supported a one-factor structure (Cogswell et al., 2006; O'Connor, Colder, & Hawk, 2004), and concurrent validation data suggests that SR reflects a combination of impulsivity and reward-reactivity (Caseras, Avila, & Torrubia, 2003; Smillie & Jackson, 2006). In sum, it seems that trait conceptualization of Gray's reward system remains an unresolved problem within RST.

A potential explanation of the discordance characterizing existing BAS measures is the historical influence of the elusive impulsivity concept on their design. This being our view, we (Jackson & Smillie, 2004) published the Appetitive Motivation Scale (AMS), which we conceived of as a potential BAS measure that deviates somewhat from the ubiquitous impulsivity-centric approach adopted thus far. The AMS demonstrates good internal consistency, good concurrent validity, and has been shown to predict multiple behavioral indices of reward-reactivity as well as the most popular BAS-type measures in the literature (see Jackson & Smillie, 2004; Smillie & Jackson, 2005, 2006). There is, however, a current paucity of data concerning basic psychometric properties of the scale (the exploratory factor analysis reported by Jackson & Smillie, 2004, lacked sufficient detail, owing to constraints of space). Further, there has been a disappointing lack of new data seeking to replicate or extend the validation studies we have published.

In the present paper, we firstly subject the AMS to a confirmatory factor analysis (CFA) to determine the viability of the proposed one-factor solution, and further examine psychometric properties through the use of item response theory (IRT; Study 1). Suggestions for revisions to the scale are to be made as necessary. Secondly, a replication and extension of Jackson and Smillie's (2004) key findings regarding validity is sought (Study 2). Recommendations will be offered concerning future use of this scale, which we hope will offer constructive aid to the successful application of Gray's theory to human personality.

Study 1

Study 1 reports on the psychometric properties of the AMS and, if necessary, proposes revisions to the measure. The first aim is to test the proposed one factor structure of the AMS using Confirmatory Factor Analysis (CFA). Jackson and Smillie (2004) used a Principal Components Analysis to explore the factor structure of the AMS ($N = 152$). They suggested a one factor solution, largely based on an inspection of the scree plot. The first eigenvalue accounted for 21% of the variance, and *most* factor loadings were above 0.30. On this basis, the scale was theorized to have a one factor structure and was utilized accordingly. Cronbach's α for the AMS is typically around .80, suggesting adequate internal consistency. The present study will build upon this preliminary research using data from a much larger sample of participants ($N = 1{,}366$), randomly assigned to either a test sample group or cross-validation sample group.

The second aim of Study 1 is to examine the psychometric properties of the AMS using Item Response Theory (IRT). IRT can potentially offer some advantages over Classical Test Theory (CTT) methods for analyzing personality data (Embretson & Reise, 2000; Reise & Henson, 2003). IRT can provide information about measurement precision across the range of the latent trait at both the item and test level, rather than simply providing a single reliability estimate for all participants. This can assist greatly in the identification of items that may contribute little to measurement precision at the total test level. For example, Gomez, Cooper, and Gomez (2005) recently used IRT to examine the BIS/BAS scales. They highlighted problems with the Reward Responsiveness subscale, showing that measurement precision was poor for high-scorers on the latent trait, and that category response curves overlapped substantially for some items. If necessary, on the basis of the CTT and IRT analyses with the test sample, revisions to the AMS will be proposed. These revisions will then be tested on the cross-validation sample.

Method

Participants

In all, 1,366 participants completed the AMS, of which 471 were male and 884 were female (11 participants did not record gender). All participants were students at the University of Queensland in Brisbane, Australia. Information about age categories was recorded for 1,257 of the participants. 43.4% of participants were aged 18 to 20 years, 30.8% were aged 21 to 25 years, 10.6% were aged 26 to 30 years, 5.6% were aged 31 to 35 years, and 9.3% were older than 35 years. Prior to the analysis of the data, the total sample was randomly assigned to either a test sample or cross-validation sample. Each sample comprised 683 participants. There were 252 males and 427 females in the test sample (4 participants did not record their gender), and there were 219 males and 457 females in the cross-validation sample (7 participants did not record gender).

Measure

The AMS consists of 20 items relating to reward-reactivity and behavioral activation (e.g., "I like to be rewarded"; "I actively look for new experiences"). The full version is freely available for research and noncommercial applications in Jackson and Smillie (2004). It should be noted that the original version of the AMS used a dichotomous response scale (true/false). In the current studies we will report on a version of the AMS using a polytomous response format. In Study 1, the AMS had a Likert-style response option format, ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). The middle response option was "Undecided." A total score is calculated by summing the item scores.

Procedure

Following ethics approval, participants were recruited via a research participation scheme and local advertisements at the University of Queensland. All testing took place in a classroom environment with groups ranging from 5 to 20 individuals. Participants completed the AMS as part of a battery of related personality questionnaires, and were asked to follow the standardized instructions for each questionnaire in the booklet. Upon completion, participants were debriefed and thanked for their time.

Data Analysis

The confirmatory factor analysis (CFA) was conducted using the MPlus 4.2 software program (Muthen & Muthen, 2006). The CFA model was tested using maximum likelihood estimation of the sample covariance matrix. Model fit was tested using the minimum fit function χ^2. As χ^2 values can potentially be inflated by large sample sizes, fit was also examined using three approximate fit indices: the root mean square error of approximation (RMSEA; Steiger, 1990), the comparative fit index (CFI; Bentler, 1990), and the standardized root mean square residual (SRMR). The RMSEA provides a measure of model fit relative to the population covariance matrix when the complexity of the model is taken into account. RMSEA values < .05 are taken as good fit, .05 to .08 as moderate fit, .08 to .10 as marginal fit and > .10 as poor fit (Browne & Cudeck, 1993; Hu & Bentler, 1999). The CFI provides a measure of the fit of the hypothesized model relative to the independent model, with values usually ranging from 0.00 to 1.00. For the CFI, values above .95 are suggestive of good model fit. SRMR is the standardized difference between the observed covariance matrix and predicted covariance matrix. Values less than .08 tend to be suggestive of good model fit (Hu & Bentler, 1999).

Exploratory factor analysis (EFA) was conducted using FACTOR 7 (Lorenzo-Seva & Ferrando, 2006), a specialist EFA software package. Factors were extracted from the sample correlation matrix using maximum likelihood estimation. The number of factors extracted was based on the results of a parallel analysis using marginally bootstrapped samples (Horn, 1965; O'Connor, 2000), the minimum average partial (MAP; Velicer, 1976) test and a visual inspection of the scree plot.

The IRT analyses were conducted using Multilog 7.0.3 (Thissen, Chen, & Bock, 2003). In IRT, the response to the item is used to obtain continuous scaled estimates of the underlying latent trait, theta (θ). Two item parameters produced by IRT are the item difficulty (or threshold) parameter and the item discrimination (or slope) parameter. The threshold parameter (β) indicates the point on the scale of the latent trait where an individual has a 0.5 probability of responding positively to the item. The item discrimination parameter (α) is the ability of an item to discriminate people of different levels of the underlying trait below and above the threshold parameter (Embretson & Reise, 2000; Steinberg & Thissen, 1995). According to Baker (2001), α values 0.01 to 0.24 are very low, 0.25 to 0.64 are low, 0.65 to 1.34 are moderate, 1.35 to 1.69 are high, and more than 1.7 are very high. Graphs of trace lines or curves are generated for each item, showing the probability of a positive response to the items as a function of the underlying trait. In the IRT models used in most applied research, these curves are logistic functions. IRT models also provide information functions for each item and for the total scale. These are called the item information function (IIF) and the test information function (TIF), respectively. The IIF indicates the measurement precision of an item across different levels of the trait, while the TIF indicates the measurement precision of the total test score across different levels of the trait. The TIF represents the sum of the constituent IIFs for that scale. IRT also provides the standard error of measurement (SEM) of the IIFs and TIF. As the SEM of a TIF is the inverse of the square root of the TIF, the SEM values can be viewed as indicators of the precision of the test at different trait levels (Embretson & Reise, 2000).

As the AMS has a polytomous response format, an appropriate IRT model in this case would be the graded response model (GRM; Samejima, 1969). The GRM has proven an appropriate model with other personality-related measures (e.g., Gomez et al., 2005; Rubio, Aguado, Hontangas, & Hernandez, 2007). With the GRM, logistic curves called category response curves (CRCs) are generated in a two-step process for each response option within each item. CRCs for each response option represent the probability of responding positively to that option conditional on the value of θ. The CRC for the first response option will be a monotonically decreasing logistic function, while the CRC for the last response option will be a monotonically increasing logistic function. The CRCs for the middle response options will all be nonmonotonic logistic functions. For any level of θ, the sum of the response probabilities should be 1. The CRCs that result can then be graphed and used to examine the properties of the item. In the GRM, discrimination parameters are constrained equal for the response options within an item, but are free to vary across items. The threshold parameters indicate the point along θ where the response categories intersect. Thus, the number of threshold parameters for each item will be equal to the number of response categories for each item minus 1. Hence, an item with five response options would provide four β parameters and one α parameter (Embretson & Reise, 2000).

Certain assumptions must be met prior to using IRT, namely unidimensionality and model-data fit. Unidimensionality can be assessed in a number of ways. Reise, Smith, and Furr (2001) have suggested that strict forms of unidimensionality may be unrealistic for "high bandwidth" personality traits, as opposed to narrower constructs. In this study, IRT will be appropriate if it can be shown a general dominant factor is present in the data. This will be examined by using one factor CFA models and examining the ratio of first to second eigenvalues using EFA. Multilog provides the observed and expected proportion of responses to each response option, with the expected proportion an estimated value based on the item parameters and latent trait distribution. Analysis of the residuals associated with the observed and expected proportions for each item response option can help illustrate model-data fit, with larger residuals indicating poorer fit.

Results and Discussion

Test Sample

Descriptive Statistics

Table 1 shows the mean, standard deviation, skewness and kurtosis values for the AMS total, separately for males and females. An independent samples *t*-test found no significant difference between males and females for the AMS total, $t(677) = 0.91$, $p > .05$. According to Curran, West, and Finch (1996), for univariate normality, skewness and kurtosis values of 0 to 2, and 0 to 7, respectively, can be taken as demonstrating sufficient normality. The skewness and kurtosis values for the total score for males and females can be seen in Table 1. For all participants, the skewness and kurtosis values for the AMS items ranged from –1.28 to 0.27 and –0.87 and 2.45, respectively. On the basis of the criteria proposed by Curran et al. (1996), all of the AMS items and the total score had sufficient normality.

Table 1. Mean, standard deviation, skewness, and kurtosis for the AMS

	Appetitive Motivation Scale total	
	Males	Females
Mean	74.38	73.70
SD	9.67	9.00
Skewness	0.01	0.09
Kurtosis	0.15	0.42

Confirmatory Factor Analysis

CFA was used to test the theorized one factor structure of the AMS. A one factor model was tested, with all 20 items loading on the latent AM factor. There were no covariances specified between the indicator residuals. The goodness-of-fit indexes were mixed, χ^2 (170, N = 683) = 1292.23, $p <$ .0001; RMSEA = 0.098 (90% CI = .093–.103), CFI = 0.66; SRMR = 0.079. The SRMR index indicated good model fit, the RMSEA indicated marginal or mediocre model fit, and the CFI indicated poor model fit. Hu and Bentler (1999) have suggested the CFI index is most sensitive to misspecified factor loadings. The standardized factor loadings for the 20 items ranged from 0.25 to 0.64, with a number of loadings below 0.35. Thus, the one factor model may show less than acceptable fit for the CFI on the basis of misspecified factor loadings. On the basis that the CFA of the theorized one factor model only showed moderate to poor model fit, an EFA was undertaken to further explore the factorial structure of the measure.

Exploratory Factor Analysis

The KMO measure of sampling adequacy was 0.83, suggesting factor analysis was appropriate for this sample. The results of the parallel analysis suggested three factors should be extracted, although O'Connor (2000) has suggested a parallel analysis can lead to an overextraction of factors. The MAP test suggested one factor should be extracted and a visual inspection of the scree plot also suggested a one factor solution was appropriate (see Figure 1 for the scree plot). We also ran two and three factor solutions, however the resultant factor structures proved largely uninterpretable, suggesting a one factor solution was preferable. The first four eigenvalues were 5.14, 1.82, 1.43 and

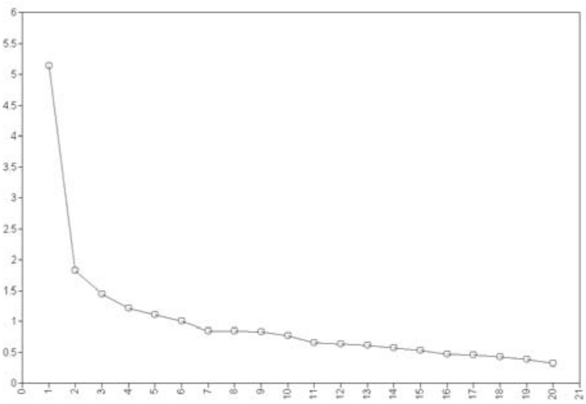

Figure 1. Scree plot for the exploratory factor analysis of the AMS.

Table 2. Factor loading matrix from exploratory factor analysis of the AMS

Items	Factor loading
1. Believe rules are stifling	0.31
2. Put plans into action	0.35
3. Like to be busy	0.36
4. Like to see how things work	0.46
5. Choose which rules to follow	0.38
6. Like things new and different	0.62
7. Like to do things spontaneously	0.54
8. Like to do things my way	0.41
9. Do several things at same time	0.43
10. Important to enjoy moment	0.44
11. Actively look for new experiences	0.64
12. Feel for how things work	0.49
13. Look for new sensations	0.60
14. Excited by what is new in my field	0.47
15. Often lots of ideas	0.51
16. Prefer not to plan too much	0.21
17. Like to be rewarded	0.40
18. Here and now is important	0.43
19. New ideas all the time	0.56
20. Enjoy new projects	0.43

1.20. The first eigenvalue accounted for 26% of the variance. Table 2 shows the extracted factor matrix for the AMS items. While most factor loadings were above 0.35, Item 1 ("I believe rules are stifling") and Item 16 ("I prefer not to plan too much") had relatively low factor loadings (in this case below 0.35). On the basis of the factor loadings, it was decided to remove Items 1 and 16 from further analyses.

Item Response Theory Analysis

To test for unidimensionality, a maximum likelihood EFA procedure similar to that reported above was used. The first eigenvalue was 4.99 and the second eigenvalue was 1.48, with the ratio between the two values being 3.37:1. In addition, the MAP test and a visual inspection of the scree plot suggested an extraction of one factor was appropriate. This would appear to suggest the presence of a sufficiently strong unidimensional factor to allow an IRT analysis. Examination of the model-data fit residuals produced by Multilog showed that most residuals were .00, with no residuals higher than .01. This suggests good model-data fit.

Table 3 shows the item threshold and discrimination parameters for each item in the revised AMS. It can be seen that all item discrimination parameters were at least moderate in value, with 5 items having high to very high values. The threshold parameters showed that the β_1 to β_3 parameters were below the mean of the latent trait for all items, while the β_4 parameter values for each item were above the mean of the latent trait. The relatively low values of the β_1 to β_3 parameters, in particular the fact that all β_3 values were below the mean of the latent trait, would appear to indicate that participants found the items relatively *easy* to endorse (e.g., for several items, individuals 1.5 to 2 *SD* units below the latent trait mean were agreeing with the item content).

Examination of the CRC plots for each item indicated that for several items there was substantial overlap between the response categories. In particular, the "agree" response option tended to largely subsume the other response categories below + 1 *SD* unit above the latent trait mean. For Item 5 ("I choose which rules to follow"), the "disagree" and "agree" response options largely covered the range below and above the mean of the latent trait, suggesting that a dichotomous

Table 3. IRT parameter estimates and standard errors for the AMS

	Item parameter estimates				
Items	α	β_1	β_2	β_3	β_4
2. Put plans into action	0.94 (0.12)	–5.19 (0.81)	–2.92 (0.38)	–1.72 (0.24)	2.60 (0.32)
3. Like to be busy	0.93 (0.12)	–5.58 (0.91)	–2.48 (0.32)	–1.47 (0.21)	1.62 (0.22)
4. Like to see how things work	1.22 (0.13)	–4.30 (0.59)	–2.30 (0.25)	–1.77 (0.19)	1.13 (0.14)
5. Choose which rules to follow	0.91 (0.11)	–4.48 (0.69)	–1.27 (0.20)	–0.57 (0.14)	2.79 (0.32)
6. Like things new and different	2.04 (0.18)	–3.22 (0.42)	–1.87 (0.15)	–1.18 (0.09)	0.93 (0.09)
7. Like to do things spontaneously	1.34 (0.12)	–3.07 (0.33)	–1.41 (0.13)	–0.56 (0.10)	1.46 (0.15)
8. Like to do things my way	0.98 (0.11)	–5.17 (0.83)	–2.36 (0.29)	–1.50 (0.20)	1.31 (0.18)
9. Do several things at same time	1.14 (0.12)	–4.52 (0.67)	–1.63 (0.19)	–0.91 (0.13)	1.45 (0.17)
10. Important to enjoy moment	1.23 (0.13)	–4.58 (0.71)	–2.87 (0.33)	–2.08 (0.23)	0.59 (0.12)
11. Actively look for new experiences	1.98 (0.16)	–2.69 (0.27)	–1.25 (0.10)	–0.45 (0.07)	1.22 (0.11)
12. Feel for how things work	1.47 (0.14)	–3.72 (0.51)	–1.90 (0.19)	–0.97 (0.11)	1.58 (0.15)
13. Look for new sensations	1.77 (0.15)	–3.37 (0.42)	–1.53 (0.13)	–0.66 (0.08)	1.33 (0.12)
14. Excited by what is new in my field	1.30 (0.12)	–3.68 (0.47)	–1.69 (0.18)	–0.91 (0.12)	1.34 (0.15)
15. Often lots of ideas	1.31 (0.12)	–3.83 (0.46)	–1.50 (0.16)	–0.46 (0.10)	1.78 (0.17)
17. Like to be rewarded	0.99 (0.11)	–5.85 (1.03)	–2.99 (0.37)	–1.71 (0.22)	0.91 (0.15)
18. Here and now is important	0.97 (0.11)	–4.66 (0.65)	–1.80 (0.23)	–0.75 (0.14)	1.98 (0.24)
19. New ideas all the time	1.43 (0.13)	–3.59 (0.44)	–1.25 (0.13)	–0.24 (0.08)	1.76 (0.16)
20. Enjoy new projects	1.17 (0.12)	–3.62 (0.44)	–1.78 (0.20)	–0.84 (0.12)	1.80 (0.19)

Note. Items 1 and 16 have been removed; item numbering is based on the original scale. α = discrimination parameter; β_1, β_2, β_3, and β_4 = threshold parameters.

Table 4. Item and test information functions for the AMS at various levels of the trait

Items	Estimated trait						
	–3.0	–2.0	–1.0	0	1.0	2.0	3.0
2. Put plans into action	0.27	0.26	0.22	0.17	0.17	0.21	0.21
3. Like to be busy	0.24	0.26	0.24	0.22	0.23	0.22	0.15
4. Like to see how things work	0.42	0.44	0.36	0.33	0.9	0.29	0.13
5. Choose which rules to follow	0.21	0.22	0.24	0.3	0.20	0.21	0.21
6. Like things new and different	1.10	1.19	1.09	0.70	1.04	0.38	0.06
7. Like to do things spontaneously	0.49	0.52	0.55	0.49	0.48	0.40	0.18
8. Like to do things my way	0.27	0.29	0.27	0.25	0.26	0.22	0.13
9. Do several things at same time	0.30	0.36	0.39	0.35	0.35	0.30	0.16
10. Important to enjoy moment	0.46	0.44	0.35	0.38	0.36	0.19	0.07
11. Actively look for new experiences	0.91	0.99	1.17	0.97	1.01	0.57	0.11
12. Feel for how things work	0.58	0.63	0.62	0.45	0.50	0.49	0.21
13. Look for new sensations	0.79	0.75	0.93	0.72	0.78	0.56	0.15
14. Excited by what is new in my field	0.45	0.48	0.50	0.43	0.44	0.36	0.16
15. Often lots of ideas	0.42	0.45	0.52	0.46	0.44	0.45	0.24
17. Like to be rewarded	0.29	0.29	0.27	0.26	0.26	0.19	0.10
18. Here and now is important	0.25	0.27	0.28	0.26	0.25	0.25	0.19
19. New ideas all the time	0.50	0.49	0.61	0.58	0.52	0.51	0.25
20. Enjoy new projects	0.39	0.41	0.41	0.35	0.34	0.35	0.22
TIF	9.31	9.79	10.03	8.58	9.01	7.12	3.92
SEM	0.20	0.19	0.18	0.20	0.20	0.26	0.44
R	0.89	0.90	0.90	0.88	0.89	0.86	0.74

Note. Items 1 and 16 have been removed; item numbering is based on the original scale. *TIF* = test information function; *SEM* = standard error of measurement; *R* = reliability.

response format would be more appropriate in this case. Despite this, there were a number of items that showed a clearer separation between response categories, although in general the response categories indicating disagreement covered less of the latent trait range than the response categories indicating item agreement. Examples in this case would be Item 11 ("I actively look for new experiences") and Item 13 ("I look for new sensations"). A notable feature of many of the CRC plots was that the middle response option ("Undecided") was largely redundant.

Table 4 shows the item and test information function values for each item and the scale as a whole, respectively. It also displays the standard error of measurement and reliability values for selected values of the latent trait. Table 4 shows that for several items the IIF values were relatively low and uniform across the entire latent trait range. Examples of this are Item 5 ("I choose which rules to follow") and item 18 ("The here and now is what is important"). There were a number of items that had relatively high IIF values across most of the latent trait range however (e.g., Items 11 and 13). There was a general tendency, however, for IIF values to decrease above +2 *SD* units above the mean of the latent trait. The TIF values were relatively high across most of the latent trait range, decreasing sharply above +2 *SD* units above the mean of the latent trait. Overall, measurement precision was relatively high for most individuals completing the AMS.

Scale Revision

The findings from the test sample, in which the factor structure and psychometric properties of the AMS were examined, can be summarized as follows: First, support for a one-factor structure of the AMS was shown to be mixed. In the CFA, the overall model χ^2 was highly significant, the RMSEA and SRMR indexes suggested good to marginal model fit, and the CFI index suggested poor model fit. In the EFA, parallel analysis suggested three factors should be extracted, while the MAP test and inspection of the scree plot suggested one factor should be extracted. Interpretability argued for a one factor solution; however, two items were found to have low factor loadings (below 0.35). It was decided on this basis to remove from further analyses Item 1 ("I believe that rules are stifling"), and Item 16 ("I prefer not to plan things too much").

Next, IRT analyses provided mixed support for the AMS in its current form. While many items had acceptable psychometric properties on the basis of this analysis, several items had CRCs showing that the response categories largely overlapped, with the "agree" response option largely subsuming the lower response categories. Also, several items had low IIF values across the latent trait range, indicating minimal contribution to measurement precision for the total scale. It was decided on this basis to remove further items showing poor psychometric properties: Item 2 ("I put plans in to action"), Item 3 ("I like to be busy"), Item 4 ("I like to see how things work"), Item 5 ("I choose which rules to follow"), Item 8 ("I like to do things my way"), Item 10 ("It is important to enjoy the present moment") and Item 18 ("The here and now is what is important"). Thus, on the basis of the CTT and IRT analyses, a total of 9 items were removed, leaving 11 items remaining in the AMS.

Cross-Validation Sample

Descriptive Statistics

The revised AMS had a mean of 40.93 (SD = 6.38) for males and a mean of 41.28 (SD = 6.25) for females. An independent samples t-test showed that this difference was not significant, $t(674) = 0.68$, $p > .05$. The skewness and kurtosis values for the individual items and the scale total were all within acceptable bounds (Curran et al., 1996). Cronbach's α for the revised AMS was 0.83, indicating the shortened measure still had good internal reliability.

Confirmatory Factor Analysis

CFA was used to test the theorized one factor structure of the AMS. A one factor model was tested, with all 11 items loading on the latent AM factor. There were no covariances specified between the indicator residuals. The goodness-of-fit indexes indicated moderate to good model-data fit, χ^2 (44, N = 683) = 265.19, $p < .0001$; RMSEA = 0.086 (90% CI = .076 – .096), CFI = 0.88; SRMR = 0.051. The standardized factor loadings for the 11 items ranged from 0.35 to 0.67. Thus, a one factor model would appear to be appropriate for the revised AMS.

Item Response Theory Analysis

An IRT analysis, using the data analytic procedure described above, was then carried out for the revised AMS with the cross-validation sample[3]. The CFA analysis presented above would suggest there is a dominant unidimensional factor in the AMS. In addition, an EFA using maximum likelihood estimation showed a strong single factor: The first eigenvalue was 4.14 and the second eigenvalue was 1.02, with the ratio between the two values being 4.06:1. The data would appear to be sufficiently unidimensional for an IRT analysis. Examination of the model-data fit residuals produced by Multilog showed that most residuals were .00, with no residuals higher than .01. This suggests good model-data fit.

The α and β parameters for the 11 items in the cross-validation sample were largely similar to those obtained in the test sample. The α parameters were in the high to very high range, and the β parameters indicated reasonably good cov-

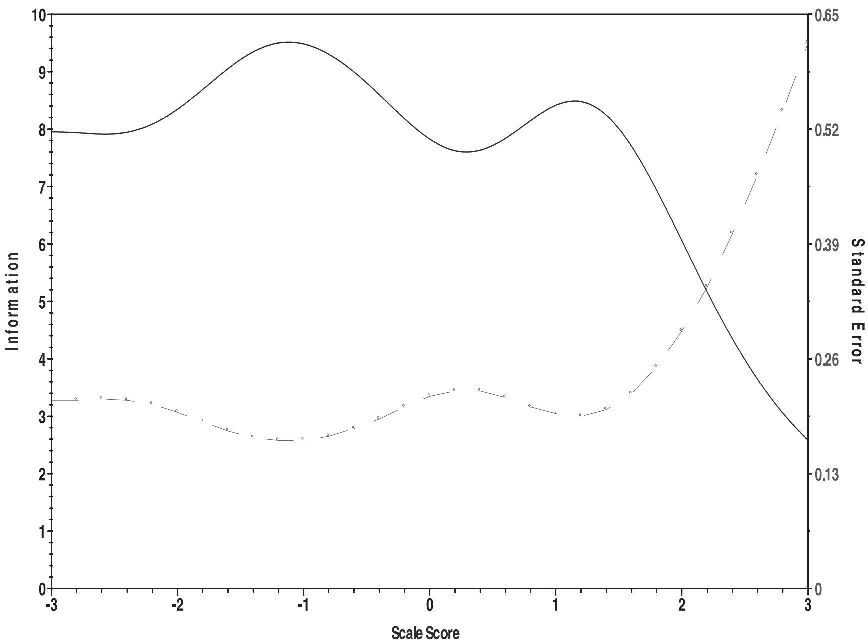

Figure 2. Test information function (——) and standard error of measurement (-----) values for the revised AMS.

[3] For reasons of space, only a brief description of the IRT analyses will be presented here. Details of the full IRT analysis can be obtained from the first author.

erage of the latent trait range. Examination of the CRC plots showed reasonably good separation between the response options, although as with the test sample the middle response option ("Undecided") was largely redundant. Item 17 ("I like to be rewarded") did perform slightly more poorly in the cross-validation sample than in the test sample. Examination of the CRC plot for this item showed that the "Agree" response option tended to subsume most of the lower response options. IIF values tended to be high for all items across most of the latent trait range, although they tended to decrease above +2 *SD* units above the mean of the latent trait. Figure 2 shows the TIF and SEM values for the revised AMS. The TIF curve is largely similar to that seen with the test sample. TIF values are relatively high across most of the latent trait range, though they decrease sharply above +2 *SD* units above the mean of the latent trait. In summary, both the CFA and IRT analyses with the cross-validation sample show that the revised AMS fits more closely with the theorized one factor structure of the scale and the remaining items have acceptable to good psychometric properties.

Study 2

Study 2 reports on the construct validity of the AMS, and compare the shortened 11-item version with the original 20-item version. Jackson and Smillie (2004) correlated the AMS with various personality measures ($N = 59$) and reported significant relationships with various BAS-related traits. The present study will build upon this research to further examine convergent and divergent validity in a larger and different sample ($N = 122$), again comparing the revised and original versions of the AMS.

Method

Participants

The participants comprised 122 individuals, of which 22 were male and 99 were female (1 participant did not record gender). All of the participants were first year psychology students at Goldsmiths, University of London. Individuals participated in the study as credit for their first year psychology course. Participants' age ranged from 17 to 45 years, with a mean age of 20.70 years ($SD = 5.24$).

Measures

Appetitive Motivation Scale (AMS Revised)

The AMS has been described in detail above. Participants in this study completed the full version of the measure. On the basis of the IRT analyses reported in Study 1, it was decided to remove the middle response option category of "Undecided"; all responses to items were made using a four point Likert-style response category, ranging from 1 ("Strongly Disagree") to 4 ("Strongly Agree"). Cronbach's α was 0.83 for the full scale and 0.81 for the revised scale in this sample. Thus, despite a near 50% reduction in length, the revised AMS maintained good internal consistency.

The BIS/BAS Scales

The BIS/BAS Scales (Carver & White, 1994) is the most widely-used self-report measure specifically developed for RST research. This questionnaire consists of a total of 20 items, each rated on a four point Likert-type scale. These form a single scale based upon Gray's Behavioral Inhibition System (BIS, see Gray & McNaughton, 2000) and three scales based upon the BAS. The BIS scale comprises 7 items measuring sensitivity to aversive events. The three BAS scales are Reward Responsiveness (5 items), Drive (4 items), and Fun Seeking (4 items). Reward Responsiveness comprises items reflecting the degree to which reward leads to positive emotions (e.g., "When I'm doing well at something, I love to keep at it"), while Drive comprises items reflecting a person's tendency to actively pursue appetitive goals (e.g., "I go out of my way to get things I want"). Fun Seeking comprises items measuring the tendency to seek out and impulsively engage in potentially rewarding activities (e.g., "I often act on the spur of the moment"). In the current study Cronbach's α was 0.74 for BIS, 0.59 for Reward Responsiveness, 0.75 for Drive, and 0.74 for Fun Seeking. Thus, apart from the Reward Responsiveness scale, the BIS/BAS Scales had acceptable internal consistency in this study.

The Sensitivity to Punishment and Sensitivity to Reward Questionnaire

The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia et al., 2001) is a 48 item measure that comprises a Sensitivity to Punishment (SP) scale and a Sensitivity to Reward (SR) scale. Both the SP and SR scales have 24 items. The SPSRQ has a dichotomous yes/no response format. Individuals are given a score of 1 for a "yes" response to an item and a score of 0 for a "no" response to an item. Thus, scores can range from 0 to 24 for the SP and SR scales. In the current study, the SP and SR scales had Cronbach's α values of 0.83 and 0.76, respectively.

The Eysenck Personality Questionnaire – Revised

The Eysenck Personality Questionnaire – Revised (EPQ-R; Eysenck & Eysenck, 1991) is a 100 item, yes–no response questionnaire measuring Extraversion, Neuroticism, Psychoticism, and Dissimulation ("Lie" scale). The EPQ-R is one of the most extensively used general personality taxonomies, and its validity and reliability has been very wide-

Table 5. Means, standard deviations, skewness, and kurtosis values for personality measures in Study 2

	AMS	FI	DI	E	N	P	BIS	RR	D	FS	SP	SR	I^7
Mean	21.99	39.12	35.14	15.03	13.30	7.61	21.10	16.82	10.74	11.58	10.83	10.56	7.72
SD	5.11	8.12	9.72	4.97	5.60	4.03	3.62	2.03	2.59	2.48	5.26	4.33	4.25
Skewness	0.10	0.01	0.34	–0.70	–0.03	0.87	–0.24	–0.74	–0.13	–0.14	0.22	0.41	0.43
Kurtosis	–0.01	–0.39	0.06	–0.31	–1.01	1.38	–0.09	1.38	–0.05	–0.48	–0.58	–0.23	–0.60

Note. AMS = Appetitive Motivation Scale (Revised), FI = Functional Impulsivity, DI = Dysfunctional Impulsivity, E = Extraversion, N = Neuroticism, P = Psychoticism, BIS = Behavioral Inhibition System, RR = Reward Responsiveness, D = Drive, FS = Fun Seeking, SP = Sensitivity to Punishment, SR = Sensitivity to Reward, and I^7 = I^7 Impulsiveness.

ly demonstrated. In the current study, the Extraversion, Neuroticism, and Psychoticism scales had Cronbach's α values of 0.85, 0.87 and 0.72, respectively.

I^7 Impulsiveness

I^7 Impulsiveness or "narrow impulsivity" (Eysenck, Pearson, Easting, & Allsop, 1985) is a widely-used 19-item measure of trait impulsivity. Its development relates to the aforementioned complexity of the impulsivity construct; in Eysenckian personality taxonomies such as the EPQ, impulsivity-related items are divided between the Extraversion and Psychoticism superfactors (see Rocklin & Revelle, 1981). Eysenck and colleagues took this to imply two distinct varieties of impulsivity, each aligned with one of these superfactors. I^7 Impulsiveness is most closely aligned with Psychoticism (Eysenck et al., 1985), which is widely regarded as a central marker for the impulsivity cluster (e.g., Pickering, 2004). In this sample, Cronbach's α for I^7 Impulsiveness was 0.81.

The Dickman Impulsivity Inventory

The Dickman Impulsivity Inventory (DII; Dickman, 1990) provides two different interpretations of impulsivity. The first, Dysfunctional Impulsivity (12 items), was designed to capture the typically negative conceptualization of impulsivity as a tendency toward quick, careless responding, and a lack of regard for future consequences (e.g., "I often get into trouble because I don't think before I act"). The second, Functional Impulsivity (11 items), offers a positive conceptualization of impulsivity, reflecting quick-thinking, and a tendency to seize opportunities (e.g., "I am good at taking advantage of unexpected opportunities, where you have to do something immediately or lose your chance"). Recently, Functional Impulsivity has been suggested to potentially reflect functioning of the BAS (Smillie & Jackson, 2006; Vigil-Colet, 2007). In this sample, Cronbach's α for Functional and Dysfunctional Impulsivity was 0.76 and 0.82, respectively.

Procedure

All participants took part in the study during a single questionnaire session organized by the Goldsmiths Department of Psychology for first year students. All participants were seated in a lecture theater and the questionnaire booklets were distributed by hand. Participants were asked to read the separate instructions for each questionnaire and then proceed to complete each questionnaire at their own pace. Following completion, participants were debriefed and thanked for their time.

Data Analysis

Exploratory factor analysis (EFA) was conducted using FACTOR 7 (Lorenzo-Seva & Ferrando, 2006). Factors were extracted from the sample correlation matrix using maximum likelihood estimation with Promax rotation. The number of factors extracted was based on the results of a parallel analysis using marginally bootstrapped samples (Horn, 1965; O'Connor, 2000), the minimum average partial (MAP; Velicer, 1976) test and a visual inspection of the scree plot.

Results and Discussion

Descriptive Statistics

Table 5 shows the means, standard deviations, skewness, and kurtosis values for each scale used in the study. All total scale scores show acceptable skewness and kurtosis values (Curran et al., 1996).

Convergent and Discriminant Validity

Table 6 shows the correlations between the full and revised AMS and each of the other scales used in the study. It can be seen that the revised and full AMS measures had very similar correlations to each of the other measures. Both AMS measures had strong positive correlations with BAS-related measures, particularly those related to reward reactivity. Correlations with impulsivity-related BAS measures were slightly weaker but still moderately positive. Both AMS measures had low to moderate negative correlations with the BIS measures[4]. The negative correlation with the SP scale was larger in magnitude than the negative correlations with the BIS and Neuroticism scales. Overall, these correlations are largely consistent with the data reported by

Table 6. Correlations between the full and revised AMS and all other personality measures

Measure	Full AMS	Revised AMS
Extraversion	0.42**	0.44**
Neuroticism	–0.15	–0.09
Psychoticism	0.26**	0.22*
I^7 Impulsiveness	0.36**	0.33**
BIS	–0.15	–0.12
Reward Responsiveness	0.16	0.22*
Drive	0.47**	0.49**
Fun Seeking	0.55**	0.55**
Functional Impulsivity	0.41**	0.38**
Dysfunctional Impulsivity	0.23*	0.21*
Sensitivity to Reward	0.43**	0.43**
Sensitivity to Punishment	–0.29**	–0.26**

**p* < .05, ***p* < .01.

Table 7. Factor loadings for the BAS/impulsivity measures

BAS Measures	Factor loadings	
	Dysimpulsivity	Reward reactivity
Appetitive Motivation Scale	0.00	**0.74**
Drive	–0.02	**0.72**
Reward responsiveness	–0.33	**0.62**
Fun Seeking	0.29	**0.59**
Functional impulsivity	0.09	**0.42**
Extraversion	0.25	**0.42**
I^7 Impulsiveness	**0.98**	–0.11
Dysfunctional impulsivity	**0.81**	–0.10
Psychoticism	**0.54**	–0.01
Sensitivity to reward	**0.40**	**0.37**

Note. Loadings = 0.35 are in **bold**.

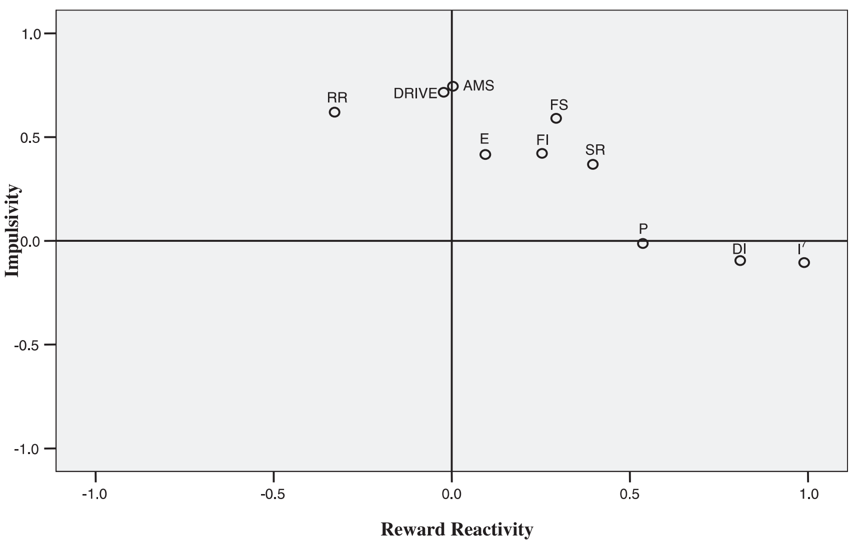

Figure 3. Rotated factor loading plot for the BAS/Impulsivity measures.

Note. AMS = Appetitive Motivation Scale (Revised), FI = Functional Impulsivity, DI = Dysfunctional Impulsivity, E = Extraversion, P = Psychoticism, RR = Reward Responsiveness, D = Drive, FS = Fun Seeking, SR = Sensitivity to Reward, and I^7 = I^7 Impulsiveness.

Jackson and Smillie (2004). These correlations also show that the revised AMS has very similar relationships with other BIS and BAS measures in relation to the full scale. If anything, the revised AMS has slightly stronger relationships with reward reactivity measures and slightly weaker relations with impulsivity related measures compared with the full scale.

Exploratory Factor Analysis

To examine more closely the placement of the revised AMS in BAS/Impulsivity construct space, all of the BAS-related scales and Impulsivity-related scales were subjected to an EFA. The KMO measure of sampling adequacy was 0.78, suggesting factor analysis was appropriate for this sample. The results of the parallel analysis, the MAP test, and a visual inspection of the scree plot all suggested two factors should be extracted. The first three eigenvalues were 4.10, 1.58, and 0.96. The first two eigenvalues accounted for 41% and 16% of the variance, respectively, and these factors were strongly positively correlated ($r = 0.52$). Table 7 shows the rotated factor matrix for the BAS measures. Consistent with previous research (e.g., Caseras et al., 2003; Smillie & Jackson, 2006), the pattern of loadings suggests that one factor could be labeled (Dysfunctional) Impulsiv-

[4] Although the literature has long remained agnostic, or even sceptical, with regard to BIS-BAS associations, a negative relationship between trait manifestations of the BIS and BAS has been explicitly predicted on the basis of recent formal models reported by Smillie et al. (2006).

ity, while the other could be labeled Reward Reactivity. The revised AMS loads strongly on the Reward Reactivity factor and does not load at all on the Impulsivity factor. It should be noted that while most of the measures tend to load strongly on only one of the factors, the SR scale (and to a lesser extent Extraversion and Fun Seeking) loaded evenly across both factors. This can be seen in the rotated factor loading plot shown in Figure 3.

In summary, the revised AMS would appear to share similar psychometric properties to the full AMS. It demonstrates good convergent and discriminant validity by positively relating to other reward oriented BAS measures, and by showing low to moderate negative correlations with BIS measures. The relationships found with other measures are broadly similar to those reported in the study which introduced the AMS (Jackson & Smillie, 2004). Unlike some other putative BAS measures, the AMS showed a strong relationship with a factor labeled Reward Reactivity, and was orthogonal to a factor labeled (Dysfunctional) Impulsivity. This finding suggests potentially greater interpretability of results employing the AMS relative to results based on other, more conceptually mixed measures which purport to index the BAS.

General Discussion

The aim of this research was to evaluate the psychometric properties of the Appetitive Motivation Scale (AMS). In Study 1, the AMS was subjected to confirmatory factor analysis, exploratory factor analysis and item response theory analysis. Results cast some doubt on the unidimensionality of the scale, and argued for the removal of 9 of the 20 items. Analyzes were then repeated on the revised AMS using a cross-validation sample. Results indicated a marked improvement, particularly in terms of the scale's intended unidimensionality. In Study 2, the revised and original AMS were compared in terms of their relationships with other RST-relevant personality measures. It was noted that the revised AMS was almost perfectly correlated with the original measure, and maintained high internal consistency despite the substantial reduction in items. Further, trait intercorrelations were consistent with Jackson and Smillie's (2004) original validation study. Of particular interest was the observation that, relative to the full-length scale, the revised AMS had slightly stronger relationships with reward-reactivity measures and slightly weaker relations with impulsivity measures. Similarly, when all BAS/impulsivity measures were subjected to an exploratory factor analysis, a clear two-factor structure emerged, in which the revised AMS loaded strongly on the reward-reactivity factor and was orthogonal to the impulsivity factor.

At the very least, the data presented here demonstrate that the revised AMS is an improvement upon the original in terms of basic psychometrics: It is a factorially cleaner and more efficient (i.e., shorter) scale, provided at essentially no cost to reliability or validity. In this respect, it may also offer a superior alternative to the more popular measures of BAS (e.g., Carver & White, 1994; Torrubia et al., 2001), which have complex or ambiguous factor structures, and, in this study, relatively lower internal consistency. Furthermore, there is also evidence to suggest that the revised AMS is a conceptually sharper measure of BAS than is otherwise currently available. Historically, the notoriously fractured construct of impulsivity has influenced trait representation of the BAS. Although Gray originally suggested that reward-reactivity *might* correspond to trait impulsivity (e.g., Gray, Owen, Davis, & Tsaltas, 1983), the distinctiveness of these concepts is becoming more apparent (e.g., Depue & Collins, 1999; Quilty & Oakman, 2004; Smillie et al., 2006). The factor loading plot shown in Figure 3 clearly supports this distinction between impulsivity and reward-reactivity scales, with some measures (e.g., SR) being more conceptually *mixed* than others. This was not the case for the revised AMS, which was orthogonal to impulsivity.

A strength of this study is that it utilized both CTT and IRT based techniques to examine the psychometric properties of the AMS. As mentioned earlier, an IRT analysis can provide additional benefits when examining personality self report measures. In particular, it can be useful to ascertain the measurement precision of each item and the total test over the range of the latent trait. In this study, we found the AMS generally has high measurement precision at the test level over most of the latent trait range. Test information did, however, decrease substantially for individuals +2 *SD* units above the mean of the latent trait. These results are similar to those found by Gomez et al. (2005), who showed the BAS scales in the Carver and White (1994) BIS/BAS Scales had relatively low test information for those high on the latent trait. It may be that BAS items tend to be worded in such a way that they discriminate poorly between those high on the latent BAS personality trait/s. This may have particularly important measurement implications for studies that utilize these self-report measures in populations that are putatively high on BAS-related traits (e.g., chronic substance users).

While the findings in this study are certainly encouraging, a number of important caveats should be kept in mind. First, the overall support for a one-factor structure in Study 1 was strong, but certainly not unequivocal. Second, although scale revision appears not to have harmed construct psychometric validity, based upon a comparison of the results from Study 2 with those of Jackson and Smillie (2004), it remains to be seen if the revised AMS is as strong a predictor of reward-reactive behavior (see Smillie & Jackson, 2005, 2006). Third, it must be acknowledged that in both studies the revised AMS was embedded in the full version of the scale, making it possible for the redundant items to potentially influence the revised scale items. A further study should administer only the revised items to confirm the revised AMS does indeed have acceptable psychometric properties. Finally, data from the cross validation sample indicated potential problems with item 17 ("I like to be rewarded"). Specifically, the *difficulty* of this item appeared to be very low, with most participants either agreeing or strongly agreeing with the content. This problem was not as apparent in the test sample and did not appear sufficiently severe to warrant removal. Also, the clear conceptual relevance of the item to the concept of *appetitive motivation* argued against removal of the item. Nevertheless, future investigators should pay close attention to this item, as it is possible that rewording may be necessary.

In conclusion, we present a thorough examination and revision of Jackson and Smillie's (2004) Appetitive Motivation Scale. It is hoped that this questionnaire will be instrumental for future RST research and related investigations, particularly those exploring potential personality manifestations of the BAS.

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