Do gamblers eat more salt? Testing a latent trait model of covariance in consumption.

Belinda C Goodwin

b.goodwin@cqu.edu.au (corresponding author)

Matthew Browne

m.browne@cqu.edu.au

Matthew Rockloff

m.rockloff@cqu.edu.au

Phillip Donaldson

p.donaldson@cqu.edu.au

Authors' affiliation: Central Queensland University

ABSTRACT

A diverse class of stimuli; including certain foods, substances, media, and economic behaviours; may be described as 'reward-oriented' in that they provide immediate reinforcement with little initial investment. Neurophysiological and personality concepts, including dopaminergic dysfunction, reward sensitivity and rash impulsivity, each predict the existence of a latent behavioural trait that leads to increased consumption of all stimuli in this class. Whilst bivariate relationships (co-morbidities) are often reported in the literature, to our knowledge, a multivariate investigation of this possible trait has not been done. We surveyed 1,194 participants (550 Male) on their typical weekly consumption of 11 types of reward-oriented stimuli; including fast food, salt, caffeine, television, gambling products, and illicit drugs. Confirmatory factor analysis was used to compare models in a 3x3 structure; based on the definition of a single latent factor (none, fixed loadings, or estimated loadings), and assumed residual covariance structure (none, a-priori / literature based, or post-hoc / data-driven). The inclusion of a single latent behavioural 'consumption' factor significantly improved model fit in all cases. Also confirming theoretical predictions, estimated factor loadings on reward-oriented indicators were uniformly positive, regardless of assumptions regarding residual covariances. Additionally, the latent trait was found to be negatively correlated with the non-reward-oriented indicators of fruit and vegetable consumption. The findings support the notion of a single behavioural trait leading to increased consumption of reward-oriented stimuli across multiple modalities. We discuss implications regarding the concentration of negative lifestyle-related health behaviours.

Keywords: *consumption, latent trait, health behaviour, substance and behavioural addictions, confirmatory factor analysis.*

INTRODUCTION

Overconsumption, whether economic, dietary, or substance-oriented, is a pressing issue in modern societies, presenting numerous health and social challenges. Psychoactive substances, energy dense food and certain media products, tend to provide immediate reward and reinforcement making them amenable to excess use in some individuals. Comorbidities amongst various forms of over-consumption are reported consistently in the literature. Greenburg, Lewis and Dodd, 1999 report moderate positive co-variance amongst alcohol, television viewing, gambling, Internet use, smoking, caffeine, and chocolate intake. In this study, college students ($n = 129$) responded to Rozin and Stoess's (1993) four-pronged addiction scale, measuring cravings, withdrawal symptoms, lack of control and tolerance. Greenburg's findings suggested variance in individual vulnerability towards more than one addictive activity or substance. More recently, positive relationships have been found between, smoking, alcohol and drug use (Bachman, Wadsworth, O'malley, Johnston & Schelenberg, 2013), smoking and caffeine (Penolazzi et al., 2012), drug use and gambling (Petry, 2001), and television and snacking (Gore, Foster, DiLillo, Kirk, & Smith West, 2003). These co-morbidity studies are primarily based on addiction scales rather than measures of frequency of consumption. The latter of which may detect mild to moderate forms of excess consumption which are more common in the general population, yet still harmful to health (Sussman, Lisha, & Griffiths, 2010). To date, bivariate relationships have been the main focus of these studies; however, it has been suggested that comorbidities amongst this broad class of hedonic experiences may reflect an underlying compulsive consumption or addictive personality trait (Faber, 1995; Villella et al., 2011; Weed, Butcher, McKenna, & Ben-Porath, 1992; Zeinali & Vahdat, 2011). Based on this view,

it is reasonable to suggest that a latent behavioural trait does exist, whereby some individuals exhibit tendencies towards high levels of consumption of reward-oriented stimuli across multiple modalities.

One plausible argument for this notion is grounded in neurophysiological evidence. Over-consumed resources tend to be artificial products (e.g. confectionary) designed to stimulate reward pathways originally intended for natural stimuli (e.g., a piece of fruit) (Barrett, 2010). Alcohol, psychoactive drugs, gambling products, energy dense food (Bergh, Eklund, Södersten, & Nordin, 1997; Blum et al., 1996b; Small, Zatorre, Dagher, Evans, & Jones-Gotman, 2001) caffeine (Yamato et al., 2002) and Internet use (Han et al., 2007; Kim et al., 2011) directly simulate dopaminergic centres in the limbic system that have evolved to reinforce behaviour towards obtaining and ingesting high value environmental resources (Hantula, 2003). Reward Deficiency Syndrome (RDS) refers to a genetic condition in which individuals develop abnormally low numbers of dopamine receptors. Individuals with RDS tend to need more hedonic stimuli to activate dopamine release in order to experience reward (Blum, Cull, Braverman, & Comings, 1996a). Drug and alcohol abuse (Blum et al., 1996a), Internet addiction (Kim et al., 2011), over-eating (Johnson & Kenny, 2010; Wang et al., 2004), and problem gambling (Bergh et al., 1997) are more likely to be exhibited by individuals with RDS. A general disposition towards excess consumption of all forms of reward-oriented stimuli would be consistent with the predictions of the RDS literature.

Personality theory, although operating on a different level of description than neurophysiological research, would also predict the existence of a latent behavioural trait that is reflected in positive co-variance amongst a broad range of hedonic consumption experiences. Traits such as impulsivity, and sensation seeking are associated with drug and alcohol abuse (Chen et al., 2007; Dawe, Gullo, & Loxton,

2004; Donohew et al., 1999; Gullo, Ward, Dawe, Powell, & Jackson, 2011), excess television viewing (McIlwraith, 1998), problem gambling (Benson, Norman, & Griffiths, 2011; Breen & Zuckeman, 1999; Fuentes, Tavares, Artes, & Gorenstein, 2006), and over-eating, (Kane, Loxton, Staiger, & Dawe, 2004; Pentz, Spruijt-Metz, Chou, & Riggs, 2011). Some findings suggest that personality traits may predict co-variation in consumption behaviour. For example, rash impulsivity has been found to explain a significant amount of covariance observed between binge eating and alcohol abuse (Kane et al., 2004) and sensation seeking was found to explained some of the covariance observed between alcohol use, caffeine intake, and smoking (Evans et al., 2006). Interestingly, the latter study was conducted on a dopamine deficient sample, highlighting the way in which neurological and personality factors may combine to predict consumption behaviour.

Somewhat surprisingly, although it is predicted by several theoretical perspectives, the existence of a behavioural trait marked by greater consumption of reward-oriented stimuli has not yet been tested, using a latent factor approach. If a reward-oriented trait is found to exist in a naturalistic (i.e. 'everyday') behavioural sense, this would have practical health implications for the identification and treatment of individuals who may possess a pattern of consumption behaviour that is detrimental to health.

Aims and Hypotheses

The current investigation aimed to test a prediction common to major theories of individual differences in reward-oriented behaviours, namely, whether or not behavioural self-report data supports the existence of a single dimensional trait characterised by increased levels of consumption of a broad class of stimuli. Importantly, we included hedonic stimuli spanning several modalities of consumption:

substances, foods, and entertainment. Neurological and personality theories imply three common, and hitherto untested, hypotheses:

H1: Models of the covariance in reward-oriented consumption incorporating a one-dimensional latent (trait) factor would fit significantly better than models without a latent factor.

H2: For latent factor models with freely estimated factor loadings, all loadings of behavioural indicators on the latent factor would be positive.

H3: Consumption of *non* reward-oriented substances should be neutrally or negatively correlated with the latent factor.

Testing these predictions requires some care, as covariance between particular indicator pairs (e.g. smoking and alcohol) may be expected to exhibit extra bivariate covariance over and above that inferred by the trait. Furthermore, it is not clear whether or not behaviours classified as reward-oriented might vary in terms of indicating the trait; a distinction that may be captured by comparing models in which factor loadings were either fixed or freely estimated. We therefore take a cautious approach, evaluating the hypotheses repeatedly in the context of three bivariate covariance assumption scenarios – detailed below, and with respect to either fixed or freely estimated factor loadings.

METHODS

Participants

Two thousand, three hundred and twenty three households were contacted via a computer-assisted phone survey technique, and the final sample comprised 1,194 adult respondents who completed the whole survey. This represents a response rate of 52%, which is considered high for this form of participant contact (Curtin, Presser & Singer,

2005). The mean age of respondents was 45 years (*SD* = 11.2), and a slightly higher proportion of females (54%) than males were interviewed. The majority of participants were born in Australia (90%), were married or in a de facto relationship (77%), and in some form of full-time paid employment (70%). Approximately half (49%) lived in a household comprising of a couple with children living in the home.

Measures

Gambling

Respondents completed the *Consumption Screen for Problem Gambling (CSPG)*, which is designed to measure the consumption of gambling products in a manner analogous to the AUDIT-C. Three items measure frequency and duration of gambling activities, with one item measuring time spent gambling during a typical day. The CSPG has been shown to have high predictive validity (100% sensitivity, 92.7% specificity) when compared with the established *Problem Gambling Severity Index* (Rockloff, 2011). The CSPG often yields highly skewed results when measured among general population samples due to a relatively small percentage of the population who use casino-style gambling products frequently. Therefore, the aggregated variable was categorised as (0 = No Gambling Activity, 1-3 = Some Gambling Activity, & 4+ = High Gambling Activity).

Media Consumption

Television and Internet use were both measured via four questions directly assessing time spent per both working and non-working day on each activity, e.g., *"On a typical work day/non-work day, how much time do you spend watching Television (hrs/mins)?"* Social networking was measured using a single item, *"During the past 12 months how often have you used online (Internet) based social networking sites such as*

Facebook, MySpace, Flickr, Twitter", scored on a Likert scale ranging from 0 = *Never* to 5 = *Everyday*. Internet use and social networking were moderately correlated ($r = .33$, $p < .001$). Since these Internet use reflects emailing and web-surfing activities and social networking also represents time spent online, the variables were standardised and summed for subsequent analyses. All five media items were negatively skewed, therefore each variable was log transformed and standardized prior to aggregation.

Dietary and substance-consumption

Caffeine. A short measure of caffeine consumption from all sources (including coffee, tea, and energy drinks) was developed, as a suitable existing scale could not be identified. The items followed the protocol described previously: (a) "*In an average week, how many days in a week would you drink tea or coffee?*" (b) "*How much would you drink on a typical day?*" Answers were standardised and summed to create a total *caffeine* variable.

Salt. A two-item scale was also developed to measure salt intake. The questions were, "*How often do you add salt to your food before or during cooking or preparation?*", and "*How often do you add salt to your food after it is cooked or prepared?*" Both items were scored on a four-point scale with responses: Never, Rarely, Sometimes, and Usually, and were summed to create a total *salt* variable.

Smoking. Participants were asked "*Approximately how many cigarettes do you smoke per day?*". The variable was highly skewed and therefore converted to an ordinal variable (0 = Non-Smoker, 1-10 = Low, 11-20 = Moderate, 21+ = High)

Drugs. Illicit drug use was measured by asking, "*Have you used any illicit drugs in the past 12 months? This includes drugs such as cannabis, ecstasy, amphetamines, etc.*", which had the responses: No, Once a month or less, or more than once a month.

Snacks. Participants were asked *"On average, how many times a week do you eat chocolate, lollies or other sweets"* and "*On average, how many times a week do you eat snacks such as chips, crackers or nuts?"* Responses were coded (0 = never, 1=less than once, 2= once, 3 = twice, 4 = three to six times, 5 =over seven times) and both items summed.

Fast Food. Participants were asked *"In an average week, how many times do you purchase foods for a meal or snack from fast food outlets such as KFC, MacDonald's, Hungry Jacks, Red Rooster?"* and *"In an average week, how many times do you purchase foods for a meal or snack from other food outlets such as Subway, pizza, bakery, service station, food or pie van, noodle bar, Chinese food, etc?"* Responses were coded (0 = never, 1 = less than once, 2 = once, 3 = twice, 4 = over three times) and both items summed.

Meat products. Participants were asked *"On average, how many times per week do you eat red meat?"* and *"On average, how many times per week do you eat meat products (such as such as sausages, frankfurter, Devon, fritz, salami, meat pies, bacon or ham)?"* (0 = never, 1=less than once, 2= once, 3 = twice, 4 = thrice, 5 = four times, 6 = over five times) and both items summed.

Fruit and Vegetables. Participants were asked *"How many serves of vegetables do you eat on a usual day?"* and *"How many serves of fruit do you eat on a usual day?"*.

Alcohol. The present survey incorporated the *Alcohol Use Disorders Identification Test – Consumption subscale* (AUDIT-C; Bush et al., 1998), a shortened three-item version of the AUDIT that only includes consumption-oriented questions. Two of the three items of the AUDIT-C measure frequency of drinking behaviour, and one item assesses quantity consumed during a typical day when drinking. The AUDIT-C is a widely

employed tool for research and diagnostic purposes (Dawson, Smith, Saha, Rubinsky, & Grant, 2012).

Ethics

The study received Human Research Ethics Committee approval and participants provided verbal informed consent preceding the phone survey.

STATISTICAL ANALYSIS

We used model comparison methods within a confirmatory factor analysis (CFA) framework to test each of the hypotheses. The primary aim was to test whether or not the introduction of a single latent factor is justified by the multivariate consumption data. CFA is commonly used to test the validity of a single factor model, and compare the ability of two different models to account for the same set of data (Wegener & Fabrigar, 2008). It provides a framework for testing our hypotheses by comparing models with and without the latent factor. Our analysis was based on recommended practice for employing CFA, that is, to compare a set of alternative models (determined prior to analysis) to decide on which model should be preferred (Schreiber, Nora, Stage, Barlow, & King, 2006). We describe below a 3x3 structured set of models for comparison. However, it should be borne in mind that our key comparison is simply that of a model with and without a latent factor, done with different assumptions for additional direct correlations between measures. Chi square difference tests were employed to compare models, along with RMSEA, AIC and BIC statistics. Models were adjusted independently in two respects: (1) the pattern of bivariate correlations (3 levels), and (2) the inclusion of a latent factor (3 levels), leading to a structured comparison of 9 models in total. The rationale for specifying this structured set of 9 models is described in detail below.

The models corresponding to the null hypothesis included no latent factor. In these three models, any correlations between measures were allowed only using direct correlations, either derived from the literature, or determined post-hoc from the data. The first alternate model form considered was one in which all behavioural indicators were fixed to have an equal loading on the latent factor (tau equivalence). In this case, all behaviours assumed to be equally reliable indicators of the hypothesised trait. The second alternative model allowed the loadings of each indicator to be freely estimated from the data, as per exploratory factor analysis. Thus, in these three models, measures were assumed to vary to the degree to which they were related to the hypothesised latent trait. In all, three forms of latent factor specification were considered: *none*, *fixed*, and *free*.

The specification of additional bivariate correlations between indicators affects the fitting of the latent factor. A somewhat naïve approach is to compare each of the latent factor models in the context of no additional correlations between indicators. This would assume that all covariance between indicators is due to the latent trait. However, it is more realistic to assume that there is extra correlation between certain indicators above and beyond that explained by a reward-oriented trait. One approach to allowing additional correlations between variables is *a-priori*, by a systematic scan of reported correlations in the literature. For example, based on previous research, alcohol, gambling, and nicotine would be expected to display additional positive covariance due to reports of their common social and environment associations (e.g., having a cigarette whilst drinking or gambling; Bobo & Husten, 2000; Lal & Siahpush, 2008). A final alternative is to specify extra bivariate correlations in a *post-hoc* manner based on statistical modification criteria on the data at hand. The bivariate correlations included as a result of the literature search and via modification criteria are provided in the

appendix. Thus, the latent factor hypothesis was considered in the context of three patterns of direct bivariate correlations: *none*, *a-priori*, and *post-hoc*.

All analyses were conducted in the statistical programming environment R (R Development Core Team, 2010). Distributions were inspected for outliers, missing data, normality, and spread. No outliers were identified and missing data was replaced using a single imputation method. Continuous variables, were approximately normally distributed. The recoded and transformed measures comprised a mixture of continuous, ordinal, and binary variables. Accordingly, a heterogeneous correlation matrix was computed using the *polycor* package, consisting of Pearson product-moment correlations between numeric variables, polyserial correlations between numeric and ordinal variables, and polychoric correlations between ordinal variables (Drasgow, 1986). The resulting correlation matrix was positive-definite, and initial screening supported further analysis: the KMO measure of sampling adequacy was .645 and Bartlett's Test of Sphericity was significant, $\chi^2(78) = 807.6, p < .001$.

RESULTS

Descriptives

Table 1 displays descriptive statistics using untransformed data. Results of a series of non-parametric gender and age comparisons indicated that males reported significantly higher levels of alcohol, salt, fast food and meat intake, and television viewing when compared to females. Female respondents reported significantly higher levels of snacking and social networking. Participants under 46 years of age reported significantly higher fast food, meat, snack, and alcohol intake along with more Internet, social network and television use, while those 46 and above reported significantly higher caffeine intake. Smokers made up 18.5% of the sample and 4.9% of participants

Insert Table 1

reported using illicit drugs in the past 12 months. Smoking did not vary significantly by age ($\chi^2(1) = .132$, $p = .136$) or gender ($\chi^2(1) = .335$, $p = .551$). Males ($\chi^2(1) = .12.772$, $p < .001$) and younger participants ($\chi^2(1) = 22.858$, $p < .001$) reported significantly higher levels of drug use.

Main Analysis

Table 2 compares fit statistics for the three models tested (None, A-priori and Post Hoc). In all three cases chi-square difference tests show that models including a latent factor were a significantly better fit to the data when compared to models specifying correlations alone. All additional fit statistics presented in Table 2, including; BIC, AIC, GFI, RMSEA, and SRMR, confirm this finding. Item loadings on the latent factor (when free to vary) were all positive[1] (see table 3), indicating that the latent factor positively predicts alcohol, drug, cigarette, fast food, snack, television, Internet, gambling product, caffeine, salt and meat consumption. In addition, Pearson Product-moment correlations show that fruit and vegetable intake is negatively associated with the latent factor in each case.

Chi-square difference tests revealed that models in which the loadings were free to vary were a significantly better fit to the data when compared to models where loadings were fixed (see table 2). Improvements were relatively minimal in each case considering the reduction in degrees of freedom between fixed and free models (None $\chi^2(10) = 120.10$, $p < .001$; A-Priori $\chi^2(10) = 61.97$, $p < .001$; and Post Hoc $\chi^2(10) = 80.70$, $p < .001$). Figure 1 provides visual representation to further illustrate this. RMSEA values reflect the degree of misfit in the proposed model with values less than .05 considered a close fit (Browne & Cudeck, 1992). Confidence intervals suggest that

Insert Table 2 & 3

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[1] Smoking alone did not load significantly on the latent factor in the A-priori model.

in the None and A-Priori scenarios, allowing loadings to vary on the latent factor did not significantly improve model fit, and in the Post hoc scenario the improvement was marginal.

Gender and Age differences

Parameter estimates for the first model were assessed separately by gender and age (see Table 3 in the Appendix). In all cases, factor loadings were uniformly positive and of similar magnitude, with only some exceptions. Drugs contributed more weight in the young sample ($b = .416$) when compared to the older sample ($b = .062$). For males, drugs ($b = .317$) and meat ($b = .291$) contributed substantially more to the latent factor whereas Internet ($b = .151$) and TV ($b = .055$) contributed considerably less when compared to females ($b = .180$, $b = .097$, $b = .328$, $b = .249$, respectively).

DISCUSSION

The current study aimed to investigate the existence of a single dimensional trait characterised by higher levels of consumption of a range of rewarding stimuli. Our first two predictions were supported in that 1) The inclusion of a latent factor significantly improved model fit over the null model in all three covariance contexts, and 2) When free to vary, all reward-oriented indicators loaded positively on the latent factor. This demonstrates that a proportion of positive co-variance amongst the consumption of alcohol, drugs, cigarettes, fast food, snacks, TV, Internet, gambling products, caffeine, salt, and meat may be attributed to a latent trait. Negative associations between fruit and vegetable intake and the latent factor suggest that the trait is specific to certain type of stimuli (e.g., reward-oriented), and is furthermore unlikely to reflect acquiescence bias – whereby individuals tend to respond positively to all statements.

Insert Figure 1

With reference to Figure 1, it may be seen that allowing factor loadings to vary produced a relatively small improvement in model fit over a model in which loadings were constrained to be homogenous, as compared to the improvement over the null model. This implies that the indicators were somewhat homogenous in terms of indicating the trait. Whilst all indicators may be construed as being hedonic, sensation-rich, appetitive, or rewarding; only some indicators can be thought of as being clearly addictive. Given the relative fit of the homogenous models, this lends credence to interpreting the latent trait in terms of an attraction to reward-oriented stimuli, rather in terms of possessing an orientation towards illicit substances. Given only a minor subset of the indicators (e.g. drugs) are not socially normative, the trait does not appear to reflect a willingness to disregard social structures.

Previous research has noted associations amongst addiction to stimuli such as television, caffeine, alcohol and chocolate (Greenberg et al., 1999), as well as gambling and energy dense food (Claes et al., 2012), which are difficult to explain without reference to a general trait-orientation towards rewarding stimuli. The findings of the present study are in line with these previous observations regarding addiction, in which the common factor among the over-consumed stimuli appears to be in delivering immediate and relatively un-effortful, dopamine-driven rewards. From a neurophysiological perspective, variation between individuals could be the result of dopamine malfunction which has been found to cause various forms of excess consumption including alcohol abuse, binge eating, problem gambling and Internet addiction; (Bergh et al., 1997; Blum et al., 1996a; Johnson & Kenny, 2010; Kim et al., 2011). It is thought that dopamine pathways originally evolved to reinforce resource acquisition and ingestion behaviours that promote survival in a resource-scarce environment. Psychoactive substances, energy dense food, and other modern day

consumer products exhibit exaggerated reward properties that activate dopamine release

more so than natural stimuli (Barrett, 2010; Nesse & Berridge, 1997; Wang et al., 2001),

leading them to be termed 'supernormal stimuli' by some authors (Barrett, 2010,

Tinbergen & Perdeck, 1950). This reasoning applies to addiction at a pathological level

as well as more common instances of mild to moderate over-consumption in the general

population. It is unclear as to the degree to which Reward Deficiency Syndrome may be

applied to understand normal individual variation in susceptibility to overconsumption

of supernormal stimuli. Nevertheless, the results of this study are consistent with an

interpretation in terms of individual variability in the functioning of dopaminergic

pathways. This is supported particularly with respect to the latent factor being associated

with a variety of stimuli with exaggerated reward properties, but being negatively

associated with the intake of natural stimuli (i.e., fruit and vegetables). A logical next

step may be to develop a measure of trait reward-oriented behaviour and examine its

associations with dopamine functioning.

Current findings also support predictions made by personality theory. Reward

sensitivity theory suggests that some individuals demonstrate heightened approach

toward appetitive stimuli (Gray, 1981). Empirical research supports this, with

Behavioural Approach Scale (BAS; Carver & White, 1994) scores associated with

increased approach toward alcohol (Franken, 2002), food (Passamonti et al., 2009), and

risky gambling behaviour (Kim & Lee, 2011). In line with the present findings, a

general tendency toward over-consumption could be a direct behavioural outcome for

highly reward sensitive individuals. Similar predictions are made regarding highly

impulsive or sensation seeking individuals (Benson et al., 2011; Chen et al., 2007; Dawe

et al., 2004; Kane et al., 2004; Pentz et al., 2011). It has been suggested that impulsivity

leads to a general vulnerability toward various forms overconsumption and addictive

behaviours (Balogh, Mayes, & Potenza, 2013; Gay, Rochat, Billieux, d' Acremont, & Van der Linden, 2008). Furthermore, research demonstrates a mediating effect of impulsivity on the relationship between addictive behaviours (Evans et al., 2006; Kane, Loxton, Staiger, & Dawe, 2004). It may be the latent factor revealed in the current study, is explained by impulsivity. Reward sensitivity, impulsivity and sensation seeking are somewhat distinct, but tend to be moderately associated (Dawe et al., 2004). A clear delineation of the unique contributions of differing personality traits as well as a latent underlying consumptive trait remains to be explored.

Limitations

In models where parameters were free to vary, some items exhibited only minimal loadings on the latent factor. Residual covariance reflects the way in which many of the behaviours are likely to be associated for a variety of different reasons. For example, a licensed gaming bar encourages drinking along side gambling in the same way that watching television at home is a favourable environment for snacking (Francis, Lee, & Birch, 2003; Gore, Foster, DiLillo, Kirk, & Smith West, 2003). In addition, parameter estimates for the none and post hoc models are similar, whereas items exhibit different loadings on the latent factor in model based on addiction research (i.e., A Priori). This could reflect the way in which variables measured using addiction scales yield varying results when compared to variables using general consumption measures, an important consideration in future research.

Appropriate existing scales were not available for many of the behavioural items measured (e.g., salt, meat and caffeine intake). Many of the variables were measured using just one or two novel items, making reliability and validity difficult to assess. We also acknowledge that much other behaviour, not measured, may prove to be reliable indicators of the latent trait (e.g., shopping, viewing pornography, and video-gaming).

It is important to acknowledge that the latent factor describes only a small amount of variance in many of the behavioural variables. Furthermore, our interpretation of the latent factor is speculative. It is recognised that many explanations for shared co-variance amongst our measures exist above and beyond the personality and neuropsychological theories mentioned. Other personality traits, environmental factors, mental health, and perceptions and motivations surrounding healthfulness are some examples of plausible reasons for individual variance in consumption behaviour. Although we refer to the factor as a latent 'trait', which by definition is stable and long lasting, this cross-sectional study lacks the ability to assess the stability of behaviour. Aims for future research should be to replicate results using an extended range of reward-oriented behaviours as indicators, investigating alternative explanations for shared co-variance, longitudinal studies, the inclusion of established addiction scales and/or the development of reliable measures of consumption.

CONCLUSION

The current research was motivated by personality and neurophysiological theories that predict the existence of a latent trait indicated by increased consumption of a variety of reward-oriented stimuli in daily life. The results support the existence of such a trait, and further that the common stimulus characteristics are that of delivering an immediate and unmediated reward directly via dopaminergic pathways. The behavioural trait towards reward-oriented stimuli appears to be manifested across multiple modalities (i.e., psychoactive substances, media, foodstuffs). This represents the first study to investigate shared co-variance amongst the consumption of a broad range of products in everyday life in terms of a latent behavioural trait, and also one of few to measure frequency of general consumption behaviour in an adult, non-clinical sample. Increased consumption of the stimuli considered here can result in negative

health outcomes. Individuals who tend towards excessive consumption of one form of stimulus will be more likely to consume a variety of other reward-oriented stimuli. This has important practical implications for population health. An overabundance of consumption opportunities, and artificial, highly attractive 'supernormal' products in the developed world has contributed to a variety of avoidable diseases. Understanding the factors behind individuals' vulnerability to overconsumption may play a useful role in future public health initiatives.

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Table 1. *Range, mean and standard deviation values for each numeric behavioural variable: Total and by gender and age (with non-parametric median comparisons).*

	Total			Male (1)		Female (2)				Under 46		46 & over			
	Range	Mean	SD	Mean	SD	Mean	SD	Z		Mean	SD	Mean	SD	Z	
Salt	0 - 8	2.51	1.96	2.69	2.01	2.36	1.91	-2.79	**	2.47	1.95	2.56	1.97	-0.81	
Fast Food	0 - 8	2.44	1.68	2.70	1.81	2.22	1.53	-4.39	***	2.92	1.72	2.02	1.51	-9.68	***
Meat Products	0 - 11	5.84	2.44	6.48	2.36	5.28	2.37	-8.25	***	6.07	2.40	5.63	2.45	-3.22	**
Caffeine	0 - 16	5.47	3.35	5.43	3.48	5.50	3.24	-0.64		4.60	3.41	6.25	3.10	-8.68	***
Snacks	0 - 10	4.92	2.36	4.72	2.40	5.09	2.31	-2.54	*	5.11	2.29	4.75	2.40	-2.77	**
^Social Networking	0 - 5	1.94	2.05	1.52	1.93	2.30	2.08	-6.58	***	2.35	2.01	1.41	1.88	-9.34	***
Alcohol (AUDITC)	0 - 12	3.75	2.94	4.70	3.18	2.93	2.45	-9.73	***	4.00	3.10	3.53	2.78	-2.40	*
Gambling (CSPG)	0 - 11	1.01	1.86	1.19	2.07	0.86	1.64	-1.91		1.00	1.79	1.02	1.92	-.083	
^TV Hours (work day)	0 - 21	2.33	2.91	2.50	3.17	2.18	2.66	-2.02	*	2.07	2.72	2.56	3.05	-4.59	***
^TV Hours (non-work day)	0 - 24	2.92	2.93	3.16	3.17	2.72	2.68	-3.12	**	2.85	2.95	2.99	2.91	-1.72	
^Internet Hours (work day)	0 - 20	1.04	1.90	.98	1.82	1.09	1.97	-1.41		1.13	1.86	0.96	1.93	-2.98	**
^Internet Hours (non-work day)	0 - 21	1.41	2.10	1.45	2.23	1.38	1.97	-0.09		1.47	1.74	1.36	2.28	-2.69	**

* = *p* <.05, **= *p* <.01, *** = *p*<.001, ^Untransformed, singular items are displayed in this table. Age categories based on median split.

Table 2. *Comparison of fit-statistics for each of the models tested and correlations between fruit and vegetable intake and latent factors*

Direct Correlations	None			A-priori			Post-hoc		
Common Factor Loadings	None	Fixed	Free	None	Fixed	Free	None	Fixed	Free
Fruit intake	--	$r=-0.164$	$r=-0.194$	--	$r=-0.144$	$r=-0.104$	--	$r=-0.160$	$r=-0.179$
Vegetable intake	--	$r=-0.152$	$r=-0.154$	--	$r=-0.143$	$r=-0.177$	--	$r=-0.145$	$r=-0.172$
χ^2	991.087^*	587.82^*	467.81^*	351.361^*	173.469^*	111.501^*	340.12^*	149.739^*	69.044^*
df	55	54	44	31	30	20	43	42	32
BIC	37339.609	36943.43	36894.262	36869.924	36699.118	36708.000	36773.662	36590.367	36580.522
AIC	37283.673	36882.41	36782.391	36691.947	36516.055	36474.087	36656.706	36468.325	36407.630
GFI	0.856	0.924	0.937	0.947	0.975	0.984	0.945	0.978	0.990
RMSEA	0.119	0.091	0.090	0.093	0.063	0.062	0.076	0.046	0.031
RMSEA (CI^)	0.113	0.084	0.083	0.084	0.054	0.051	0.069	0.039	0.021
RMSEA (CIʸ)	0.126	0.098	0.097	0.102	0.073	0.073	0.084	0.055	0.041
SRMR	0.119	0.082	0.066	0.078	0.046	0.040	0.083	0.049	0.027
$\chi^2(df)$ difference test	$403.27\,(1)^*$			$177.89\,(1)^*$			$190.38\,(1)^*$		
		$120.02\,(10)^*$			$61.97\,(10)^*$			$80.70\,(10)^*$	

Notes: $^*p < .001$; r = Pearson Product Moment Correlation with the latent factor.

Table 3. *Unstandardized and Standardised estimates for the models where loadings were free to vary on the latent factor.*

Direct Correlations	None				A-priori				Post-hoc			
	B	*β*	SE	*z*	*B*	*β*	SE	*z*	*B*	*β*	SE	*z*
Drugs	1.000	0.558	0.04	15.04*	0.461	0.294	0.04	7.26*	1.000	0.480	0.05	9.60*
Fast Food	0.568	0.317	0.04	8.62*	1.000	0.639	0.06	11.72*	0.776	0.356	0.04	8.49*
Gambling	0.796	0.444	0.04	12.12*	0.435	0.278	0.05	6.17*	0.895	0.410	0.04	10.05*
Smoking	0.836	0.466	0.04	12.71*	0.105	0.067	0.04	1.56	0.992	0.455	0.06	8.27*
Salt	0.529	0.295	0.04	8.01*	0.268	0.171	0.04	4.37*	0.728	0.334	0.04	8.47*
Caffeine	0.454	0.253	0.04	6.87*	0.316	0.202	0.04	4.70*	0.753	0.345	0.05	7.23*
Alcohol	0.704	0.392	0.04	10.71*	0.251	0.160	0.04	3.68*	0.526	0.241	0.04	5.70*
Meat	0.358	0.200	0.04	5.40*	0.412	0.263	0.04	6.68**	0.240	0.193	0.04	4.81*
Snacks	0.244	0.136	0.04	3.67*	0.497	0.317	0.04	5.73*	0.352	0.161	0.04	3.86*
Internet	0.283	0.158	0.04	4.25*	0.410	0.262	0.04	6.05*	0.220	0.101	0.04	2.50*
TV	0.224	0.125	0.04	3.36*	0.253	0.161	0.04	3.78*	0.449	0.206	0.04	5.07*

$* = p < .001$
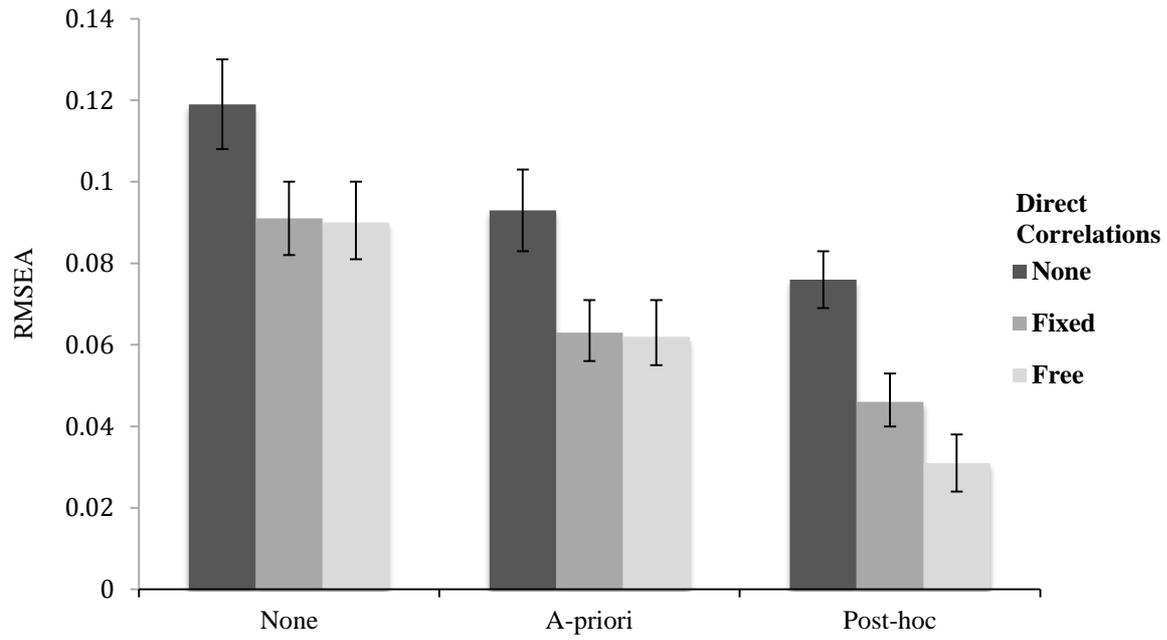
Figure 1. RMSEA (and 95% CIs) plotted for visual demonstration of differences in model fit.

Appendix

A literature search was conducted for cross-sectional studies that reported bivariate

regression or correlation relationships between the variables considered in this study. These

were then specified as direct correlations in the a-priori correlation model. The variables and

citations are given below in Appendix Table 1.

Appendix Table 1. *Associations amongst reward-oriented behaviours in the literature. Basis*

for A-Priori direct correlation specification.

Variable	Correlated with	Citation
Alcohol	Smoking	Bobo & Husten, 2001; Greenberg, Lewis, & Dodd, 1999
Alcohol	Drugs	Bachman, Wadsworth, O'malley, Johnston, & Schulenberg, 2013
Alcohol	TV	Greenberg et al., 1999
Alcohol	Gambling	Greenberg et al., 1999
Alcohol	Internet	Greenberg et al., 1999
Alcohol	Caffeine	Greenberg et al., 1999
Alcohol	Snacks	Greenberg et al., 1999
Smoking	Drugs	Bachman et al., 2013
Smoking	TV	Greenberg et al., 1999
Smoking	Gambling	Greenberg et al., 1999
Smoking	Internet	Greenberg et al., 1999
Smoking	Caffeine	Greenberg et al., 1999; Penolazzi et al., 2012
Smoking	Snacks	Greenberg et al., 1999
Drugs	Gambling	Petry, 2001
TV	Gambling	Greenberg et al., 1999
TV	Internet	Greenberg et al., 1999
TV	Caffeine	Greenberg et al., 1999
TV	Snacks	Greenberg et al., 1999; Gore, Foster, DiLillo, Kirk, & Smith West, 2003
Gambling	Internet	Greenberg et al., 1999; Villella et al., 2011
Gambling	Caffeine	Greenberg et al., 1999
Gambling	Snacks	Greenberg et al., 1999
Internet	Caffeine	Greenberg et al., 1999
Internet	Snacks	Greenberg et al., 1999
Caffeine	Snacks	Greenberg et al., 1999

For full references from table refer to reference list in manuscript.

The post-hoc group of models were those in which the direct correlation matrix was specified

by the data at hand in a stepwise process using modification indices, in a model which

included a latent factor with freely estimated loadings. Specifically, correlation inclusion was

based on the largest expected parameter change of the chi-square statistic. The process was

stopped when adding of an additional degree of freedom would result in a non-significant chi-square change. Note that this mode of correlation specification is vulnerable to over-fitting due to sampling variability. Therefore, the generally improved fit of post-hoc models as compared to a-priori specification should not be interpreted. Importantly, the hypotheses of the present study pertained to model comparisons *within* each direct correlation condition (none / post-hoc / a-priori). We also comment that, due to the presence of the latent factor, this list of 'significant' bivariate correlations is not equivalent to the significant *raw* bivariate correlations. For example, the raw correlation between gambling and salt consumption was significant +0.10 (t=3.35, p <0.001), but after accounting for the latent factor, inclusion of a further residual correlation was not justified.

Appendix Table 2. *Direct correlations included in the Post Hoc scenario for fixed and free to vary factor loadings.*

		Correlation Coefficients	
Variable	Correlated with:	*Loadings Fixed*	*Loadings free to vary*
Drugs	Smoking	.272	.165
Drugs	Caffeine	-.102	-.163
Smoking	Caffeine	.168	.107
Snacks	Smoking	-.196	.188
Fast Food	Internet	.147	.177
Smoking	TV	-.156	-.161
Alcohol	Gambling	.162	.172
Drugs	Alcohol	.146	.142
Fast Food	Smoking	-.109	-.140
Snacks	Fast Food	.134	.150
Snacks	Internet	.099	.128
Fast Food	Meat	.106	.112

Appendix Table 3. *Item factor loadings for the first model displayed separately by gender and age groups.*

	Under 46	**46 and over**	**Male**	**Female**
Alcohol	.482	.275	.338	.345
Caffeine	.379	.401	.430	.334
Drugs	**.416**	**.062**	**.317**	**.180**
Fast Food	.284	.244	.360	.302
Gambling	.429	.364	.405	.420
Internet	.029	.151	**.157**	**.328**
Meat	.292	.190	**.291**	**.097**
Salt	**.263**	**.402**	.287	.209
Smoking	.364	.341	.290	.351
Snacks	.054	.131	.200	.158
TV	.139	.233	**.055**	**.158**

Large discrepancies mentioned in main text are bolded.