Do Extraverts Get More Bang for the Buck? Refining the Affective-Reactivity Hypothesis of Extraversion

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ABSTRACT

One of the most robust observations in personality and emotion research is the finding that extraverts are happier than introverts. Some theorists have attributed this to differential reactivity of the brain reward system, which is central to many biologically-inspired models of Extraversion. This 'affective-reactivity hypothesis', which suggests that extraverts should be more susceptible to the induction of positive affect, has so far received very mixed empirical support. In this paper we consider a more biologically plausible account of extraverts' affective-reactivity. Over five experiments we demonstrate that extraverts show greater affective-reactivity only in response to clearly *appetitive* stimuli and situations (e.g., where rewards are being pursued). Conversely, after merely *pleasant* stimuli and situations (without any reward-approach element), extraverts and introverts respond similarly. We also show that it is specifically *activated* affect (e.g., feelings of alertness), rather than pleasantly *valenced* affect (e.g., feelings of contentment), which characterizes the affective-reactivity of extraverts. Such reactions may potentially facilitate the reward-seeking behavior associated with Extraversion, but seem unlikely to explain the broadly happy disposition of extraverts.

Key words: Extraversion, Affective-Reactivity, Positive Affect, Pleasant Affect, Activated Affect, BAS.

Do Extraverts Get More Bang for the Buck? Refining the Affective-Reactivity Hypothesis of Extraversion

Extraversion is a personality construct describing coherent patterns of basic psychological processes (i.e., affect, behavior, cognition, desire or ABCDs) that vary between individuals (Wilt & Revelle, 2009). Among the most salient of these processes is Positive Affect (PA); indeed, the finding that extraverts are happier than introverts is one of the most reliable observations in the personality literature (Costa & McCrae, 1980; Diener & Lucas, 1999; Lucas, Le, & Dyrenforth, 2008; Tellegen, 1985). Dozens of cross-sectional studies have reported a significant positive association between measures of trait Extraversion and chronic PA; according to a recent meta-analysis the correlation between these constructs is .41 (Lucas et al., 2008). Experience sampling and diary studies show that this relationship is stable over all time periods studied, such that *"Extraverts are happier than introverts in general, over short time periods, and even in the moment"* (Wilt & Revelle, 2009, p. 36). These also have helped to support the view that causality flows from Extraversion to PA rather than vice versa (Wilt, Noftle, Fleeson & Spain, in press). The similarity of this relationship across different measures (Lucas & Fujita, 2000) makes it difficult to dismiss the happiness of extraverts as a trivial consequence of semantic overlap, as Extraversion measures differ considerably in their affective content (Pytlik Zillig, Hemenover, & Dienstbier, 2002). Overall, it seems that this phenomenon reflects core processes at the crossroads of personality and emotion.

One prominent theory which attempts to explain the happiness of extraverts is the *'affective-reactivity hypothesis'* (ARH; Gross, Sutton & Ketelaar, 1998, see also M. Eysenck, 1987; Larsen & Ketelaar, 1991; Tellegen, 1985). The ARH grew out of biologically-motivated theories which linked Extraversion with functioning of the brain's reward system (e.g., Gray, 1973, 1987). In the personality and social psychology literature this system is now widely referred to as the *Behavioral Activation System* or BAS (e.g., Carver & White, 1994; Elliot & Thrash, 2002; Smillie, Dalgleish & Jackson, 2007). The BAS is thought to regulate appetitive motivation, facilitating the direction and energization of approach behavior toward desired goals (e.g., Depue & Collins, 1999; Gray, 1973, 1987). The grounding of this conceptual system in midbrain dopamine processes (e.g., Pickering & Gray, 1999; Pickering & Smillie, 2008) is in close keeping with a vast neuroscience literature concerning the communication of reward-related information by dopamine neurons (e.g., Knutson & Cooper, 2005; McClure, York, & Montague, 2004; Robbins & Everitt, 1996; Shultz, 1998). Support for the idea that Extraversion may be importantly linked with these processes has been demonstrated by studies linking extraverted personality with indices of dopamine function at multiple levels of analysis (e.g., Depue & Collins, 1999; Pickering, 2004; Rammsayer, 1998; Reuter, Netter, Toll & Hennig, 2002; Smillie, Cooper & Pickering, 2011; Smillie, Cooper, Proitsi, Powell, & Pickering, 2010; Wacker, Chavanon & Stemmler, 2006). Similarly, at the level of personality assessment, it has been concluded that BAS-related concepts (e.g., reward-sensitivity, approach motivation) may represent the common core of Extraversion and related dimensions of personality such as Positive Emotionality (e.g., Elliot & Thrash, 2002; Lucas, Diener, Grob, Suh, & Shao, 2000).

The ARH elucidates potential affective implications of the 'reactive-BAS' account of Extraversion. Specifically, if PA is increased by rewarding or pleasant stimuli and situations

– the typical ingredients of positive mood induction paradigms (Westermann, Spies, Stahl & Hesse, 1996) – this increase should be greater for those with a more reactive reward system (Tellegen, 1985). This is the logic underpinning the central tenet of the ARH; that given the same positive experience, extraverts will experience more PA than their introverted counterparts as a result of their stronger reactivity to rewards. This prediction was well-supported in a now-classic mood induction study by Larsen and Ketelaar (1991), in which PA was induced by having participants visualize themselves in two desirable scenarios, (1) winning the lottery and going on holiday, and (2) feeling healthy and relaxed on a beautiful day and then finding a $5 bill. (Affectively negative and neutral scenarios were also administered.) Immediately afterward, momentary PA was measured by asking participants to rate the extent to which they felt *enthusiastic, excited, elated, peppy, euphoric,* and *lively*. These items were selected to be broadly representative of widely-accepted measures of state PA, most notably, the PA scale from the Positive and Negative Affect Schedule (PANAS; Watson, Clark & Tellegen, 1988). In support of the ARH, it was found that extraverts reported greater PA than introverts after the positive-affect induction (but not after negative or neutral inductions). Similar findings have since been obtained using strikingly different mood induction procedures (e.g., Gomez, Cooper & Gomez, 2000; Gross et al., 1998). Assuming state-trait isomorphism, these elevated PA states may accumulate over time and space, such that extraverts are happier on average than introverts (Fleeson, 2001; Revelle & Scherer, 2009).

Despite encouraging findings from some experiments, the ARH has received very mixed empirical support overall. Indeed, Lucas and Baird (2004) noted that over one-third of studies examining the affective-reactivity of extraverts have yielded null results. Such a checkered track record may indicate that the ARH has been inadequately specified, or that undetected moderators are at play. Indeed, a closer look at the theoretical foundations of the ARH invites a specific proposal of this kind. Specifically, in most theoretical formulations of the BAS construct it has always been suggested that this system regulates *approach toward* reward rather than *consumption of* reward (e.g., Depue & Morrone-Strupinsky, 2005, Figure 3; Gray, 1987, p. 249, 271). A distinction of this nature has persisted in the broader affective neuroscience literature in terms of reward desire (so-called '*wanting'*) versus reward enjoyment (so-called *'liking'*) (e.g., Berridge, Robinson & Aldridge, 2009). This literature has confirmed that dopaminergic reward-processing functions subsumed by the BAS are involved in the approach, rather than the enjoyment, of reward and appetitive goals. Several lines of argument converge on this point from multiple levels of analysis (for reviews see: Ashby, Isen & Turken, 1999; Kringelbach & Berridge, 2009; Treadway & Zald, 2010; Wise, 2004). Specific evidence includes the observation that reward consumption is preserved in genetically-engineered dopamine deficient mice, whilst reward pursuit is disrupted (Robinson, Sandstrom, Denenberg, & Palmiter, 2005). Similarly, in humans, administering a dopamine agonist modulates vigor of responding for reward (Al-Adawi, Powell & Greenwood, 1998) but does not increase PA (Jayaram-Lindsrtom, Wennberg, Hurd & Franck, 2004; Leyton et al., 2002; Rothman, 1994). According to most accounts this latter process is regulated via forebrain opioid circuits– the brain's pleasure system (Ashby et al., 1999; Barbano, & Cador, 2007; Kringelbach, 2010).

If the BAS is engaged only in the context of reward pursuit, it seems likely that the ARH will be supported only in appetitive scenarios (i.e., during actual or simulated pursuit of reward or desirable goals). Indeed, the mood induction procedure used by Larsen and Ketelaar (1991) involved visualization of highly appetitive situations (i.e., winning the lottery, finding money). Similarly, the procedure used in a later study by Gomez et al. (2000) involved participants performing a behavioral task during which financial rewards could be earned through accurate performance. Both of these studies provided clear support for the ARH. In contrast, Lucas and Baird (2004, studies 2-5) induced PA by having participants watch a stand-up comedy video. Similarly, Helmers, Young and Pihl (1997), induced PA by having participants reflect on and describe a happy moment in their lives. These studies mostly failed to support the ARH (support was found by Lucas and Baird in just one of four studies using comedy videos). These examples encourage the view that the kind of positive stimuli or situation may be critical for understanding affective-reactivity. Our analysis may explain why the ARH has received such mixed support, and furthermore leads to a more specific and biologically plausible articulation of the theory. If accurate, then one would only expect extraverts, relative to introverts, to experience greater increases in PA during appetitive scenarios or in response to appetitive stimuli. In contrast, merely pleasant mood inductions that are not characterized by motivationally salient or rewarding stimuli should not differentially impact extraverts and introverts in terms of PA.

We evaluated this hypothesis over five experiments. Experiment 1 examined the affective reactivity of extraverts in response to merely pleasant positive stimuli (guided imagery). Experiment 2 then conceptually replicated experiment 1 using a different mood induction modality (video clips), different self-report measures, and a much larger sample. Experiment 3 then attempted to replicate a previous study (Gomez et al. 2000) that used a highly appetitive mood induction procedure (i.e., actual reward pursuit in the context of a go/no-go task). Experiment 4 then attempted to fully replicate and extend experiments 1-3, examining the affective reactivity of extraverts in relation to both pleasant and appetitive scenarios within a single mood induction paradigm (guided imagery). Finally, experiment 5 provided a conceptual replication of experiment 4 using a different mood induction modality (video clips), and examined whether individual differences in self reported reward-reactivity account for the affective reactivity of extraverts. Together, the five experiments help to clarify the inconsistent results of previous studies in this area, and enrich our understanding of emotion-related processes in personality.

Experiment 1

Participants

One-hundred and twenty nine adults (25% male) aged between 18 and 42 (M = 20.91, SD = 3.48) were recruited from a British university. All participants were undergraduate psychology students who participated for course credit.

Materials and Procedure

Extraversion and PA Measures

The Eysenck Personality Questionnaire-Revised (EPQ-R; Eysenck & Eysenck, 1991) is a 100-item questionnaire that provides scores for the three broad dimensions of Eysenck's Giant Three Model along with a measure of socially desirable responding (lie scale). Participants respond to each item using a dichotomous (yes/no) response scale, and scores are summed in order to provide total personality scores. In the current study, we focused only on the Extraversion scale (23 items), a sample item from which is '*Can you easily get some life into a rather dull party?'* The EPQ-R has been used extensively in past research and has good reliability and validity (Eysenck & Eysenck, 1991). Cronbach's Alpha for EPQ-R Extraversion in the present study was acceptable ($\alpha = 0.80$).

The 50-item International Personality Item Pool-Five Factor Model (IPIP-FFM; Goldberg, 1999) assesses the five broad domains of the Five Factor Model, as measured by the NEO-PI-R (Costa & McCrae, 1992). In the current study, we focused only on the Extraversion scale (10 items). Each item is a descriptive phrase (e.g. '*Am the life of the party*'), and participants were instructed to indicate how accurate this phrase is for them, using a 5-point Likert-type scale. As for the EPQ-R, scores for individual items are summed to produce a total Extraversion score. Previous studies have shown support for the five factor structure (Ehrhart, Roesch, Ehrhart, & Kilian, 2008) and reliability and validity (Donnellan, Oswald, Baird, & Lucas, 2006) of the IPIP-FFM. Cronbach's Alpha for IPIP-FFM Extraversion in the present study was acceptable ($\alpha = 0.79$).

PA was assessed using the Positive and Negative Affect Schedule (PANAS; Watson, et al., 1988). The PANAS provides scores for two orthogonally related dimensions of affective state: positive and negative. The PANAS consists of 20 adjectives, 10 assessing PA states (e.g. enthusiastic) and 10 assessing negative affect (NA) states (e.g. afraid). In the current study, we focus on the PA items. Participants used a five point Likert-style response scale to indicate the degree to which their feelings matched each adjective at that current moment ("right now"). The responses across the PA items were summed to produce a total PA score. The PANAS has been used widely in the mood induction literature and has been shown to have very good reliability and validity (Crawford & Henry, 2004). Importantly, it is the measure most typically employed in previous tests of the ARH (e.g., Gomez et al., 2000; Gross et al., 1998). Cronbach's Alpha for PANAS PA pre-mood induction was 0.91 and for post-mood induction was 0.93; for PANAS NA pre-mood induction this value was 0.82 and for post-mood induction was 0.83.

Mood Induction Procedure

All testing took place individually in a sound-proof laboratory. Participants were randomly assigned to one of the following mood induction conditions: positive (n = 43), negative (n = 43) or neutral (n = 43). Prior to undertaking the mood induction procedure, participants completed the EPQ-R and IPIP-FFM. Participants then completed the PANAS to provide a baseline measure of their current affect state. Descriptive statistics for each experimental group are displayed in in Table 1. Immediately afterward, participants undertook a guided imagery task designed to alter affective state, adapted from the mood induction procedures used by Larsen and Ketelaar (1991) and Mayer, Allen, and Beauregard (1995). In the guided imagery task, participants were given two brief written vignettes and were asked to visualize and imagine themselves in each scenario described, focusing on how they would feel in that situation. Participants were also instructed that their recall of the scenarios would be tested later in the experiment, and that getting into the feeling of the scenarios would aid recall.

Participants were given the following specific written instructions for each condition: *"Read the following four scenarios and imagine yourself experiencing the events as vividly as you can. Picture the event happening to you. Try to imagine all the details of the situation. Close your eyes and picture in your 'mind's eye' the surroundings as clearly as possible. See the people or objects; hear the sounds; experience the event happening to you. Think the thoughts and feel the same feelings that you would actually think in this situation. Let yourself react as if you were actually there".*

The vignettes themselves were adapted from those used in previous mood induction studies. The positive scenarios were taken from the 'Happy' mood induction scenarios developed by Mayer et al. (1995), and were selected for their pleasant but non-goal-directed content. An example was: *'You unexpectedly run into someone you like. You go for coffee and have a great conversation. You discover that you think alike, and share many of the same interests'.* The negative scenarios were also adapted from Mayer et al. (1995); an example was: *'Your best friend just got married and is moving far away from you, making it very difficult for the two of you to see each other again'*. The neutral scenarios were adapted from Larsen and Ketelaar (1991); an example was: *'You are shopping at the supermarket for groceries that you need to purchase for your dinner'.*

As part of the guided imagery task, we also used congruent background music to enhance the induction of affective state. Combined modality procedures have been shown to be highly effective for inducing mood (Mayer et al., 1995; Westermann et al., 1996). The following music was used for each of the mood induction conditions: 1) Positive: the Mazurka from 'Coppelia' by Delibes, 2) Negative: a half-speed version of 'Russia under the Mongolian yoke' by Prokofiev and 3) Neutral: the Largo movement from 'The New World Symphony' by Dvorak. These pieces of music have been shown in previous studies to reliably induce the intended affective state (Mayer et al., 1995; Yeung, Dalgleish, Golden, & Schartau, 2006).

Once participants understood the instructions for the guided imagery task, the experimenter began the background music and left the participant to begin the task. Participants were asked to spend four minutes on each scenario; thus the entire mood induction procedure lasted a total of eight minutes. A computer-based timer triggered a flash of light and brief message on a computer screen indicating when the participant should move to the second scenario. At the conclusion of the imagery task, the participants were immediately given the PANAS to complete again. Participants were then informed that the task had finished and were debriefed. In accord with ethical considerations, all participants who received a negative mood induction were given a brief positive mood induction at the conclusion of the session.

Results and Discussion

Preliminary Statistics

At baseline, there were no significant differences among experimental groups on any of the personality or affect measures (see Table 1). The two measures of Extraversion were highly intercorrelated, $r(127) = 0.54$, $p < .001$. IPIP-Extraversion was positively related to pre-PA, $r(127) = 0.29$, $p < .001$, but EPQ-R-Extraversion was not, $r(127) = 0.10$, $p = .25$. Neither EPQ-R-Extraversion, $r(127) = 0.15$, $p = .09$, IPIP-Extraversion, $r(127) = 0.02$, $p = .84$, or pre-PA, $r(127) = -0.05$, $p = .61$, were related to pre-NA.

To test the effectiveness of the mood induction procedure, we used a 2 (pre-post PANAS score) x 3 (mood condition) x 2 (affect type) mixed ANOVA to examine the effect of mood condition on change in PA and NA. This yielded a significant three-way interaction, $F(1, 126) = 13.47$, $p < .001$, $\eta_p^2 = 0.18$, indicating that the pre-post change in affect depended on both mood condition and affect type. Follow-up tests confirmed that PA increased from baseline in the positive mood condition, $F(1, 42) = 9.96$, $p = .003$, $\eta_p^2 = 0.19$, whilst NA increased from baseline in the negative mood condition, $F(1, 42) = 13.81$, $p < .001$, $\eta_p^2 = 0.25$, and neither PA, $F < 1$, *ns*, $\eta_p^2 = 0.02$, nor NA, $F < 1$, *ns*, $\eta_p^2 = 0.02$, changed in the neutral condition. Two one-way ANOVAs were then conducted to examine differences across the three mood conditions for post PANAS scores: The effect of mood condition on post-PA was significant, $F(2, 126) = 7.44$, $p = .001$, $\eta_p^2 = 0.11$, with Tukey's post hoc tests showing the positive mood induction group having significantly higher post-PA scores compared to the neutral condition ($p = .008$) and the negative condition ($p = .001$) (see Table 1). The effect of mood induction on post-NA was also significant, $F(2, 126) = 13.33$, $p < .001$, $\eta_p^2 = 0.18$, with Tukey's post hoc tests showing the negative mood induction group having significantly higher post-NA scores compared to the neutral condition ($p < .001$) and the positive condition ($p < .001$) (see Table 1). Overall, this pattern of results clearly supports the efficacy of the mood manipulation

Extraversion and Affective-Reactivity

Having demonstrated that the mood induction procedure was effective in inducing the intended mood states, we examined the effect of mood condition and Extraversion on post-PA. To evaluate our predictions we used moderated multiple regression, which provides the most appropriate means to examine interactions between continuous (i.e., Extraversion) and categorical (i.e., mood condition) variables (Cohen, Cohen, West & Aiken, 2003)[1]. For the first analysis, after standardizing continuous predictors to reduce multicolinearity, pre-PA and gender were entered at step 1 of a hierarchical multiple regression[2]. The resulting model was statistically significant, $R^2 = .38$, $F(2,126) = 39.10$, $p < .001$, and pre-PA contributed to significantly to prediction, $\beta = .61$, $t(126) = 8.71$, $p < .001$, with gender making a more marginal contribution, $\beta = .12$, $t(126) = 1.73$, $p = .09$. At step 2, EPQ-R-Extraversion was entered, along with two dummy variables each reflecting a condition contrast (the first dummy variable contrasted the positive with the neutral and negative conditions whilst the second contrasted the negative with the neutral and positive conditions). There was a significant increment in prediction at this step, $R^2_{ch} = 0.11$, F_{ch} $(3,123) = 9.25$, $p < .001$, and the overall model was again significant, $R^2 = .50$, $F(5,123) = 24.26$, $p < .001$. Neither EPQ-R-Extraversion, $\beta = .02$, $t < 1$, *ns*, nor the negative condition contrast, $\beta = -.09$, $t(123) = 1.23$, $p = .22$, contributed significantly to prediction, but the positive condition contrast did, $\beta = .28$, $t(123) = 3.82$, $p < .001$. At step 3, two product terms were entered, these reflecting the interaction between EPQ-R-Extraversion and each of the two dummy condition variables. Although the overall model remained significant, $R^2 = .50$, $F(7,121) = 17.52$, $p < .001$, there was no significant increment in R^2 at step 3, $R^2_{ch} < 0.01$, $F_{ch} < 1$, *ns*. Inspection of the interaction terms revealed that the relationship between EPQ-R-Extraversion and post-PA did not depend on the positive condition contrast, $\beta = .12$, $t(121) = 1.28$, $p = .204$, nor the negative condition contrast, $\beta = .06$, $t < 1$, *ns*. Analysis of simple slopes confirmed that the relationship between EPQ-R-Extraversion and post-PA was non-significant for the neutral, $\beta = -0.08$, $t < 1$, *ns*, negative, $\beta = 0.03$ $t < 1$, *ns*, and positive, $\beta = 0.11$, t $(121) = 1.02$, $p = .31$, mood induction conditions.

When this analysis was repeated for IPIP-Extraversion, results at step 1 were of course identical. At step 2 there was then a significant increment in prediction, $R^2_{ch} = 0.13$, F_{ch} $(3,123) = 11.10$, $p < .001$, and the overall model was significant, $R^2 = .52$, $F(5,123) =$

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[1] We note that in this experiment and all other experiments presented in this paper, alternative analyses – specifically, analysis of variance following dichotomisation of continuous measures – produced substantively identical results.

[2] We thank an anonymous reviewer for this suggestion – the considerable imbalance in gender frequencies in most of our studies makes this an appropriate analytic strategy. For most studies this produced slightly more conservative results.

25.93, $p < .001$. Again, neither IPIP-Extraversion, $\beta = .14$, $t(123) = 2.15$, $p = .03$, nor the negative condition contrast, $\beta = -.08$, $t(123) = 1.12$, $p = .26$, contributed significantly to prediction, but the positive condition contrast did, $\beta = .29$, $t(123) = 4.03$, $p < .001$. At step 3 there was again no significant increment in R^2, $R^2_{ch} < 0.01$, $F_{ch} < 1$, *ns*, although the overall model remained significant, $R^2 = .52$, $F(7,121) = 18.55$, $p < .001$. Non-significant interaction terms revealed that the relationship between IPIP-Extraversion and post-PA did not depend on the positive condition contrast, $\beta = -.03$, $t < 1$, *ns*, or the negative condition contrast, $\beta = .07$ $t < 1$, *ns*. This was reflected in analysis of simple slopes, which confirmed that the relationship between EPQ-R-Extraversion and post-PA was non-significant for the neutral, $\beta = 0.12$, $t(121)= 1.02$, $p = .31$, and positive, $\beta = 0.06$, $t < 1$, *ns*, mood induction conditions. Interestingly, this relationship did reach significance in the negative mood induction condition, $\beta = .224$, $t(121) = 2.15$, $p = .03$.

As we predict that the null hypothesis will be retained, we calculated the Bayes factor, which is the probability of the data under the null hypothesis relative to the probability of the data under an alternative hypothesis (Rouder & Speckman, 2009; Wetzels et al., in press). In this study, the null hypothesis is that the effect of mood induction on PA will not be moderated by Extraversion. We obtained a Bayes factor for the null hypothesis of .001 for both EPQ-R and IPIP Extraversion scores, which means that the data were approximately 1,000 times more likely to have occurred under the null hypothesis. This magnitude of effect is thought to constitute decisive evidence for the null hypothesis (Jeffreys, 1961).

These results clearly show that PA was successfully and exclusively induced in participants who read vignettes describing pleasant/happy scenarios whilst listening to pleasing music. Contrary to predictions from the ARH, extraverts did not respond more strongly to the positive mood induction condition in terms of PA. The relationship between Extraversion and post-PA was only significant for IPIP-Extraversion in the negative mood induction condition – an effect that is at odds with the ARH. For experiment 2 we used archival data to conceptually replicate this study using a different mood induction procedure and different questionnaire measures. Again, a procedure was sought which had been previously shown to be successful in inducing PA, but which did not involve salient appetitive elements. Furthermore, to help rule out the possibility that low power may provide an explanation for the results of experiment 1, we sought a much larger sample size for experiment 2.

Experiment 2

Participants

Experiment 2 consisted of 252 participants (49% male; age information not available) who participated as part of a psychology research participation scheme at a North American university. Participants received course credit for participation. These participants are a subset of the data reported by Rafaeli and Revelle (2006) and are available on the public-domain data handling system R (R Development Core Team, 2010; http://www.r-project.org/) as part of the Psych package (Revelle, 2010). Data concerning Extraversion have not previously been reported.

Materials

Extraversion and PA Measures

The Eysenck Personality Inventory (EPI; Eysenck & Eysenck, 1964) is a 57-item questionnaire assessing Extraversion and Neuroticism, along with a 'lie scale' to detect strategic dissimulation. As for study 1 we focused only on the Extraversion scale (24 items). Participants respond to this inventory by answering 'Yes' or 'No' to a series of questions (e.g., "*Do you like going out a lot*?"). The content of the EPI is very similar to that of the EPQ-R, but has a stronger focus on the impulsive-outgoing aspects of Extraversion and less emphasis on sociability (Rocklin & Revelle, 1981). Cronbach's Alpha for EPI Extraversion was acceptable in the present study (α = .80).

PA and NA were assessed following the mood induction using items from the Motivational States Questionnaire (MSQ; Revelle & Anderson, 1996), which is composed of 72 adjectives from various affective inventories (Larsen & Diener, 1992; Thayer, 1986; Watson et al., 1988). Rafaeli and Revelle (2006) previously identified adjectives from the MSQ that are the best markers of PA and NA based on angular distance between items. In the current study, participants were asked to rate the four best markers of PA (*delighted, happy, pleased,* and *satisfied*) and NA (*blue, depressed, sad*, and *unhappy*) with respect to how they felt "at this moment" using a 4-point scale (0 = "not at all" to 3 = "very much"). Total scores are formed by taking the mean response to all items. Cronbach's Alphas for PA and NA post-mood induction were each 0.92.

Mood Induction Procedure

All testing took place in small groups. Participants were randomly assigned to one of the following mood induction conditions: happy (n = 84), sad (n = 84) or neutral (n = 85). Descriptive statistics for the three groups on all variables are depicted in Table 1. Mood was induced using previously validated film clips (Rafaeli & Revelle, 2006). The experimenter informed participants that they would be watching a short film and that they should not talk to each other during or after the clip. The experimenter then turned off the lights and started the film. All clips lasted just over 9 min, and consisted of the following: (1) Sadness: taken from a PBS *Frontline* episode (May 1985) depicting World War II concentration camps; (2) Neutral: taken from a *National Geographic* film depicting animals grazing in their natural habitat; and (3) Happy: taken from the 1989 film *Parenthood* depicting a children's birthday party. Immediately after watching the clip, participants completed the MSQ. At the conclusion of the study, those participants who had viewed the sad clip were shown a brief clip from the film *Parenthood* at the request of the ethical review board. All participants were given a comprehensive debriefing.

Results and Discussion

Preliminary Statistics

At baseline, there were no significant differences on EPI-Extraversion (see Table 1). Affect was measured after the mood manipulation only, and therefore we are unable to ascertain correlations between Extraversion and affect prior to the experiment.

To test the effectiveness of the mood induction procedure, we used a 3 (mood condition) x 2 (affect type) mixed ANOVA to examine the effect of mood condition on PA and NA. This yielded a significant interaction, $F(2, 249) = 123.80$, $p < .001$, $\eta^2_p = .50$, indicating that the effect of mood condition differed by affect type. Therefore, two one-way ANOVAs were conducted to examine differences across the three mood manipulation conditions for PA and NA scores, respectively. The effect of condition on PA was significant, $F(2, 249) = 11.24$, $p < .001$, $\eta^2_p = .08$. Tukey post-hoc tests revealed that PA was significantly higher in the happy mood manipulation condition than the sad ($p < .001$) and neutral ($p < .001$) conditions; PA did not differ significantly between the neutral and the sad condition

(p = .27) (see Table 1). The effect of condition on NA was also significant $F(2, 249) = 63.42$, $p < .001$, $\eta^2_p = .34$, with Tukey post-hoc tests showing that NA was significantly higher in the sad mood manipulation than the neutral ($p < .001$) and happy ($p < .001$) conditions; NA did not differ significantly between the neutral and happy conditions (p = .21) (see Table 1).

Extraversion and Affective-Reactivity

Primary analyses examined the moderating effect of Extraversion on the induction of PA. As for experiment 1, moderated multiple regression was conducted. Continuous predictors were standardized to reduce multicolinearity, and gender was entered at step 1 of a hierarchical multiple regression. At step 2, EPI-Extraversion was entered, along with two dummy variables each reflecting a condition contrast (the first dummy variable contrasted the happy with the neutral and sad conditions whilst the second contrasted the sad with the neutral and happy conditions). The overall model was significant, $R^2 = .11$, $F(4,247) = 7.54$, $p < .001$, and there was a significant increment in prediction at this step, $R^2_{ch} = .11$, $F_{ch}\ (3,247) = 9.60$, $p < .001$. EPI-Extraversion, $\beta = .86$, $t(247) = 2.17$, p =.03, the happy condition contrast, $\beta = 3.68$, $t(247) = 4.42$, $p < .001$, and the sad condition contrast, $\beta = -3.02$, $t(247) = 3.65$, $p < .001$ each contributed significantly to the prediction of PA. At step 3 the two interaction terms were entered, these reflecting the interaction between EPI-Extraversion and each of the two dummy condition variables. Although the overall model remained significant, $R^2 = .11$, $F(6,245) = 5.05$, $p < .001$, there was no significant increment in R^2 at step 3, $R^2_{ch} < 0.01$, $F_{ch} < 1$, *ns*. Inspection of the interaction terms revealed that the relationship between Extraversion and PA did not depend on the happy condition contrast, $\beta = -.11$, $t < 1$, *ns*, nor the sad condition contrast, $\beta = -.56$, $t < 1$, *ns*. Analysis of simple slopes confirmed that the relationship between EPI-Extraversion and PA was non-significant for the neutral, $\beta = 0.68$, $t\ (245) = 1.02$, p = .31, sad, $\beta = 1.00$, t =1.48, p = .14, and happy, $\beta = 1.02$, $t\ (245) = 1.42$, p = .16, mood induction conditions.

In order to more directly examine the likelihood of the null hypothesis (i.e., the effect of mood induction on PA should not be moderated by Extraversion), we repeated analyses described in experiment 1 to compute the Bayes factor. The Bayes factor for the null hypothesis was equal to .005, indicating that the data were approximately 200 times more likely to have occurred under the null hypotheses. As for experiment 1, these results constitute decisive evidence in favor of the null hypothesis (Jeffreys, 1961).

Results of experiment 2 replicated those of experiment 1 using different methods and measures and a much larger sample. Once again we successfully induced PA, this time by having participants watch a humorous, 'feel-good' scene from a movie. There was again no support for the ARH, as extraverts did not respond more strongly to the positive mood induction condition in terms of PA. This is despite the fact that our large sample size and lack of baseline affect measures in the model likely increased the chances of our obtaining a significant Extraversion x condition interaction. The null finding matches our earlier theoretical inference that merely pleasant stimuli (e.g., humorous/'feel-good' video clips) may not provide the motivationally salient reward-approach cues to which extraverts are thought to be especially reactive. In experiment 3 we employ an explicitly appetitive mood induction scenario; one in which PA is induced by having participants actually engage in behavioral pursuit of reward. We selected a go/no-go task during which affect was manipulated by either rewarding participants for correct responses with monetary gains or punishing them for incorrect responses with monetary losses. This paradigm has been shown to induce PA and NA (Gomez & McClaren, 1997), and to yield support for the ARH (Gomez et al., 2000). We expected to replicate findings by Gomez and colleagues, and, in doing so, conceptually replicate Larsen and Ketelaar (1991).

Experiment 3

Participants

Ninety-seven adults (33% male) aged between 18 and 30 years of age (*M* = 19.49, *SD* = 2.10) were recruited from a British university. All participants were undergraduate psychology students who participated in exchange for course credit.

Materials and Procedure

Extraversion and PA Measures

Extraversion was assessed using the EPQ-R, which was described earlier in experiment 1. State affect was measured using the PANAS, also described in experiment 1. Cronbach's Alpha for EPQ-R Extraversion in the present study was 0.85, and for PANAS PA pre-mood induction was 0.93, PANAS PA post-mood induction was 0.91, PANAS NA pre-mood induction was 0.87 and PANAS NA post-mood induction was 0.79.

Mood Induction Procedure

All testing took place individually in a sound-proof laboratory. Participants were randomly assigned to either a positive (n = 52) or negative (n = 45) mood induction condition. Prior to undertaking the mood induction procedure, participants completed the EPQ-R, followed by a baseline measure of the PANAS. Table 1 depicts descriptive statistics on all variables for both experimental groups. Positive and negative affect states were induced by inviting participants to perform a go/no-go task during which it was possible to either win or lose money. This task has been previously shown to induce PA and NA (Gomez, et al., 2000; Gomez & McLaren, 1997).

The go/no-go task consisted of 96 trials, divided into 8 blocks of 12 trials. Each trial involved the presentation of one of 12 two-digit numbers on a computer monitor, presented randomly. In each trial, the number was presented until the participant responded by pressing the space bar of a standard keyboard, or for a maximum of 3 seconds if the participant did not respond. The inter-trial-interval was 1.5 seconds. Of these 12 numbers, six were covertly tagged as 'good' numbers and six were covertly tagged as 'bad' numbers. Participants were instructed to learn, by trial and error, which numbers were 'good' and which were 'bad'. To provide familiarization with the workings of the task, 18 practice trials were presented before the 96 test trials.

Participants who served in the gain-approach condition were instructed that every time they responded to a 'good' number or refrained from responding to a 'bad' number they would gain £0.05, and that there was no loss of money for failing to respond to a 'good' number or for responding to a 'bad' number. Correct responses resulted in visual feedback for 1 second on the monitor indicating they had won £0.05. Participants who served in the loss-avoid condition started with a bonus of £5.00, which was indicated to them. They were instructed that every time they failed to respond to a 'good' number, or responded to a 'bad' number, they would lose £0.05, and that they would not gain money for responding to a 'good' number or not responding to a 'bad' number. Incorrect responses resulted in visual feedback for 1 second indicating that they had lost £0.05. All instructions were provided to participants on the computer monitor prior to beginning the task. The task used a random set of numbers for each participant and did not use double-digit numbers containing the same number (e.g. 88), as these were considered too distinctive. At the conclusion of the task, participants completed the PANAS a second time. Participants were then informed that the study was completed and were debriefed. Lastly, participants were informed of their task performance and paid any money they had won.

Results and Discussion

Preliminary Statistics

At baseline, there were no significant differences among experimental groups on any of the personality or affect measures (see Table 1). EPQ-Extraversion was positively related to pre-PA, $r(95) = 0.27$, $p < .001$, but not to pre-NA, $r(95) = -0.05$, $p = .60$. Also, pre-NA and pre-PA were unrelated, $r(95) = 0.02$, $p = .83$.

A 2 (pre-post) x 2 (mood condition) x 2 (affect type) mixed ANOVA was conducted to confirm that the gain-approach and loss-avoid conditions had their intended effects upon PA and NA. There was a significant three-way interaction, $F(1, 95) = 27.29$, $\eta_p^2 = 0.22$, indicating that change in affect depended on both experimental condition and affect type. Follow-up tests confirmed that PA increased in the gain-approach condition, $F(1, 52) = 23.65$, $\eta_p^2 = 0.30$, while NA increased in the loss-avoid condition, $F(1, 43) = 19.04$, $\eta_p^2 = 0.31$. Also, post-PA was higher following approach of gains than following avoidance of losses, $F(1, 96) = 15.55$, $p < .001$, $\eta_p^2 = 0.14$, and post-NA was higher following avoidance of losses than approach of rewards, $F(1, 96) = 7.13$, $p = .009$, $\eta_p^2 = 0.07$. These results support the validity of the mood induction manipulation (see also Table 1)

Because mood was induced by having participants approach reward (maximize financial gains) or avoid punishment (minimize financial losses), it was important to demonstrate that the amount of money won/lost during the go/no-go task was unrelated to mood induction condition or personality. A one-way ANOVA confirmed that the average amount of money accrued in the gain-approach condition (£3.58) did not differ from that retained in the loss-avoid condition (£3.64), $F < 1$, *ns.* Even more important was the observation that total money accrued/retained was unrelated to trait Extraversion (gain-approach, $r(95) = -0.03$, $p > .05$; loss-avoid, $r(95) = 0.06$, $p > .05$). As such, any support found for the ARH in this study cannot be attributed to, for instance, extraverts finishing the task with more money than introverts in the gain-approach condition.

Extraversion and Affective-Reactivity

Focal analyses examined the effect of mood condition on PA as a function of Extraversion, again employing moderated multiple regression. Continuous predictors were standardized to reduce multicolinearity, and a hierarchical regression was conducted with pre-PA and gender entered at step 1, Extraversion and Condition (a single dummy variable reflecting the binary condition contrast) entered at step 2, and the Extraversion x Condition interaction term entered at step 3. The model was significant at step 1, $R^2 = .40$, $F(2,94) = 31.62$, $p < .001$, with pre-PA contributing significantly to prediction, $\beta = .63$, $t(94) = 7.92$, $p < .001$, and gender making no significant contribution, $\beta = -.03$, $t < 1$, *ns*. At step 2 there was a significant increment in prediction, $R^2_{ch} = 0.17$, F_{ch} (1,92) = 18.50, $p < .001$, and the overall model remained significant, $R^2 = .57$, $F(4,92) = 30.77$, $p < .001$. Both EPQ-Extraversion, $\beta = .16$, $t(91) = 2.22$, $p = .03$, and the condition contrast, $\beta = -.40$, $t(91) = 5.81$, $p < .001$, contributed significantly to prediction. In line with our hypotheses, there was a near-significant increment in R^2 at step 3, $R^2_{ch} = 0.02$, F_{ch} (1,91) = 3.96, $p = .05$, and, equivalently, the coefficient for the interaction term approached significance, $\beta = -.18$, $t(91) = 1.99$, $p = .05$. This confirms that the relationship between Extraversion and PA was dependent upon experimental condition. Analysis of simple slopes confirmed that Extraversion was unrelated to PA in the loss-avoid condition, β = -.12, $t < 1$, *ns*, but positively and significantly predictive of PA in the gain-approach condition, β = .27, $t(91) = 3.00$, $p = .003$. The relationship between Extraversion and PA within each mood induction condition is plotted in Figure 1.

In contrast to findings from experiments 1 and 2, these results yield clear support for the ARH. Our data replicate findings presented by Gomez et al. (2000), and closely mirror results from the vignette-based experiment by Larsen and Ketelaar (1991). For the third time we successfully induced PA, on this occasion by enabling participants to pursue financial gains during a behavioral task. However, increases in positive affect in this condition were greater for those scoring more highly on a measure of Extraversion. This flows directly from our theoretical evaluation of the ARH – which attributes the greater affective-reactivity of extraverts to a more reactive reward system – from the position of biological plausibility. Specifically, because this reward system or 'BAS' is activated during appetitive scenarios, such as when one is engaged in the behavioral pursuit of reward, we should only expect extraverts (i.e., BAS-reactive individuals) to experience increased PA during such circumstances.

Experiment 4

Our first three experiments might be seen to simply repeat the mixed findings in the literature concerning the ARH. However, our goal is to explain, and so predict, these varying results. In combination, our first three experiments support our theorizing regarding the conditions under which the ARH will be confirmed or disconfirmed. In experiment 4 we wanted to conceptually replicate and extend experiments 1-3 within a single paradigm. This is a crucial step in demonstrating support for our hypotheses, because the divergent results obtained so far might be due to apparently trivial differences between mood induction modalities. That is, there may be some basic difference between the non-appetitive inductions of PA employed in study 1 and 2 and the appetitive induction of PA in study 3 (e.g., length of procedure, level of activity required, stimulus strength etc) that offers an alternative explanation of our findings to the one we provide. For this reason we returned to the methodology used in experiment 1, which induced affective states via guided imagery. This modality is of particular interest because of its use by Larsen and Ketelaar (1991), whose positive findings, we argue, can be attributed to the highly appetitive nature of the scenarios they employed (i.e., involving winning/finding money). As such, in experiment 4 we also employ appetitive vignettes but contrast these with merely pleasant vignettes of the kind used in experiment 1.

A second aim of experiment 4 was to substantively extend experiments 1-3 by providing a more finely grained analysis of affective-reactivity. Research into the structure of affective states has placed increasing emphasis on the distinction between *valence* and *activation* (e.g., Carrol, Yik, Russell & Feldman Barrett, 1999; McNeil, Lowman & Fleeson, 2010; Morrone, Depue, Scherer & White, 2000; Russell & Feldman Barrett, 1999; Yik, Russell & Steiger, 2011). Valence ranges from pleasantness (e.g., *cheerful*) to unpleasantness (e.g., *miserable*). Activation, on the other hand ranges from high activation-arousal states (e.g., *alert*) to lower activation-arousal states (e.g., *still*). 'PA' therefore subsumes pleasantly-valenced states that may be activated (e.g., *elated*), deactivated (e.g., *content*) or intermediate (e.g., *pleased*). The ARH, as it is frequently described in the literature, supposedly concerns Extraversion-dependent effects of positive mood inductions on pleasant *valence*. For instance, Lucas & Fujita (2000, p. 1039) noted that "…extraverts may be more sensitive to rewards, which makes them more likely to experience pleasant affect…" However, most studies that have supported the ARH, including experiment 3 of the present paper, have employed the PANAS, the content of which is clearly representative of highly *activated* PA. Example PANAS items include *interested, active,* and *alert*, whilst adjectives such as *happy*, *cheerful,* or *content* are not sampled at all (Watson et al., 1988). As activated PA is a mixture of valence and activation, it might be asked which of these processes best captures the affective-reactivity of extraverts observed in experiment 3 and previously.

To our knowledge, only one study has contrasted valence and activation in tests of the ARH. Lucas and Baird (2004, study 1) attempted to replicate Larsen and Ketelaar's (1991) study using identical scenarios, but this time measuring both pleasant valence (example items were '*pleasant'* and '*good'*), and activation (example items were '*awake'* and '*alert'*). No Extraversion x mood condition interaction was found when predicting pleasant valence, but this effect was significant when predicting activation. When this finding is considered alongside previous studies that have assessed PA using measures which strongly index activated states – including Larsen and Ketelaar (1991), Gomez et al. (2000) and experiment 3 of the present paper – it is tempting to suggest that the ARH may apply specifically to activated states. However, Lucas and Baird (2004) did not arrive at such a suggestion because they replicated their finding in only two out of five further studies using pleasant mood induction stimuli (humorous video clips and paper-format jokes and cartoons). As such, they concluded that examination of activated affect yielded only "mixed" support for the ARH (p. 473). However, based upon the findings from experiments 1-3 of the present paper, we would not expect extraverts to respond any differently to introverts unless a clearly appetitive mood induction procedure was used. It is possible that Lucas and Baird (2004) would have replicated the pattern of results obtained in their first study if they had continued to employ clearly appetitive, goal-related mood induction procedures throughout their subsequent studies. We are now in the position to test this prediction.

Several lines of argument suggest that, not only should the ARH apply especially to appetitive scenarios, but also to activated affective states in particular. First, a broadly specified concept of activation-arousal has long been included among the outputs of the BAS (e.g., Fowles, 1980; Gray & Smith, 1969) and potentially serves to focus attention on appetitive goals (Revelle, 1993; Thayer, 1989). Second, the supposedly dopamine-driven state of 'wanting', described earlier, is often defined in animal learning studies as the behavioral vigor with which rewards are approached (Robinson et al., 2005), which is almost indistinguishable from operational definitions of BAS-driven activation-arousal (e.g., Gray, 1982, p. 470). Third, although pleasant mood is often not induced by dopaminergic agonists (Leyton et al., 2002), arousal states that are central to the concept of activated affect are (Berridge, 2006; Lu, Jhou, & Saper, 2005; Nishino, Mao, Sampathkumaran & Shelton, 1998), as is vigour of responding for reward (Al-Adawi, Powell & Greenwood, 1998). Similarly, one of the critical neural systems involved in the regulation of arousal and alertness is the dopamine system (Arnsten, 1998; Rammsayer, 1998). Finally, recent efforts to describe approach-motivated states do so using adjectives that are representative of activated affect (e.g., *excitement* and *enthusiasm*; Gable & Harmon-Jones, 2008), which have been explicitly suggested to represent "a state of incentive motivation" (Morrone-Strupinsky & Lane, 2007, p. 1271, see also Bradley & Lang, 2007, Figure 2.2). All of this encourages the view that the affective state which reward-reactive individuals might experience to a relatively greater extent in an appetitive, reward-pursuit scenario might be best described in terms of high activation rather than pleasant valence. Accordingly, in experiment 4 we predicted that extraverts would again respond more strongly than their introverted counterparts when appetitive scenarios are employed (replicating experiments 1-3 within a single paradigm), but also specifically in terms of activated (as opposed to pleasantly valenced) affect.

Method

Participants

One-hundred and seven adults (23% male) aged between 18 and 41 (*M* = 20.99, *SD* = 4.31) were recruited from a British university. All of the participants were undergraduate psychology students who participated for course credit.

Materials

Extraversion and Affect measures

As per study 1 and 3, Extraversion was measured using the EPQ-R. In this study Cronbach's Alpha was acceptable, α = 0.82. To measure Pleasant and Activated Affect, we administered the UWIST Mood Adjective Checklist (UMACL; Matthews, Jones, & Chamberlain, 1990). This measure is comprised of 29 adjectives that are rated using a four point Likert-style response scale. In this study, participants were asked to rate each adjective in terms of how they felt at that current moment. Factor analytic studies of the adjectives have yielded three factors: Hedonic Tone, Energetic Arousal and Tense Arousal. Hedonic Tone consists of adjectives reflecting pleasant affect (e.g., *cheerful, happy*), whilst Energetic Arousal consists of adjectives reflecting activated PA (e.g., *alert, vigorous*). Tense Arousal consists of adjectives reflecting activated NA (e.g., *tense, jittery*), but was not of relevance to the present hypotheses. Total scores for all three factors are created by summing ratings across the appropriate adjectives. The UMACL has been shown to have very good reliability and validity (Matthews et al., 1990). Cronbach's Alpha for Hedonic Tone pre-mood induction was 0.86 and for post-mood induction was 0.89; for Energetic Arousal pre-mood induction this value was 0.80 and for post-mood induction was 0.82.

Mood Induction Procedure

All testing took place individually in a sound-proof laboratory. Participants were randomly assigned to one of the following three mood induction conditions: positive-appetitive (n = 33), positive-pleasant (n = 33) and neutral (n = 41). Prior to undertaking the mood induction procedure, participants completed the EPQ-R along with a baseline measure of the UMACL scales. Descriptive statistics for all groups are displayed in Table 1.

Mood was induced via guided imagery, consisting of vignettes and background music. The basic procedure for the mood induction followed that outlined above in Study 1. This included telling participants that they would be asked to recall key details of the vignettes. The vignettes used in this study were adapted from previous mood induction studies (Larsen & Ketelaar, 1991; Mayer et al., 1995). Six scenarios were constructed in total, two for each mood induction condition. Merely pleasant vignettes consisted of scenarios concerning pleasure and contentment, without any appetitive or reward-pursuit elements. An example was '*You are lying in the warmth of the sun on a tropical beach, with the sound of gentle waves in the background*'. Conversely, appetitive vignettes consisted of scenarios concerning explicit reward-pursuit elements. An example was '*You buy a lottery* *ticket and you win £1000.00 instantly*'. Neutral scenarios were similar to that used in study 1, including '*You are shopping at the supermarket for groceries that you need to purchase for your dinner*'. The following music was used to accompany each of the mood induction conditions in order to maintain comparability with results of the first experiment: 1) positive-pleasant: Venus from 'The Planets' by Holst, 2) positive-appetitive: Waltz of the Flowers from the 'Nutcracker Suite' by Tchaikovsky and 3) Neutral: the Largo movement from 'The New World Symphony' by Dvorak.

Once participants understood the instructions for the guided imagery task, the experimenter began the background music and left the participant to commence the task. The guided imagery task lasted a total of eight minutes. Participants were asked to spend four minutes on each scenario; a computer-based timer triggered a flash of light and brief message on a computer screen indicating when the participant should move to the next scenario. At the conclusion of the imagery task, the participants were immediately given the UMACL to complete a second time. Participants were then informed that the task had finished and were debriefed.

Results and Discussion

Preliminary Statistics

At baseline, there were no significant differences among experimental groups on any of the personality or affect measures (see Table 1). EPQ-R-Extraversion was unrelated related to baseline Energetic Arousal, $r(105) = 0.10$, $p = .30$, but significantly related to Hedonic Tone, $r(105) = 0.23$, $p = .02$. Hedonic Tone and Energetic Arousal were strongly positively related, $r(105) = 0.61$, $p < .001$.

To confirm that the mood induction procedure was effective in inducing the targeted affective states, we conducted a 2 (pre-post) x 3 (mood condition) x 2 (affect type) mixed ANOVA. This revealed a significant three-way interaction, $F(2, 104) = 8.29$, $p < .001$, $\eta_p^2 = 0.14$. Follow-up tests indicated that Hedonic Tone increased from baseline in both the pleasant, $F(1, 32) = 23.90$, $p < .001$, $\eta_p^2 = 0.43$, and appetitive, $F(1, 32) = 15.71$, $p < .001$, $\eta_p^2 = 0.33$, mood conditions, whereas Energetic Arousal increased from baseline in the appetitive condition, $F(1, 32) = 25.20$, $p < .001$, $\eta_p^2 = 0.44$, but not in the pleasant condition $F < 1$, *ns*, $\eta_p^2 = 0.001$. Energetic Arousal did not change from baseline in the neutral condition, $F(1, 40) = 1.67$, $p = .204$, $\eta_p^2 = 0.04$, but Hedonic Tone decreased somewhat, $F(1, 40) = 6.42$, $p = .02$, $\eta_p^2 = 0.14$. A one-way ANOVA revealed that the effect of mood condition on post Energetic Arousal was significant, $F(2, 104) = 11.01$, $p < .001$, $\eta_p^2 = 0.18$, with Tukey's post hoc tests showing the appetitive mood induction group having significantly higher post scores compared to the pleasant mood group ($p < .001$) and the neutral group ($p < .001$) (see Table 1). Additionally, the effect of mood induction on post Hedonic Tone was also significant, $F(2, 104) = 8.09$, $p < .001$, $\eta_p^2 = 0.13$, with Tukey's post hoc tests showing the pleasant mood induction group having significantly higher post Hedonic Tone compared to the neutral condition ($p = .003$) but similar Hedonic Tone to those in the appetitive condition ($p = .63$) (see Table 1). Overall, this pattern of results shows that both pleasant and activated affect were induced in the appetitive mood condition, while only pleasant affect was induced in the non-appetitive pleasant condition.

Extraversion and Affective-Reactivity

Moderated regression was employed to test the prediction that Extraversion would only predict increased Energetic Arousal, and only after the appetitive mood condition. Continuous predictors were standardized to reduce multicolinearity, and both gender and pre-Energetic Arousal was entered at step 1 of a hierarchical multiple regression. This resulted in a significant preliminary model, $R^2 = .33$, $F(2,103) = 25.43$, $p < .001$, with Energetic Arousal, $\beta = 0.58$, $t(103) = 7.12$, p < .001, but not gender, $\beta = 0.08$, $t < 1$, *ns*, contributing significantly to prediction. At step 2, Extraversion was entered, along with two dummy variables each reflecting a condition contrast (the first dummy variable contrasted the appetitive condition with the positive and neutral conditions whilst the second contrasted the pleasant condition with the appetitive and neutral conditions). This produced a significant increment in prediction, $R^2_{ch} = 0.21$, $F_{ch}(3,100) = 15.27$, $p < .001$, and the overall model was again significant, $R^2 = .54$, $F(5,100) = 23.57$, $p < .001$. EPQ-R-Extraversion, $\beta = .15$, $t(100) = 2.14$, $p = .04$, and the appetitive contrast, $\beta = .40$, $t(100) = 5.23$, $p < .001$, were significant predictors in the model, but the pleasant contrast was not, , $\beta = -.07$, $t < 1$, *ns*. At step 3 when the two interaction terms were entered, the increment in R^2 approached significance, $R^2_{ch} = 0.023$, F_{ch} $(2,98) = 2.55$, $p = .08$, and the overall model remained significant, $R^2 = .56$, $F(7,98) = 18.08$, $p < .001$. Inspection of the interaction terms revealed that the relationship between Extraversion and Energetic Arousal did not depend on the pleasant contrast, $t(98) = 1.23$, $p = .22$, but did vary over levels of the appetitive contrast, $t(98) = 2.25$, $p = .027$. In accord with predictions, analysis of simple slopes confirmed that the relationship between Extraversion and Energetic Arousal was non-significant for the neutral condition, $\beta = -0.01$, $t < 1$, *ns,* or pleasant condition, $\beta = 0.16$, t $(98) = 1.41$, $p = .16$, but was significant for the appetitive mood induction condition, $\beta = 0.34$, t $(98) = 2.82$, $p = .006$. The relationship between Extraversion and activated affect within each mood induction condition is plotted in Figure 2.

When these analyses were repeated supplementing Hedonic Tone for Energetic Arousal, the model at step 1 was again significant, $R^2 = .36$, $F(2,103) = 28.34$, $p < .001$, with pre-Hedonic Tone, $\beta = .59$, $t(103) = 7.45$, $p < .001$, but not gender, $\beta = .07$, $t < 1$, *ns*, contributing significantly to prediction. At step 2 there was a significant increment in R^2, $R^2_{ch} = 0.13$, $F_{ch}(3,100) = 8.53$, $p < .001$, and the overall model remained significant, $R^2 = .49$, $F(5,100) = 18.94$, $p < .001$, with pre-Hedonic Tone, $\beta = .59$, $t(103) = 7.45$, $p < .001$, but not gender, $\beta = .07$, $t < 1$, *ns*, contributing significantly to prediction. At step 3 the increment in R^2 fell well short of significance, $R^2_{ch} = 0.014$, $F_{ch}(2,98) = 1.41$, $p = .25$, although the overall model remained significant, $R^2 = .50$, $F(7,98) = 14.04$, $p < .001$. Inspection of the interaction terms revealed that the relationship between Extraversion and Hedonic Tone did not depend on the appetitive-neutral contrast, $t < 1$, *ns,* nor the pleasant-neutral contrast, $t(98) = 1.68$, $p = .10$. Analysis of simple slopes confirmed that the relationship between Extraversion and Hedonic Tone was statistically non-significant in the neutral, $\beta = 0.18$, t $(98) = 1.50$, $p = .14$, appetitive, $\beta = 0.04$, $t < 1$, *ns*, and pleasant, $\beta = -0.11$, $t < 1$, *ns*, conditions.

In summary, results of experiment 4 yielded clear support for all of our predictions within a single paradigm. For a fourth time our attempt to induce mood was successful, this time demonstrating a sharp distinction between pleasant and activated states. Hedonic Tone, a marker of pleasant affect, was increased in both positive mood conditions. Energetic Arousal, a marker of activated affect, was increased only in the appetitive mood condition (as found in conceptually similar work, e.g., Gable & Harmon-Jones, 2008). In accord with our predictions, extraverts experienced greater levels of activated affect than their introverted co-participants after the appetitive condition (replicating experiment 3) but not after the pleasant condition (replicating experiments 1 and 2). According to our arguments detailed earlier, this is because individual differences in reward-reactivity should emerge only during appetitive mood induction procedures in terms of activated affect.

Experiment 5

The results of experiment 4 are consistent with our explanation for why in experiment 1 and 2 we found no support for Larsen and Ketelaar's (1991) classic study regarding the affective-reactivity of extraverts. Specifically, it seems that this effect is not simply unreliable, as concluded by Lucas and Baird (2004), but rather is highly specific to the way in which mood is induced and the aspect of mood that is assessed. Again, however, this should not suggest that extraverts respond differently to introverts depending on the mood-induction *modality*. Indeed, while experiment 4 demonstrated increased activated affect in extraverts in response to vignettes describing reward pursuit situations, experiment 3 demonstrated this in the context of a behavioral task involving actual reward pursuit. To confirm the findings of experiment 4, and their invariance across mood-induction modalities, we provided a further test of our hypotheses using film clips to induce mood. This was achieved by simply extending the methodology employed in experiment 2. We anticipated finding that the 'happy' clip used in experiment 2 (i.e., the birthday party scene from the film *Parenthood*) would induce pleasant affect equally for extraverts and introverts, as observed using the MSQ positive affect scale, items from which are pleasantly valenced but neutral with respect to activation-deactivition. Conversely, we expected a film clip selected for its clear reward-pursuit elements (described below) to induce activated affect, and for this effect to be more pronounced for extraverts than for Introverts.

A second aim of experiment 5 was to examine whether the variance that Extraversion shares with purpose-built trait markers of reward-reactivity accounts for the increased energetic arousal in response to appetitive stimuli observed in experiments 3 and 4. This is an important step toward confirming the supposed mechanism responsible for extraverts' stronger responses to reward. To our knowledge, no previous research has confirmed that the affective-reactivity of extraverts, when this is observed, is attributable to Extraversion-related differences in reward-reactivity. Although Extraversion is correlated with trait measures of reward-reactivity (e.g., the "BAS scales" of Carver & White, 1994), and may have a partial basis in such processes as regulated by the mesolimbic dopamine system, it seems unlikely that Extraversion is entirely reducible to reward-reactivity (Revelle & Wilt, 2008). Indeed, Extraversion typically shares around 30% of its variance with reward-reactivity questionnaires. According to the ARH, it is this variance that specifically accounts for extraverts' increased activated affect in response to appetitive stimuli or scenarios.

Method

Participants

One-hundred-and-four adults (20% male) aged between 18 and 38 (M = 20.35, SD = 3.39) participated. All of the participants were psychology students who participated for course credit.

Materials

Extraversion, Reward-Reactivity and Affect measures

As per experiments 1, 3, and 4, Extraversion was measured using the EPQ-R. In this study Cronbach's Alpha was acceptable, α = 0.75. Variation in trait reward-reactivity was measured using the BIS/BAS scales presented by Carver and White (1994). Three BAS scales capture different aspects of reward-reactivity, such as motivation by and seeking of reward (e.g., '*When I see an opportunity for something I like, I get excited right away*'). Items are responded to using a four-point Likert scale from 1 = strongly agree to 4 = strongly disagree. These measures have been shown to predict behavioral responses to reward (Smillie et al., 2007) as well as neural markers of dopamine function and reward-reactivity (Reuter, Schmitz, Corr, & Hennig, 2006; Sutton & Davidson, 1997). In this study Cronbach's Alpha for each scale was acceptable, α = 0.79 (BAS-Drive), 0.67 (BAS-Fun Seeking) and 0.68 (BAS-Reward). To measure Pleasant and Activated Affect, we again administered the UWIST Mood Adjective Checklist (UMACL; Matthews et al., 1990) in order to obtain scores for Hedonic Tone and Energetic Arousal. Cronbach's Alpha for Hedonic Tone pre-mood induction was 0.86 and for post-mood induction was 0.86; for Energetic Arousal pre-mood induction this value was 0.68 and for post-mood induction was 0.81.

Mood Induction Procedure

All testing took place individually in a sound-proof laboratory. Participants were randomly assigned to one of the following three mood induction conditions: positive-appetitive (n = 36), positive-pleasant (n = 36) and neutral (n = 32). Prior to undertaking the mood induction procedure, participants completed the EPQ-R and BIS/BAS scales along with a baseline measure of the UMACL scales. Descriptive statistics for all three groups are displayed in Table 1.

Mood was induced using a set of three film clips based on those used in experiment 2 and reported previously (Rafaeli & Revelle, 2006). The three clips consisted of the following: (1) Neutral: taken from Gross and Levenson (1995) depicting a repeated montage of colored lines; (2) Pleasant: taken from the 1989 film *Parenthood* depicting a children's birthday party (this was a slightly shorter edit of the same scene used in experiment 2); and (3) Appetitive: taken from the 2006 film *Casino Royale* depicting the well-known fictional protagonist *James Bond* pursuing and finally capturing a villain. The appetitive clip was selected from three candidate clips with the assistance of three expert raters. A noteworthy feature of this clip is that it clearly depicts goal-directed behavior and goal success but is not 'pleasant' in any obvious way. Its influence on affect may therefore be subtly different to the appetitive scenario used in experiment 4, which increased both Hedonic Tone and Energetic Arousal. For all participants in all conditions, the UMACL scales were administered a second time immediately after viewing the clip. Participants were then debriefed and thanked for their time.

Results and Discussion

Preliminary Statistics

There were no significant differences among experimental groups on any of the personality or affect measures at baseline (see Table 1). EPQ-R-Extraversion was not related to baseline Energetic Arousal, $r(102) = 0.04$, $p = .70$, or Hedonic Tone, $r(102) = 0.08$, $p = .40$. Baseline Hedonic Tone and Energetic Arousal were moderately intercorrelated, $r(102) = 0.22$, $p = .03$.

To confirm the efficacy of the mood induction procedure, we conducted a 2 (pre-post) x 3 (mood condition) x 2 (affect type) mixed ANOVA. This revealed a significant three-way interaction, $F(2, 101) = 5.60$, $p = .002$, $\eta_p^2 = 0.10$. Follow-up tests showed that Energetic Arousal did not change from baseline following the neutral clip, $F < 1$, *ns*, η_p^2 = 0.02, while Hedonic Tone decreased somewhat, $F(1, 31) = 8.99$, $p = .005$, $\eta_p^2 = 0.22$. Energetic Arousal increased from baseline following both the appetitive clip, $F(1, 35)$ =

13.29, $p < .001$, $\eta_p^2 = 0.28$, and the pleasant clip, $F(1, 35) = 11.11$, $p = .002$, $\eta_p^2 = 0.24$. Conversely, Hedonic Tone increased non-significantly after the pleasant clip, $F(1, 35) = 2.19$, $p = .14$, $\eta_p^2 = 0.06$, and decreased non-significantly after the appetitive clip, $F(1, 35) = 1.88$, $p = .18$, $\eta_p^2 = 0.05$. The lack of a formally significant increase in Hedonic Tone following either positive clip was unexpected, but may have resulted from a somewhat higher baseline level of Hedonic Tone in both the pleasant and appetitive groups relative to the neutral group (*M*s = 24.28, 24.11, vs. 22.15); $t_{contrast}(101) = 2.74$, $p = .007$. The efficacy of the pleasant clip is nevertheless supported by the change in Hedonic Tone during this condition ($M = 0.81$) relatively to the appetitive and neutral conditions (*M*s = -0.92 and -1.34); $t_{contrast}(101) = 2.79$, $p = .006$. Furthermore, a one-way ANOVA confirmed that the effect of video clip on post Hedonic Tone was also significant, $F(2, 101) = 8.71$, $p < .001$, $\eta_p^2 = 0.15$, with Tukey's post hoc tests showing the pleasant mood induction group having significantly higher post Hedonic Tone compared to the neutral condition ($p = .001$) and modestly higher post Hedonic Tone to those in the appetitive condition ($p = .14$) (see Table 1). Similarly, the effect of video clip on Energetic Arousal was also significant, $F(2, 101) = 10.59$, $p < .001$, $\eta_p^2 = 0.17$, with Tukey's post hoc tests showing the appetitive mood induction group to have significantly higher post scores compared to the neutral group ($p < .001$), and similar scores to the pleasant group ($p = .66$) (see Table 1). Overall, results show good support for the efficacy of the appetitive video for inducing activated affect, and more mixed but nevertheless positive support for the efficacy of the pleasant video for inducing pleasant affect.

Extraversion and Affective-Reactivity

Main analyses aimed to replicate key findings from experiment 4, showing that Extraversion would predict increased Energetic Arousal after viewing the appetitive film clip. As for all other experiments, moderated regression was employed. Continuous predictors were standardized to reduce multicolinearity, and pre-Energetic Arousal was entered along with gender at step 1 of a hierarchical regression. This model explained a significant amount of variance in post-Energetic Arousal, $R^2 = .34$, $F(2,101) = 26.03$, $p < .001$, with a significant contribution to prediction by baseline Energetic Arousal, $\beta = .56$, $t(101) = 6.82$, $p < .001$, but not gender, $\beta = -.12$, $t(101) = 1.44$, $p = .15$. Extraversion was then entered at step 2, along with two dummy variables reflecting the contrast for appetitive (versus neutral and pleasant) and pleasant (versus neutral and appetitive) clips. This resulted in a significant increment in variance accounted for by the model, $R^2_{ch} = 0.10$, $F_{ch}(3,98) = 5.90$, $p = .001$, and the overall model was again significant, $R^2 = .44$, $F(5,98) = 15.48$, $p < .001$. Both the appetitive, $\beta = .35$, $t(98) = 3.91$, $p < .001$, and pleasant, $\beta = .26$, $t(98) = 2.85$, $p = .005$, contrasts contributed significantly to prediction, but Extraversion did not, $\beta = .08$, $t(101) = 1.01$, $p = .32$. Finally, the two product terms (reflecting the interaction between Extraversion and each of the contrast terms) were entered at step 3. The increment in R^2 at step 3 approached significance, $R^2_{ch} = .03$, $F_{ch}(2,96) = 2.39$, $p = .09$, and the overall model was again significant, $R^2 = .47$, $F(7,96) = 12.05$, $p < .001$. Inspection of the interaction terms revealed that the relationship between Extraversion and Energetic Arousal did not depend on the pleasant contrast, $\beta = 0.07$, $t < 1$, *ns*, but instead varied over levels of the appetitive contrast, $\beta = 0.22$, $t(96) = 2.11$, $p = .04$. In accord with predictions, analysis of simple slopes confirmed that the relationship between Extraversion and Energetic Arousal was non-significant for the neutral condition, $\beta = -0.07$, $t < 1$, *ns,* and the pleasant condition, $\beta = 0.03$, $t < 1$, *ns*, but significant for the appetitive condition, $\beta = 0.38$, t

(96) = 2.36, p = .02. The relationship between Extraversion and activated affect within each mood induction condition is plotted in Figure 3.

As per experiment 4, we again sought to confirm that the ARH would not be supported when Hedonic Tone was examined rather than Energetic Arousal. Pre-Hedonic Tone was entered along with gender at step 1 of a hierarchical regression, resulting in a significant model, R^2 = .45, F(2,101) = 41.04, p < .001. Baseline Hedonic Tone was a strong contributor to prediction, β = .66, t(101) = 8.96, p < .001, while the effect of gender was considerably weaker, β = -.12, t(101) = 1.57, p = .12. Extraversion was then entered at step 2, along with two dummy variables reflecting the appetitive and pleasant mood condition. This produced a significant increment in variance accounted for, R^2_{ch} = .06, F_{ch} (3,98) = 3.65, p = .02, and the overall model was again significant, R^2 = .50, F(5,98) = 19.90, p < .001. The pleasant contrast contributed significantly to prediction, β = .27, t(98) = 3.10, p = .003, but the appetitive contrast, β = .09, t (98) = 1.01, p = .31, and Extraversion, β = -.04, t < 1, *ns*, did not. Finally, the two interaction terms were entered at step 3. At this final step the increment in variance accounted for was near-zero, R^2_{ch} = 0.002, F_{ch} < 1, *ns*, although the overall model remained significant, R^2 = .50, F(7,96) = 14.05, p < .001. Coefficients for both interaction terms approached zero, all βs < ± 0.07, all ts < 1, *ns*, and analysis of simple slopes revealed that the relationship between Extraversion and Hedonic Tone was near-zero in all three conditions, all βs < ± 0.10, all ts < 1, *ns*.

Does Reward-Reactivity Explain Affective-Reactivity?

According to the ARH, the affective-reactivity of extraverts is owing to a more sensitive reward system or BAS. To assess whether individual differences in reward-reactivity were indeed responsible for the increased Energetic Arousal experienced by extraverted participants after the appetitive film clip, we repeated the above regression model of Energetic Arousal after controlling for variation in trait BAS scores. At step 1, the three BAS scales were entered along with pre-Energetic Arousal and gender, resulting in a statistically significant model, R^2 = .39, F(5,98) = 12.48, p < .001. Baseline Energetic Arousal, β = .49, t(98) = 5.74, p < .001, and BAS-Drive, β = .24, t(98) = 2.64, p = .01, were significant contributors to prediction, but Gender, β = -.12, t(98) = 1.42, p = .16, BAS-Reward, β = -.09, t(98) = 1.04, p = .30, and BAS-Fun, β = -.002, t < 1, *ns*, were not. Extraversion was then entered at step 2, along with the two dummy condition contrasts. This resulted in a significant increment in variance accounted for by the model, R^2_{ch} = 0.08, F_{ch} (3,95) = 4.91, p = .003, and the overall model was again significant, R^2 = .47, F(8,95) = 10.57, p < .001. Both the appetitive, β = .34, t(95) = 3.74, p < .001, and pleasant, β = .21, t(95) = 2.34, p = .02, contrasts contributed significantly to prediction, but Extraversion did not, β = .04, t < 1, *ns*. Finally, the two interaction terms were entered at step 4. The increment in R^2 at step 3 was statistically non-significant, R^2_{ch} = .02, F_{ch}(2,93) = 2.01, p = .12, but the overall model was again significant, R^2 = .49, F(10,93) = 9.11, p < .001. Inspection of the interaction terms revealed that neither the pleasant contrast, β = 0.04, t < 1, *ns*, nor the appetitive contrast, β = 0.20, t(93) = 1.94, p = .06, reached statistical significance. Analysis of simple slopes showed that the relationship between Extraversion and Energetic Arousal was again non-significant for the neutral condition, β = -0.09, t < 1, *ns,* and the pleasant condition, β = -0.03, t < 1, *ns*, but was borderline significant for the appetitive condition, β = 0.32, t(93) = 2.04, p = .05.

This supplementary analysis does not strongly argue for dispositional BAS sensitivity an the mechanism underlying the affective reactivity of extraverts. Granted, when the Carver and White (1994) BAS scales were controlled for, BAS-Drive predicted increased Energetic Arousal as a main effect and the interaction between Extraversion and condition no longer reached significance. On the other hand, the impact of controlling for BAS scores was quite modest, as shown, for instance, by the coefficients for our simple slopes analysis, which are not so dissimilar to those obtained when analyses did not control for BAS scores. This may not be so surprising, however, as one should not necessarily expect the Extraversion x condition interaction to hinge upon the BAS-Energetic Arousal relationship. Indeed, excluding Extraversion from step 2 of our regression model had minimal impact on the Extraversion x appetitive condition contrast coefficient (which falls from β = .22 to .19), but individual differences in Extraversion obviously lie at the heart of this effect. Another cautionary note is that by adding three new variables in the model (decreasing our degrees of freedom), we may have simply lowered our chances of finding a significant Extraversion x condition interaction.

A potentially more powerful and direct means to examine the role of reward-reactivity in the present findings is to remove any variance that Extraversion shares with reward-reactivity before conducting our analyses. In this data, 20% of the variance in Extraversion was accounted for by reward-reactivity. To remove this variance, we computed a residualised variable by saving the standardized residuals from a multiple regression in which Extraversion was regressed on the three BAS scales of Carver and White (1994). This residualised variable, which reflects variation in Extraversion that is *unrelated* to variation in trait reward-reactivity, was highly correlated with the raw Extraversion scores, r = .90, indicating that it is still meaningful and interpretable as a measure of this trait. (Compare this relationship with that between the two measures of Extraversion employed in experiment 1: r = .54.) We then repeated our regression analyses, replacing the original Extraversion scale with the residualised variable, which was also used to compute the interaction terms. At step 1, with pre-Energetic Arousal and Gender entered, the model was identical to that presented earlier. At step 2, with the two dummy coded contrast terms and residualised Extraversion entered, there was a significant increment in variance accounted for, R^2_{ch} = 0.10, $F_{ch}(3,98)$ = 5.65, and the overall model was significant, R^2 = 0.44, $F(5,98)$ = 15.24, p < .001. Both the pleasant contrast, β = .26, $t(98)$ = 2.84, p = .006, and the appetitive contrast, β = .36, $t(98)$ = 3.94, p < .001, contributed significantly to prediction but residualised Extraversion did not, β = .04, t < 1, *ns*. At step 3, when the two interaction terms were entered, the increment in R^2 did not approach significance, R^2_{ch} = 0.01, F_{ch} < 1, *ns*. Neither the appetitive contrast, β = 0.13, $t(96)$ = 1.14, p = .26, nor the pleasant contrast, β = -0.007, t < 1, *ns*, reached significance. This lack of support for the ARH was plainly reflected by analyses of simple slopes, which revealed a non-significant relationship between residualised Extraversion and Energetic Arousal in the appetitive, β = 0.22, t (96) = 1.47, p = .15, pleasant, β = -0.03, t < 1 *ns*, and neutral, β = -0.02, t < 1 *ns*, mood induction conditions.

Yet another means to examine the role of reward-reactivity in our affective reactivity findings would be to compare sub-facts of EPQ-R Extraversion that vary in their strength of relationship with trait BAS scores. Although EPQ-R Extraversion has no formally identified subscales, we constructed a 'BAS-rich' facet (EPQ-R items 6, 11, 16, 24, 28, 45, 61, 69 and 72, α = .66) and a 'BAS-lean' subscale (EPQ-R items 1, 20, 36, 40, 51, 63, and 94, α = .61) based upon high/low item-level correlations with BAS Fun, Reward and Drive (excluded items – 33, 55, 58, 67, 78, 90 – had mixed relationships with the three BAS scales). Both the 'rich' and 'lean' facets were significantly correlated with raw Extraversion scores (*rs* = .84 and .78) and, to a weaker extent, with each other (*r* = .49). When we again repeated our moderated regression model of post-Energetic Arousal, results at step 1 were again identical to that presented earlier. At step 2, with the two dummy terms and 'BAS-rich' Extraversion entered, there was a significant increment in variance accounted for, R^2_{ch} = 0.10, $F_{ch}(3,98) = 5.84$, and the overall model was significant, $R^2 = 0.44$, $F(5,98) = 15.41$, $p < .001$. Both the pleasant contrast, $\beta = .26$, $t(98) = 2.85$, $p = .005$, and the appetitive contrast, $\beta = .36$, $t(98) = 3.92$, $p < .001$, contributed significantly to prediction but 'BAS-rich' Extraversion did not, $\beta = .07$, $t < 1$, *ns*. At step 3, when the two interaction terms were entered, the increment in R^2 was significant, $R^2_{ch} = 0.034$, F_{ch} (2,96) = 3.14, $p = .048$. The appetitive contrast was a significant contributor to prediction, $\beta = 0.23$, $t(96) = 2.33$, $p = .022$, but the pleasant contrast was not, $\beta = 0.018$, $t < 1$, *ns*. 'BAS-rich' Extraversion was a strong predictor of Energetic Arousal in the appetitive condition, $\beta = 0.47$, t (96) = 2.65, $p = .009$, but not in the pleasant, $\beta = -0.01$, $t < 1$ *ns*, or neutral, $\beta = 0.04$, $t < 1$ *ns*, conditions.

Repeating this analysis for 'BAS-lean' Extraversion, results at step 1 were again identical to that presented earlier. At step 2, with the two dummy terms and 'BAS-lean' Extraversion entered, there was a significant increment in variance accounted for, R^2_{ch} = 0.10, $F_{ch}(3,98) = 5.63$, and the overall model was significant, $R^2 = 0.44$, $F(5,98) = 15.22$, $p < .001$. Both the pleasant contrast, $\beta = .26$, $t(98) = 2.85$, $p = .005$, and the appetitive contrast, $\beta = .36$, $t(98) = 3.99$, $p < .001$, contributed significantly to prediction but 'BAS-lean' Extraversion did not, $\beta = .04$, $t < 1$, *ns*. At step 3, when the two interaction terms were entered, the increment in R^2 fell short of significance, $R^2_{ch} = 0.02$, F_{ch} (2,96) = 2.09, $p = .13$, as did both the appetitive contrast, $\beta = 0.19$, $t(96) = 1.59$, $p = .12$, and the pleasant contrast, $\beta = -.004$, $t < 1$, *ns*. 'BAS-lean' Extraversion predicted Energetic Arousal in the appetitive condition only at the trend level, $\beta = 0.26$, t (96) = 1.95, $p = .053$, and was a non significant predictor in the pleasant, $\beta = -0.08$, $t < 1$ *ns*, and neutral, β = --0.07, $t < 1$ *ns*, mood induction conditions.

In sum, in a variety of supplementary analyses attempting to statistically or mechanically remove variance in dispositional reward-reactivity from trait Extraversion we are unable to recover clear support for the ARH in this data. This suggests that, within the appetitive condition, BAS scores might mediate the relationship between trait Extraversion and increased activated affect. Unfortunately, a formal test of mediation requires 405 observations (Fritz & MacKinnon, 2007), an order of magnitude larger the sample of 36 participants in our appetitive condition. It is nevertheless interesting to note that the raw correlation between Extraversion and post-Energetic Arousal (whilst controlling for pre-Energetic Arousal and gender) is almost halved when the three BAS scales are also statistically controlled (r = .11 vs. .19). Such a pattern of association is again suggestive of mediation, but should of course be interpreted only as a potential forecast of what future research targeting mediation may reveal.

Overall, results of experiment 5 reinforce the preceding empirical data in this paper, and offer preliminary support for the mechanism that has long been assumed to drive affective reactivity. Extraversion was again unrelated to increases in Hedonic Tone, a marker of pleasant affect, after watching neutral, pleasant and appetitively-toned film clips. Conversely, Extraversion predicted increased Energetic Arousal, a marker of activated affect, only after viewing a short video clip depicting an appetitive goal-directed scene (a protagonist chasing and capturing a villain). The size of this effect ($\beta = .38$) was similar to that observed in study 4, when mood was induced using appetitively-toned vignettes (e.g., winning money; β = .34), and in study 3, when mood was induced by delivering financial rewards during a behavioural task (β = .27). Statistically controlling for trait BAS scores weakened support for the ARH, albeit modestly. Furthermore, when trait BAS was directly partialled out of Extraversion there was a clear lack of support ARH, even though this residualised Extraversion variable was strongly correlated with raw Extraversion scores. Similarly, while a 'BAS-rich' subscale of Extraversion yielded strong support for the ARH, a 'BAS-lean' subscale did not, despite the fact that both were highly correlated with the full scale. Future research might build upon these analyses via formal tests of mediation, which would require much larger samples than provided in this experiment. In sum, we conclude that extraverts experience greater increases in activated affect during appetitive scenarios, and this is accounted for by individual differences in self-reported reward-reactivity.

General Discussion

The *'Affective-Reactivity Hypothesis'* (ARH; Gross et al., 1998) predicts that, given the same positive experience, extraverts should experience more PA due to a more reactive reward system. This putatively explains the typically greater happiness of extraverts (Diener & Lucas, 1999) in terms of long-term accumulation of enhanced pleasantly-valenced experiences. However, the ARH has so far received puzzlingly mixed empirical support – some studies strongly affirm its key postulates, while others fail to yield so much as a suggestive trend (see Lucas & Baird, 2004). We consider that this is the result of imprecise functional analysis of the Behavioural Approach System (BAS), which is thought to provide a partial biological basis for Extraversion. Early proponents of the ARH apparently viewed the BAS as synonymous with a 'pleasure system' (e.g., Tellegen, 1985), however the BAS might be better described as a 'desire system'; it regulates appetitive motivation, driving behavior towards reward (Pickering & Smillie, 2008; Smillie et al., 2011). Therefore, if extraverts are characterized by a more sensitive BAS, differential BAS-related affective-reactivity should only emerge in appetitive, reward-pursuit scenarios. Conversely, in scenarios that are pleasant and enjoyable but otherwise non-appetitive (in that they involve no pursuit of reward), extraverts and introverts should respond similarly. Results from the five experiments presented here confirm these predictions, using a variety of experimental paradigms and psychometric measures. Specifically, when participants were asked to imagine themselves in highly appetitive situations, view a protagonist engaging in such situations, or engage in reward pursuit themselves, extraverts experienced stronger affective reactions than introverts. Conversely, when participants were asked to imagine themselves in merely pleasant situations such as relaxing on the beach, or were shown enjoyable but non-appetitive stimuli such as a short clip from a 'feel-good' movie, extraverts and introverts responded similarly in affective terms.

The second issue we identify as a potential source of confusion in previous research is the tendency to conceptualize affect in somewhat monolithic terms. In the same way that facets of NA such as sadness, anxiety and disgust have long been recognized as distinct, there are important (but often overlooked) distinctions between different aspects of PA (e.g., pride versus amusement; Sauter, 2010). The dimensions of activation and valence provide a useful framework for structuring different aspects of affect. Activated affect is concerned with states that are inherently arousing or energizing (e.g., to feel 'alert' or 'vigorous'), while positively-valenced or pleasant affect is concerned with states that are merely hedonically shaded (e.g., to feel 'pleased' or 'cheerful'). As Lucas and Fujita (2000) note, the ARH proposes that extraverts "have a temperamental susceptibility to experience greater pleasant affect" [p. 1039]. However, studies in affective neuroscience suggest that, while the neural processes connected with the BAS (i.e., the mesolimbic dopamine system) are potentially involved in the experience of activated affect (Berridge, 2006; Lu et al., 2005; Nishino et al., 1998), they are not directly involved in the experience of pleasant affect (Ashby et al., 1999; Leyton et al., 2002; Panksepp, 2006). In addition, previous confirmations of the ARH, including experiment 3 of this paper, have tended to employ PA scales that clearly index highly activated affect. This led us to suggest that not only would the affective-reactivity of extraverts be restricted to appetitive scenarios, but also to activated affect. This was confirmed in experiments 4 and 5, in which extraverts showed greater affective-reactivity only after appetitive mood inductions, and only in terms of scores on a measure of activated affect.

One of the potential contributions of the present research is clarification of previous findings investigating the affective-reactivity of extraverts. Lucas and Baird (2004) noted that around half of the studies investigating the ARH failed to find greater affective-reactivity in extraverted participants. They then conducted their own investigation across six new experiments, and obtained similarly mixed results. The theoretical analysis supported in the present paper offers a new vantage point for evaluating tests of the ARH. Specifically, we would expect to observe support for the ARH in studies that have used an appetitive scenario to induce mood (as opposed to a non-appetitive positive mood induction), and a mood state questionnaire which assesses activated affect (e.g., Energetic Arousal, PANAS-PA) as opposed to pleasant affect (e.g., Hedonic Tone, MSQ-PA). Table 2 provides a summary of published studies that have specifically set out to test the ARH. For each study the correlation between Extraversion and affect is reported, according to whether an appetitive or non-appetitive scenario was used, and whether activated or pleasant affect was assessed. In addition, a tick is used to indicate whether a significant interaction or contrast was found indicating that the Extraversion-affect relationship varied across mood induction conditions. Note that one study mentioned in the introduction (Helmers et al., 1997) did not report sufficient data to describe or allow estimation of an effect size and was thus excluded.

As can be clearly seen from the weighted average correlations reported at the bottom of Table 2, in appetitive scenarios and where activated affect is measured, the association with Extraversion is indicative of a medium effect size (i.e., $r = .30$). In all other instances this association approaches a small effect size (i.e., $r = .10$)(Cohen, 1998). Another way of evaluating this data is in terms of the typical strength of research findings in psychology. According to Hemphill (2003), the strongest 33% of published significant effect sizes in psychology are equal to or greater than $r = .30$, while the weakest 33% of published significant effect sizes in psychology are equal to or lesser than $r = .20$. As such, the strength of evidence for the affective-reactivity hypothesis is comparable to the strongest findings reported in psychology, but only where appetitive scenarios are administered and activated affect is measured. In all other instances the strength of evidence is comparable to the weaker findings in the psychology literature. Finally, it striking to note that, at an individual study level, the ARH has been confirmed every single time an appetitive mood induction procedure is used and activated PA is assessed (owing to the presence of a significant interaction or contrast between Extraversion and mood induction condition). In studies where this is not the case, the crucial test of the ARH has almost always come back negative (the two exceptions having assessed activated affect following comedy clips or cartoons). If there were no rationale for dividing up the studies in Table 2, it would appear as though the ARH had been supported in only 1/3 of published studies, and we would be forced to concur with Lucas and Baird's (2004) conclusion; that affective-reactivity is not a robustly observable characteristic of Extraversion. Instead, due to our rethinking of the ARH, our conclusion is very much to the contrary.

What is the critical feature of mood induction procedure that should determine whether it should be classified as appetitive versus non-appetitive? This is an important question that almost certainly will require further research before we can be confident in making firm distinctions. However, it is well understood that the brain reward system is involved in the approach or pursuit of reward (Pickering & Smillie, 2008; Wise, 2004). Accordingly, the critical feature of all of our appetitive inductions is that they involved motivationally-salient gain of some kind in the context of approaching or pursuing some reward goal. For example, in experiment 3 we created a situation in which participants were able to gain (vs lose) money. Similarly, in experiment 4 participants imagined themselves attaining a dramatic gain (e.g., winning the lottery) as a result of their behavior (e.g., buying a lottery ticket). We pushed this 'pursuit' idea even further in the experiment 5 by presenting a 'chase scene' clip, which depicted a protagonist pursuing a villain. All of these induction methods are in stark contrast to merely pleasant enjoyment of a static situation (e.g., vignettes about relaxing on the beach). Of course, it was not possible to ensure that participants entertained no thoughts about reward gain whilst reading our pleasant scenarios. For instance, the scenario in experiment 1 regarding having coffee with a new friend might be interpreted as the beginning of a potentially rewarding (e.g., perhaps sexual) relationship. This is also the case for our neutral vignettes – a grocery-shopping scenario might conceivably lead to thoughts about purchasing mouth-watering deserts. However, it seems unlikely that these pleasant and neutral scenarios would uniformly be perceived as appetitive, as any explicit motivationally-salient reward cues were carefully omitted.

There may be additional important distinctions that were not made in these experiments. For instance, as all our appetitive scenarios involved approach/pursuit and also receipt of reward, we were unable to determine whether there were important differences between these two stages of reward processing. Some research has examined these issues, for instance, in terms of differences in brain responses to anticipation versus delivery of reward (e.g., Dillon et al., 2008; Shankman, Sarapas, & Klein, 2011). Very little of this work has yet examined the differential role of Extraversion in these processes, and results so far have been mixed, with Extraversion sometimes predicting brain activation only during anticipation of reward (Knutson & Bhanji, 2006) and other times predicting brain activation only during receipt of reward (Cohen, Young, Baek, Kessler & Ranganath, 2005). Clarification of the precise way in which Extraversion relates to the dynamics of reward-processing is clearly a key question for further research.

Implications for Affective-Reactivity

In these experiments and in our synthesis of previous research we have provided clear empirical support for a refined conceptualization of the ARH. The data in Table 2 are poorly explained by the ARH in its original, broader articulation, but elegantly explained if we specify that Extraversion-dependent affective-reactivity applies specifically to appetitive situations and in terms of activated affect. We also submit that our reformulation of this hypothesis is theoretically stronger than that first proposed by Larsen and Ketelaar (1991), from the perspective of biological plausibility, as it is in closer keeping with current understanding of the functional neuroscience of the BAS. This statement is not intended to criticize personality researchers whose work predated critical research on this subject, much of which has been facilitated by relatively recent advances in neuroscience (see Smillie, 2008). It was only a decade ago that the neurophysiological substrates of the BAS were mapped out in detail (Depue & Collins, 1999; Pickering & Gray, 1999), and our understanding of how such neural systems relate to affective experience is, of course, imperfect (Kringelbach & Berridge, 2009, 2010). As Gray himself noted around the time of the early formulation of the ARH, "There has been little work relating the BAS to human emotion" (Gray, 1991, p. 122); fortunately, this state of affairs has begun to improve.

Data that negate a direct link between the brain reward system and pleasant affect are surprising when first encountered, yet decisive and convincing once digested. Clear examples include evidence that potentiation of dopamine release does not increase pleasant PA (e.g., Rothman, 1994), and that increased dopamine release often occurs during negative affective states (e.g., stress) (Arnsten, 1998; Ashby et al., 1999). The distinction between the concepts of 'wanting' versus 'liking', and their operationalization in animal models (e.g., Robinson et al., 2005), has helped characterize the BAS as a 'desire system' rather than a 'pleasure system' (Kringelbach & Berridge, 2009; Treadway & Zald, 2010). Extending this notion to suggest that the BAS may regulate activated affect rather than pleasant affect is admittedly somewhat more speculative, but possibly supported by data linking dopamine function with arousal, alertness, wakefulness and behavioral vigor (Al-Adawi et al., 1998; Berridge, 2006; Lu et al., 2005; Nishino et al., 1998; Rammsayer, 1998). Indeed, others have suggested that activated states may focus attention on appetitive goals (e.g., Thayer, 1989) thereby facilitating successful approach behavior. It is easy to recollect, or at least imagine, how one feels when watching a beloved football team score a decisive goal, bringing them within reach of victory. The feeling is perhaps qualitatively similar as we progress toward the personal or professional goals of utmost value and significance to us. On these occasions we are perhaps less likely to say that we are pleased and cheerful, than we are to proclaim that we are aroused and electrified. Though further research is necessary, it seems very likely that the system responsible for regulating appetitive motivation toward desired goals might also be directly or indirectly associated with such activated affective states.

Overall, results of the present research support the notion that extraverts react strongly to reward-approach situations in terms of subjective affective experience. This complements previous research showing that Extraversion predicts appetitive responses at a neural (e.g., Cohen, 2005; Reuter et al., 2002; Smillie et al., 2011; Wacker et al., 2006) and behavioral (e.g., Pickering, 2004) level of analysis. It also fits well with recent molecular genetic studies showing that Extraversion is associated with variation in genetic polymorphisms linked with dopamine function (e.g., Smillie et al., 2010; cf, Munafo, Yalcin, Willis-Owen, & Flint, 2008). This burgeoning literature, as a whole, strengthens the view that extraverted personality is based partly in the functions of the brain reward system (Depue & Collins, 1999; Pickering & Smillie, 2008; Rammsayer, 1998). It seems less likely, however, that the findings presented here support the ARH in terms of its original purpose, namely, to explain why extraverts tend on average to be happier than introverts. As noted elsewhere, if the happiness of extraverts is due to increased susceptibility to activated affect, then measures of Extraversion should selectively predict such chronic states rather than (or more strongly than) chronic pleasant mood, which does not appear to be the case (Lucas & Baird, 2004; Lucas & Fujita, 2000). This would suggest that a tendency for extraverts to feel particularly activated in appetitive situations – experiencing 'more bang for the buck', as it were – is a somewhat separate phenomenon to their tendency to feel generally happy. We make this suggestion tentatively, however, as most research to date has typically considered the Extraversion-happiness relationship in terms of broad measures of life satisfaction and subjective well-being (e.g., Diener & Lucas, 1999; Diener, Kesebir, & Tov, 2008) rather than narrow, dissociable facets of affect.

Limitations and Concluding Remarks

The present research has several limitations that should be acknowledged. One limitation was that experiment 3 did not include a neutral-mood control condition. This was partly because it was unclear how to implement a 'neutral' condition in the context of a task where learning occurs via trial, error and feedback. Giving feedback might have engaged appetitive motivation (approaching accuracy rather than monetary incentives), and giving no feedback would have rendered the task meaningless. It was decided that the negative-mood condition would provide an adequate control condition, as has been our experience with similar tasks used in previous research (Smillie & Jackson, 2006). Experiment 2 also had some limitations in terms of available data (i.e., no baseline assessment of affect, no participant age information), however these were more minor compromises than is often the case for archival data. Experiments 1 and 4 suffer from slight ambiguity with respect to the separate contribution of the music and the vignettes to the induction of affective states. We opted for this strategy because combining vignettes with matching music has a strong pedigree in the mood induction literature (Westermann et al., 1996). We would also note that this kind of ambiguity affects many other mood induction procedures (e.g., film clips often have soundtracks, and behavioral tasks often include tones or sounds when rewards are given). Although careful manipulation checks showed that all procedures were effective in terms of their impact upon targeted affective states, this issue may warrant attention in further research.

Other limitations include the fact that, although both the design of the experiments and our interpretation of results were strongly influenced by the notion of a brain reward system or BAS, we did not provide any direct assessment of the functions of this system. We should emphasize that our primary question in this paper was "under what experimental conditions will support for the ARH be observed?" Now that we have answered this, the next step in this literature is to confirm that extraverts' affective reactivity is indeed attributable to the BAS. Experiment 5 provided preliminary encouragement for this view, showing that the ARH could not be confirmed when individual differences in reward-reactivity were statistically or mechanically removed from trait Extraversion scores. To our knowledge, this is the very first time this has been demonstrated, or even attempted, in the ARH literature. However, self-report assessments of BAS sensitivity are unlikely to directly index the functioning of the brain reward system (see Smillie, 2008). Future investigations of affective-reactivity might therefore take advantage of neuroscience methods such as EEG (e.g., Smillie et al., 2011) and fMRI (e.g., Cohen, 2005). Now that we have strong evidence in favor of the ARH, and knowledge of the conditions in which affective-reactivity will be observed, costly neuroscientific investigation of this phenomenon is more economically justifiable.

Finally, and in brief, caution is always warranted when interpreting relationships among self-report questionnaires (e.g., between personality and mood-state measures). This is especially important when studying the relationship between Extraversion and happiness, as many measures of extraverted personality include items with affect-relevant content (Pytlik Zillig et al., 2002). We guarded against potentially tautological relationships in our study by relying mainly on assessment of Extraversion using the EPQ-R, in which affective content is low relative to other measures of Extraversion. In any case, it would be tenuous to argue that our key findings result from a semantic tautology (i.e., item overlap), as we find that the relationship between Extraversion and affective state varies over experimental conditions.

In conclusion, we have proposed and supported a refined version of the theory that extraverts differ from introverts in their affective-reactions to positive situations. Our findings suggest that extraverts' affective-reactivity is specific to appetitive or reward-pursuit situations, rather than to positively-toned situations more generally. Furthermore, while extraverts do not experience larger boosts in pleasant *valence* they do experience more *activated* affect during such motivationally-salient situations. In short, extraverts get 'more bang for the buck'; a conclusion that chimes closely with a growing literature linking extraverted personality with biobehavioral reward-reactivity. This seems unlikely to account for the robust finding that extraverts are, in a broad and general sense, happier than their introverted counterparts. Nevertheless, it is an important finding that reconciles a divided literature, and enriches our understanding of dynamic processes in personality, emotion and motivation.

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