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Is it all in the reward? Peers influence risk-taking behaviour in young adulthood

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Abstract

The presence of peers is suggested to increase risk-taking behaviour by heightening response to reward. The current study investigated this using a computerised financial risk-taking task which was performed twice by a group of young adults (n=201, median age 19.8 years); once alone and once while in the presence of two peers. An overall increase in risk-taking was observed when with peers compared to when alone (CHANGE). CHANGE was positively associated with self-reported levels of reward responsiveness and fun seeking while older age and lack of perseverance were associated with reduced CHANGE. The association between risk-taking when with peers and both resistance to the influence of peers and age was indirect through reward responsiveness. Reward responsiveness was positively associated with impulsiveness. Only in those who showed a peer-related decrease in risk-taking (1/3 of participants), risk-taking in the presence of peers was associated with increased impulsiveness. The current findings suggest an important role for reward responsiveness in risk-taking behaviour and demonstrate the influence of peers. Increased understanding of these processes has direct implications for prevention and intervention efforts. Placing risk-taking behaviour within varying (social) contexts with an eye for differences in personality, development and emotions provides ample scope for future research.

Keywords: risk-taking, young adult, peer influence, reward, age, behavioural control

Is it all in the reward? Peers influence risk-taking behaviour in young adulthood

Adolescence and young adulthood span a formative period of human development, characterised by increases in affective reactivity, greater interest in and sensitivity towards peer-relationships, as well as an enhanced capacity to engage in behaviour directed towards long term goals (Carr-Gregg, Enderby, & Grover, 2003; Steinberg et al., 2008). While these developmental changes promote the skills necessary for greater independence and social interaction, they also create greater vulnerability to emotional and behavioural dysregulation and are consequently associated with both opportunities and risks (Steinberg, 2005).

Risk-taking behaviours are those that concurrently involve the chance of a beneficial outcome but also possible negative or harmful consequences (Boyer, 2006; Ernst, Pine, & Hardin, 2006). Even though potentially harmful, risk-taking behaviour is presumably engaged in because of the prospect of a desirable outcome or because the behaviour in itself is rewarding (Reniers, Beierholm, & Wood, In Press). Consequently, risk-taking is associated with a sensitivity to the instant consequences of decisions (Mitchell, Schoel, & Stevens, 2008) and is focussed on the anticipation of positive outcomes rather than sustained costs (Galvan, Hare, Voss, Glover, & Casey, 2007; Gardner & Steinberg, 2005). Particularly during adolescence, we see an increase in risk-taking behaviour (Arnett, 2000; Gardner & Steinberg, 2005), popularly thought to be associated with the rapid development of the brain's reward system and a more steadily development of the brain's regulatory control system (Steinberg, 2008). Increased risk-taking in adolescents may at least partly be due to an imbalance in the development of these two systems (Casey, Jones, & Somerville, 2011; Steinberg, 2008; Van Leijenhorst et al., 2010), suggesting not only increased sensitivity to reward but also immature impulse control and increased sensation seeking. Indeed, adolescents can reason about risk and estimate vulnerability to risk at a similar level as adults

(Reyna & Farley, 2006; Steinberg, 2008), but struggle to make the safer choice when they actually find themselves in a risky situation (Millstein & Halpern-Felsher, 2002; Steinberg, 2008).

Risk-taking behaviour is not limited to adolescence but extends throughout the lifespan as individuals of all ages are tempted and influenced by emotions and impulses that increase the likelihood of taking risks (Willoughby, Good, Adachi, Hamza, & Tavernier, 2013). It is often overlooked but adolescents and young adults have been shown to be equally susceptible to taking risks (Arnett, 2000) and even though the actual level of risk-taking may be lower in young adulthood than during adolescence, it is increased compared to adulthood (Gardner & Steinberg, 2005). Thus, it is this extended developmental period of adolescence and young adulthood that shows increased risk-taking behaviour (Arnett, 2000; Gardner & Steinberg, 2005). Considering the lack of research on risk-taking behaviour during young adulthood, the current study focussed on this age group specifically.

Particularly during adolescence and young adulthood, decision-making is modulated by emotional and social factors, such as the presence of peers (Blakemore & Robbins, 2012; Steinberg, 2008; Steinberg & Monahan, 2007). This may be because young people spend a substantial amount of time with their peers and identify themselves with each other's behaviour (Boyer, 2006; Steinberg, 2008). They may engage in risky behaviour to achieve and maintain status, to meet expectations of peers, or to be accepted by and belong to a group (Brown, 2011; Brown & Larson, 2009). Risk-taking behaviour becomes more frequent and riskier when with peers (Gardner & Steinberg, 2005), and it has been suggested that their presence heightens sensitivity to the potential reward value of risky decisions (Chein, Albert, O'Brien, Uckert, & Steinberg, 2010; Steinberg, 2008). Indeed, risk-taking in the presence of peers has been shown to result in increased activation of reward related brain regions, such as the ventral striatum and orbitofrontal cortex (Chein et al., 2010). Increased risk-taking has

furthermore been linked to higher levels of self-reported sensitivity to reward (Scott-Parker, Watson, King, & Hyde, 2012) and reduced behavioural control (Deckman & DeWall, 2011; Stanford, Greve, Boudreaux, Mathias, & Brumbelow, 1996), while self-reported ability to resist the influence of peers has been negatively related to anti-social risk-taking behaviour (Steinberg & Monahan, 2007).

Increases in sensitivity to the influence of peers start early in adolescence (Brown, 2011; Reitz, Zimmerman, Hutteman, Specht, & Neyer, 2014). While the effect peers have on behaviour may decline between adolescence and adulthood (Gardner & Steinberg, 2005; Steinberg & Monahan, 2007), in line with increased development of the behavioural control system (Chein et al., 2010), it is still overtly present for young adults (Gardner & Steinberg, 2005) and may even be present across the entire lifespan (Reitz et al., 2014). Young adulthood is characterised by identity formation and exploration in terms of love, work and worldviews (Arnett, 2000). Interaction with peers, who they can identify themselves with, can play an important role in this. Peers can exert their influence via various mechanisms such as reinforcement, encouragement, pressure, and displaying behaviours that can be modelled or avoided. Furthermore, peers can provide or obstruct occasions or contexts for the pursuit of behaviours, or display antagonistic behaviours such as bullying (Brown & Larson, 2009). The psychosocial capacities that underlie one's ability to resist these influences continue to develop into young adulthood (Gardner & Steinberg, 2005).

The current study aimed to confirm and advance recent findings of the influence of peer presence on risk-taking (Chein et al., 2010; Gardner & Steinberg, 2005; Steinberg, 2008) by investigating the effect of peer observation and encouragement on specifically financial risk-taking and in a group of young adults. By focussing on this specific age group and by using a well-established behavioural task that involves financial risk-taking in combination with self-report, this study aimed to increase knowledge on the previously hypothesised

(Chein et al., 2010) increased sensitivity to the potential reward value of risky decisions when in the presence of peers. In contrast to this neuroimaging study, in which the heightened sensitivity to rewarding properties of risky decisions was demonstrated by greater activation in reward-related brain regions (Chein et al., 2010), in the current study a positive association between change in risk-taking behaviour (when with peers compared to when alone) and self-reported levels of reward responsiveness was postulated to signify the heightened sensitivity to reward when with peers. We predicted 1) increased risk-taking behaviour on the youth version of the Balloon Analogue Risk Task (BART-Y) (Lejuez et al., 2007) in the condition where peer presence and peer encouragement were present in comparison to the condition in which the task was performed when alone (as previously demonstrated). In addition, we predicted 2) this change in risk-taking behaviour (when with peers compared to when alone) to be positively associated with self-reported levels of reward responsiveness, a measure that represents positive responses to the occurrence or anticipation of reward. To highlight the importance of age in the context of peer-related risk-taking, we furthermore predicted 3) a decrease in the influence of peers on risk-taking behaviour with increased age and that 4) a stronger self-reported resistance to the influence of peers would be associated with reduced change in risk-taking behaviour when with peers compared to when alone. We also predicted that, consistent with findings by Chein et al. (2010) demonstrating that activity in the cognitive control areas of the brain did not vary with social context, 5) the change in risk-taking behaviour when with peers compared to when alone would not be associated with self-reported levels of impulsiveness. This was postulated to demonstrate the lack of association between a more slowly developing regulatory control system and peer-related influences on risk-taking behaviour. To investigate the influences of development (age) and socio-emotional factors (resistance to peer influence) on risk-taking in the presence of peers, the associations between age and self-reported resistance to peer influence, as well as

responsiveness to reward, and their direct and indirect associations with risk-taking behaviour during task performance when in the presence of peers, were examined using path analysis. Here we chose to focus specifically on absolute risk-taking in the presence of peers, rather than the change in risk-taking when with peers compared to when alone, to investigate the impact of reward responsiveness, age and resistance to peer influence on peer-related risk-taking directly. A variable such as resistance to peer influence should not have an impact on risk-taking when alone as no peers would be present, and a change variable for this measure would not be informative. Consistent with the suggestion of heightened sensitivity to rewarding properties of risky decisions when with peers (Chein et al., 2010), we predicted that 6) a model with direct associations of reward responsiveness, age and resistance to peer influence with risk-taking in the presence of peers would provide a good fit to the data. Finally, consistent with Chein et al. (2010), we predicted that 7) impulsiveness would not have a significant impact on risk-taking in the presence of peers per se nor on reward responsiveness, when controlling for age.

Methods & materials

Participants

Two hundred and one participants (159F: 42M), aged 18-24 years (median 19.8 years), were recruited in groups of three friends via advertisement and via the University online Research Participation Scheme (RPS). Of these participants, 82.6% indicated the United Kingdom as their country of origin. Ethnicity of the participants was 78.6% white, 10.9% Asian-Oriental, 5.5% Asian-Indian, 2.5% mixed, 1.5% Black/African-Caribbean and 1% specified other. The only exclusion criterion was non-fluency in English. Participants gave informed consent and received between £5 and £20 (median £15, range £7.50-20)

depending on their performance on the BART-Y. Psychology undergraduates also received study credits. Ethical approval was granted by the School of Psychology Ethics Board.

Measures

The *BART-Y* (Lejuez et al., 2007) was used as a behavioural measure of risk-taking behaviour. This computer task is based on the real-life concept that risk-taking is rewarded up to a point until further risk-taking leads to negative outcomes. Participants are asked to pump up balloons which reward them with points contributing to a cash prize. The risk comes with the increasing size of the balloon; the larger the balloon becomes the more points can be won but the greater the risk of the balloon bursting, leading to a loss of points from that balloon. Before each pump, the participant can save the points accrued from the current balloon or choose to take the risk and pump the balloon once more in order to get more points. The saved points are translated into prizes. Each prize is equivalent to a cash reward to provide a real life incentive for risky behaviour on the task: small, £2.50; middle, £5; big, £7.50; bonus, £10. Each balloon is randomly assigned a bursting point from one pump to a maximum of 128 pumps. The probability of each balloon bursting increases from 1/128 on the 1st pump and 1/127 for the 2nd pump, to a burst probability of 1/1 for the 128th pump. The average explosion point of balloons is 64 pumps. When a balloon bursts or points are saved a new balloon will appear until all 30 balloons have been completed.

The index of risk-taking is the total adjusted number of pumps (Lejuez et al., 2002). This is the average number of pumps for the balloons which did not burst and ensures that risk-taking scores are not constrained by the balloons' explosion point (Lejuez, Aklin, Zvolensky, & Pedulla, 2003). Performance on the BART is related to a variety of self-reported risk-taking behaviours such as risky sexual behaviour, smoking, gambling or riding in a car without a seatbelt on (Lejuez et al., 2007; Lejuez et al., 2002; Lejuez, Simmons,

Aklin, Daughters, & Dvir, 2004) and has an acceptable level of test-retest reliability (r=0.77, p<0.001) (White, Lejuez, & de Wit, 2008).

The *Behavioral Inhibition System/Behavioral Activation System (BIS/BAS) scales* (Carver & White, 1994) assess the two general motivational systems that underlie behaviour and affect. The Behavioral Inhibition System (BIS) is sensitive to punishment, non-reward, and novelty, and inhibits behaviour that may lead to negative outcomes (e.g. "I worry about making mistakes"). The Behavioral Activation System (BAS) is sensitive to reward, non-punishment, and escape from punishment, and is associated with movement towards goals. There are three BAS-related subscales: Drive (persistent pursuit of desired goals, e.g. " I go out of my way to get things I want"), Fun Seeking (desire for new rewards and a willingness to go for a potentially rewarding event on the spur of the moment, e.g. "I'm always willing to try something new if I think it will be fun"), and Reward Responsiveness (positive responses to the occurrence or anticipation of reward, e.g. " When I get something I want, I feel excited and energized"). The questionnaire consists of 24 items, rated on a 4-point Likert scale (Very true for me, Somewhat true for me, Somewhat false for me, Very false for me) with higher scores reflecting higher sensitivity. The measure has adequate internal reliability (Cronbach's alpha ranging from 0.68 to 0.88 on the subscales for participants in the US, UK and Italy) (Leone, Perugini, Bagozzi, Pierro, & Mannetti, 2001) as well as convergent and discriminant validity (Carver & White, 1994). Note, as bursting a balloon on the BART-Y was associated with a loss of points that were built up for that trial (note these points had not been awarded yet), no direct punishment such as losing points from the overall total was incurred. Therefore, the association between sensitivity to punishment (BIS subscale) and performance on the BART-Y was not explored.

The *Resistance to Peer Influence (RPI) scale* (Steinberg & Monahan, 2007) uses 10 pairs of statements to assess general resistance to the influence of peers (e.g. "Some people go along with their friends just to keep their friends happy BUT Other people refuse to go along with what their friends want to do, even though they know it will make their friends unhappy"). Respondents are asked to choose the statement that describes best which sort of person they are like and to rate this statement to be either Really True or Sort of True. The scores are coded on a 4-point Likert scale with high scores reflecting greater resistance to peer influence. The RPI has adequate internal reliability (Cronbach's alpha ranging from 0.70 to 0.76 for lower income, detained, community and serious offender samples) and external validity (Steinberg & Monahan, 2007).

The *Barratt Impulsiveness Scale (BIS-11)* (Patton, Stanford, & Barratt, 1995) consists of 30 items measuring impulsivity on a 4-point Likert scale with higher scores indicating higher levels of impulsiveness. The questionnaire encompasses three subscales with each two first order factors: attentional (attention and cognitive instability, e.g. "I am restless at the theater or lectures" and "I have "racing" thoughts"), motor (motor and perseverance, e.g. "I do things without thinking" and "I change jobs") and non-planning (self-control and cognitive complexity, e.g. "I say things without thinking" and "I get easily bored when solving thought problems") impulsivity. The BIS-11 is the most widely used self-report measure of impulsivity (Stanford et al., 2009) and has good internal consistency (Cronbach's alpha ranging from 0.79 to 0.83 for undergraduate students, substance-abuse patients, general psychiatric patients and prison inmates) (Patton et al., 1995).

The *Urgency, Premeditation, Perseverance, Sensation seeking (UPPS-P) impulsive behavior scale* (Lynam, Smith, Whiteside, & Cyders, 2006; Whiteside & Lynam, 2001) assesses distinct personality facets associated with impulsive behaviour labelled as Urgency (negative e.g. "I tend to act without thinking when I am really excited"; positive e.g. "When I

am in great mood, I tend to get into situations that could cause me problems"), (lack of) Premeditation (e.g. "My thinking is usually careful and purposeful"), (lack of) Perseverance (e.g. "I generally like to see things through to the end"), and Sensation Seeking (e.g. "I would enjoy water skiing"). The questionnaire consists of 59 items for which participants rate their level of (dis)agreement on a 4-point Likert scale with higher scores reflecting more impulsive behaviour. The scales have good internal reliability (Cronbach's alpha for all subscales above 0.80 for male adolescents, female adolescents and both genders grouped together) (d'Acremont & Van der Linden, 2005) as well as construct validity (Whiteside, Lynam, Miller, & Reynolds, 2005). Its additional value to the BIS-11 for use in this study is that it assesses impulsive behaviour in emotional contexts, both positive and negative, which has important value for risk-taking in the emotionally loaded context of the presence of peers.

Procedure

Participants were not given the opportunity to practise the BART-Y but were guided through the instructions as provided with the task. Any questions they had were answered at this stage to ensure the task requirements were well understood. Participants were tested in triads and each member of a triad completed the BART-Y twice: once alone and once with their two peers present. As each member of a triad performed the task in the presence of their peers, this meant that besides completing the task twice (once alone and once with their peers present), each participant observed the task twice (once for each of their peers). For the first set of participants (n=102), each member of a triad completed the alone condition before the peers condition. Although no difference was observed in performance of participants who performed the peers condition first, second or third within their triad, the order of conditions (alone versus peers) was counterbalanced for the remainder of the participants (n=99) in order to avoid any possible practice effects between conditions (Reynolds, Macpherson,

Schwartz, Fox, & Lejuez, 2013). In both conditions, participants were encouraged to perform well and gain the 'bonus' prize. When observing in the peers condition, participants were explicitly told to encourage their peer to perform well and gain the 'bonus' prize. Thus the instructions given to participants in both conditions constituted of encouragement with the difference being the person(s) giving the encouragement (experimenter versus peers) and the timing of the instructions (in the alone condition encouragement was solely given by the experimenter at the start of the task while in the peers condition peers gave additional encouragement throughout the task performance). Self-report measures were completed alone after completion of the tasks and handed to the experimenter in a sealed and coded envelope ensuring confidentiality. With regards to the assessment of impulsiveness, half of the participants completed the UPPS-P (n=102) while the other half completed the BIS-11 (n=98). Immediately after completion of the study participants were paid the amount of money they won during performance of the two BART-Y task conditions.

Statistical analysis

Data were analysed using IBM SPSS Statistics 21 and IBM SPSS Amos 21 for Windows (IBM Corp., Armonk, NY). A percentage difference in risk-taking in the peers compared to the alone condition of the BART-Y (CHANGE) was calculated for each participant as an index of the influence of peers on risk-taking behaviour. Percentages were used to demonstrate an individual's relative increase or decrease in the peers condition compared to the alone condition. Due to non-normality of the data and the relatively small size of the samples for sub-analyses non-parametric tests were conducted. Differences between the alone and peers conditions and between those who showed a peer-related increase in risk-taking behaviour and those who showed a peer-related decrease in risk-taking behaviour were investigated using the Wilcoxon signed-rank test. Spearman's rank

correlation was employed to investigate associations for reward, age, resistance to peer influence, gender, triad characteristics and impulsiveness with CHANGE. Path analysis was employed to investigate direct and indirect associations of reward responsiveness, age and resistance to peer influence with risk-taking behaviour in the presence of peers. Finally, partial correlations (Spearman's rank correlation) controlling for age were used to investigate the association of impulsiveness with risk-taking when in the presence of peers and reward responsiveness.

Results

Data of one participant had to be excluded due to a fault in the computer task. In the alone condition, 5 participants won the small prize (£2.50), 56 the middle prize (£5), 126 the big prize (£7.50) and 13 the bonus prize (£10). In the peers condition, 2 participants won the small prize (£2.50), 31 the middle prize (£5), 132 the big prize (£7.50) and 35 the bonus prize (£10). Table 1 presents further descriptive information on participants' performance on the BART-Y and the self-report measures.

1) Increased risk-taking when with peers compared to when alone

As predicted, participants took significantly more risks in the peers condition than in the alone condition, Z=4.903, p<0.001, with an effect size (Field, 2005; Rosenthal, 1991) of r=0.35. The median increase was 7.2% (range -63.1-256.8%). There was a significant order effect (alone or peers condition performed first) (Z=-6.222, p<0.001, r=-0.44) with those who performed the alone condition first (n=152) showing a median increase in peer-related risk-taking of 12.9% (range -35.7 - 256.8) while those who performed the peers condition first (n=48) showed a median decrease in risk-taking behaviour of 8.4% (range -63.1 - 29.0).

However, not all participants showed an increase in risk-taking behaviour when in the presence of peers: 132 participants (66%) took more risks when with peers than when alone, 67 participants (33.5%) took fewer risks when with peers compared to when alone and 1 participant (0.5%) took the same amount of risks in both conditions. Secondary analyses explored group differences between those who showed a peer-related increase versus those who showed a peer-related decrease in risk-taking behaviour. Those who showed a peer-related decrease in risk-taking behaviour were significantly older than those who showed a peer-related increase in risk-taking behaviour (Z=7.617, p<0.05, r=0.54). Those who showed a peer-related decrease in risk-taking behaviour had a median age of 20.1 (range 18.2-23.0) years old while those who showed a peer-related increase in risk-taking behaviour had a median age of 19.4 (range 18.2-24.0) years old. There was a significant order effect (alone or peers condition performed first) for those who showed a peer-related increase in risk-taking behaviour (Z=-3.214, p=0.001, r=-0.23). Those who performed the alone condition first (n=116) showed a median of 19.5% CHANGE (range 0.1-256.8%) while those who did the peers condition first (n=16) showed a median of 7.4% CHANGE (range 0.6-29.0%). For those who showed a peer-related decrease in risk-taking behaviour, no significant effect of order was observed. Those who showed a peer-related increase in risk-taking behaviour scored significantly higher on fun-seeking (Z=2.245, p<0.05, r=0.16) and reward responsiveness (Z=2.080, p<0.05, r=0.15) than those who showed a peer-related decrease in risk-taking behaviour. Those who showed a peer-related increase in risk-taking had a median of 10 (range 4-16) on fun-seeking and a median of 15 (range 5-20) on reward responsiveness, while those who showed a peer-related decrease in risk-taking had medians of 9 (range 4-15) and 9 (range 5-20) respectively.

2) *A positive association between reward responsiveness and CHANGE*

There was a weak positive association between CHANGE and reward responsiveness (r_s=0.18, p<0.05). Secondary analyses exploring the association of CHANGE with other measures of reward (BIS/BAS subscales) revealed a weak positive association between CHANGE and fun seeking (r_s=0.17, p<0.05), but no significant association was observed for CHANGE with drive for reward.

3) The influence of peers on risk-taking behaviour decreases with age

A weak negative association was observed between CHANGE and age (r_s=-0.18, p<0.05). This parallels the earlier difference in mean age seen between those who show peer-related increases and those who show peer-related decreases in risk-taking behaviour reported above.

4) No association between resistance to peer influence and CHANGE

Contrary to our prediction, no significant association was observed for CHANGE with resistance to peer influence.

Secondary analyses were carried out to investigate whether having riskier friends would make you more inclined to take risks yourself. The average of the adjusted number of pumps in the alone condition of the two peers in a triad was correlated with the participant's CHANGE score. This revealed a weak negative association (r_s=-0.16, p<0.05), suggesting that lower scores of peers were associated with slightly higher CHANGE scores. A correlation with similarity scores (calculated as the absolute difference between the peers' scores with a smaller number indicating higher similarity) was not significant (r_s=0.04, p>0.05). A comparison of CHANGE scores of triads that were of the same gender and triads that consisted of both genders did not reveal significant differences.

- Insert Table 1 about here –

5) A negative association between impulsiveness and CHANGE

Opposite to our prediction, lack of perseverance (subscale BIS-11, completed by n=98) showed a weak negative association with CHANGE (r_s=-0.22, p<0.05). Secondary analyses revealed that of the participants who completed the BIS-11, those who showed a peer-related decrease in risk-taking (n=43) scored significantly higher on perseverance than those who showed a peer-related increase in risk-taking (n=55) (Z=2.291, p<0.05, r=0.16). Those who showed a peer-related decrease in risk-taking had a median of 8 (range 4-12) while those who showed a peer-related increase in risk-taking had a median of 7 (range 4-13). No further differences on measures of impulsiveness were observed between those with a peer-related increase or decrease in risk-taking behaviour.

6) Direct and indirect associations of reward responsiveness, age and resistance to peer influence with risk-taking in the presence of peers

Path analysis was employed to investigate how peers influence risk-taking behaviour. Note, as peer-related risk-taking was central to the model, the variable risk-taking in the presence of peers was used rather than CHANGE. The model depicted reward responsiveness, age and resistance to peer influence as variables that influence performance on the BART-Y when in the presence of peers. A good fitting model implies that the postulated associations among the variables are plausible (Byrne, 2001; Ullman, 2001). Models were estimated using a maximum likelihood algorithm and model fit was judged using guidelines provided by Byrne (2001), Hu & Bentler (1999) and Kline (1998). The following goodness of fit measures are reported: the model χ^2, Root Mean Squared Error of

Approximation (RMSEA) with its 90% confidence intervals, Bentler's Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Standardised Root Mean Square Residual (SRMR) and Aikaike's Information Criterion (AIC). Path coefficients and the amount of variance explained by the model (R^2) were also examined.

The first model depicted direct associations of reward responsiveness, age and resistance to peer influence with risk-taking in the presence of peers. Contrary to prediction, this model did not provide a good fit to the data (see Table 2, model 1) with associations for both resistance to peer influence and age with risk-taking in the peer condition being redundant having a significance of $p>0.05$ and associations for both resistance to peer influence and age with reward responsiveness being suggested. As the modifications that were indicated by the modification indices were in line with our prediction that the presence of peers would heighten sensitivity to the potential reward value of risky decisions, albeit with a more direct influence on reward responsiveness than was initially expected, these direct associations with reward responsiveness were deemed meaningful and were therefore specified in model 2. This modified model with the recommended changes incorporated (direct associations of resistance to peer influence and age with reward responsiveness rather than direct associations of these variables with risk-taking in the presence of peers) provided good fit to the data (see Table 2, model 2). The associations between the variables were significant and the model explained 9% of the variance in reward responsiveness and 2% of the variance in risk-taking in the presence of peers. These values and the standardised regression weights of model 2 are presented in Figure 1. A sensitivity analysis for non-normality with bootstrapping (Bollen-Stine bootstrap $p=0.293$) confirmed good model fit. The path models investigating the direct and indirect associations between resistance to peer influence and reward responsiveness, and age and reward responsiveness can be found in Figure 2. The direct associations are depicted in Figure 2.1 and present associations between

resistance to peer influence and risk-taking with peers, age and risk-taking with peers, and reward responsiveness and risk-taking with peers. The indirect associations are depicted in Figure 2.2 and present the association between resistance to peer influence and risk-taking with peers through reward responsiveness, and age and risk-taking with peers through reward responsiveness. Standardised direct, indirect and total effects predicting risk-taking in the presence of peers are presented in Table 3, as well as the standard errors and 95% confidence intervals corresponding to each parameter.

- Insert Figure 1 and 2 and Table 2 and 3 about here –

Path analysis is extremely sensitive to sample size; if the sample size is too small, the estimates of the parameters are unstable which may be reflected in large SEs and non-significant tests for their significance. Samples <100 are considered small and a ratio of 10 cases for each parameter is deemed acceptable but with double the amount of cases being strongly recommended (Kline, 1998). Considering this, we chose not to conduct a path analysis for each group incorporating the impulsivity measure in model 2 but instead performed a partial correlation for impulsiveness measures with risk-taking in the presence of peers and reward responsiveness controlling for the effect of age. No correlations were found with risk-taking in the presence of peers, but significant positive associations were observed for negative urgency (UPPS-P; r_s=0.40, p<0.001) and self-control (BIS-11; r_s=0.21, p<0.05) with reward responsiveness. When the partial correlation for risk-taking in the presence of peers controlling for age was repeated for those who showed a peer-related increase or decrease in risk-taking separately, a significant positive association was observed for perseverance (UPPS-P; r_s=0.50, p<0.05, n=21), attention (BIS-11; r_s=0.34, p<0.05, n=40) and cognitive complexity (BIS-11; r_s=0.40, p=0.01, n=40) in those who showed a peer-related

decrease in risk-taking behaviour. No significant associations were observed for those who showed a peer-related increase in risk-taking behaviour.

Discussion

The current study investigated the influence of peer observation and encouragement on risk-taking behaviour using a financial risk-taking task in a group of young adults and observed a predicted overall increase in risk-taking when with peers compared to when alone. This CHANGE score was, as hypothesised, positively related to reward responsiveness and fun seeking while older age and low perseverance were associated with reduced CHANGE. Secondary analyses revealed that those who showed a peer-related decrease in risk-taking were significantly more impulsive than those who showed a peer-related increase in risk-taking. Contrary to prediction, no significant association was observed for CHANGE with resistance to peer influence, but having riskier friends was associated with increased CHANGE. Path analysis showed that the association between risk-taking when with peers and both resistance to the influence of peers and age was indirect through reward responsiveness, rather than a direct association. Contrary to prediction, responsiveness to reward was associated with increased impulsiveness, reflected in a tendency to experience strong impulses in conditions of negative affect and reduced self-control. Only in those who showed a peer-related decrease in risk-taking was such risk-taking associated with increased impulsiveness, reflected in reduced perseverance, reduced attention and increased cognitive complexity.

Consistent with previous research (Cavalca et al., 2013; Gardner & Steinberg, 2005; Weigard, Chein, Albert, Smith, & Steinberg, 2014) and our prediction, we observed an increase in risk-taking behaviour when participants were in the presence of their peers compared to when they were alone, although others have only found this effect in younger

participants (Chein et al., 2010). Consistent with our predicted and observed positive association for CHANGE with responsiveness to reward and fun seeking, the mere receipt of peer feedback or anticipation of positive appraisal by the peers in the current study may have introduced an additional, socially rewarding factor to the decision making process which influenced the choice of whether to take a further risk or not (Ruff & Fehr, 2014). In support of this, Chein et al. (2010) demonstrated that, compared to when alone, risk-taking under the observation of peers increased activity in reward-related regions of the brain in young people. This activity predicted subsequent risk-taking behaviour. The current findings provide further support for this theory by demonstrating the association between resistance to peer influence and risk-taking when with peers to be indirect through responsiveness to reward (model 2). Rather than the predicted direct association with risk-taking in the presence of peers, the presence and encouragement of peers may have added a socially rewarding factor to the decision making process, reflected in the indirect association of resistance to peer influence and risk-taking in the presence of peers through reward responsiveness. By taking more risks and winning more points (aiming for the bonus prize) participants may have also gained appreciation or approval from their peers which may have contributed to maintenance or achievement of status and acceptance within their group of friends.

It needs noting that in the study by Chein et al. (2010), the increased activity in reward-related brain areas corresponded to lower levels of self-reported resistance to peer influence. Reward responsiveness is a self-report measure that represents positive responses to the occurrence or anticipation of reward. In this study, this measure was deemed particularly valuable as we suggest that it may capture, in addition to the financial reward that could be won on the task, the additional social reward (e.g. approval or acceptation) that may be offered by the presence of peers. In this sense, and consistent with the findings of Chein et al. (2010), a negative coefficient may have been expected in the model depicting a direct

association between resistance to peer influence and reward responsiveness. However, the measure of reward used in this study is self-report based and therefore may not necessarily match actual behaviour when in that situation. But more importantly, it may be that those who are less susceptible to external influences, in this case the socio-emotional influence of peers, are more sensitive to the financial reward that is associated with the risky decision (and less to the social reward that the presence of peers offer). This may be presented in the positive coefficient in the path model. These findings highlight on one hand the importance of reward responsiveness in risk-taking and at the same time emphasise its complexity. Further investigation of the role of reward in risk-taking and its association with socio-emotional factors is therefore warranted.

Individuals who score high on reward responsiveness have also been shown to work harder for financial rewards (Chumbley & Fehr, 2014). This may be associated with a strategy that first seeks to maximise the likelihood of a reward, and then to maximise the amount of that reward (Scheres & Sanfey, 2006). This was first demonstrated by lower offers to a partner when there is certainty of this offer being accepted (Dictator Game) and higher offers in case of a possibility of rejection by the partner (Ultimatum Game). Like in these games, reward responsiveness in the current study could have been associated with the strategic component of decision-making, potentially to ensure reward is obtained rather than risking obtaining nothing. The presence of peers may have added a social reward with a high likelihood of receipt to the decision-making process, leaving the option to take more risks to increase the potential financial outcome. Although speculative, this possibility cannot be excluded as an explanation for the current findings and may inspire new directions of research in this area.

Even though they explained a very small amount of variance in our model (9% and 2% of the variance in reward responsiveness and in risk-taking in the presence of peers

respectively), the predictors were significant and position responsiveness to reward in a central position in the association between risk-taking when with peers and both resistance to the influence of peers and age. This makes reward (responsiveness) an invaluable variable for research into the influence of peers on risk-taking behaviour. Indeed, many of the risk activities that young people participate in, such as drinking alcohol, smoking, and taking drugs, are portrayed as 'fun' and 'cool', making them socially more rewarding to the individuals involved. By consequence of this heightened reward value, responsiveness to the reward is increased and raises the likelihood and/or frequency of the potentially rewarding, albeit risky, behaviour.

Importantly, although the presence of peers increased risk-taking behaviour overall, for a third of the participants a reduction in peer-related risk-taking was observed. It may be that this latter group of individuals may have reached a more mature balance between seeking rewards and controlling one's thoughts and actions. This suggestion is certainly consistent with our finding that those who showed a peer-related decrease in risk-taking behaviour were significantly older than those who showed a peer-related increase in risk-taking behaviour as well as our observed association of reduced CHANGE with older age. However, the age difference between the two groups was only marginal (median age of 20.1 versus 19.4 years old). Whilst these subtle changes could be associated with maturation of one's ability to control thoughts and actions, it is likely that additional factors play a role in explaining peer-related changes in risk-taking behaviour. Indeed, risk-taking involves more than just the anticipation of or responsiveness to a reward and factors such as development (Steinberg, 2008), anxiety and avoidance (Sercombe, 2014), but also personality, emotion and (social) context (Cyders et al., 2014; Reniers, Beierholm, & Wood, In Press; Steinberg, 2008) should be considered. Individuals differ in their propensity to take risks and personality characteristics such as sensitivity to reward and punishment, impulsivity and sensation

seeking, openness to experience and extraversion have commonly been linked to risk-taking behaviour (see for example (Boyer, 2006; Chein et al., 2010; Deckman & DeWall, 2011; Lauriola & Leven, 2001; Lejuez et al., 2002; Nicholson, Soane, Fenton-O'Creevy, & Willman, 2005; Robbins & Bryan, 2004; Scott-Parker et al., 2012) while emotion (Morgan, Jones, & Harris, 2013; Roidl, Siebert, Oehl, & Hoger, 2013) and specific contexts such as variation in reward/loss magnitude (Bornovalova et al., 2009) and ambiguity regarding the likelihood of winning/losing (Tymula et al., 2012) have also demonstrated importance. Our finding of an association between heightened responsiveness to reward and an increased tendency to experience strong impulses under conditions of negative affect, as well as reduced self-control, is consistent with this vast amount of research and emphasises the importance of the consideration of emotions, personality and context in risky situations.

Our findings of higher scores on fun-seeking and reward responsiveness and lower scores on impulsiveness (increased perseverance) for those who showed a peer-related increase in risk-taking behaviour compared to those who showed a peer-related decrease in risk-taking behaviour are consistent with an imbalance between the rapid developing reward system and the more steadily maturing regulatory control system. For those who showed a peer-related decrease in risk-taking we observed an association between risk-taking in the presence of peers with reduced perseverance, reduced attention and increased cognitive complexity which seems in line with this suggestion too. It needs noting though that we would have expected to find the association for CHANGE and impulsiveness in those who showed a peer-related increase in risk-taking behaviour but instead observed this in those who showed a peer-related decrease in risk-taking behaviour. It may be that those who are less susceptible to external influences, in this case the socio-emotional influence of peers, are less sensitive to the heightened reward value of risky decisions that are made in the presence of peers and instead, are more likely to have their responses driven by internal influences

such as their impulsive personality. This is highly speculative but nonetheless emphasises the need for research that considers these factors and cautions generalisability of findings within limited contexts.

Young people spend a substantial amount of time with their peers and identify themselves with each other's behaviour (Boyer, 2006; Steinberg, 2008), thereby setting the stage for risk-taking in the presence of peers. We believe that the use of friends, rather than unfamiliar age matched peers, has created a more ecologically valid social context. It needs noting though that unfamiliar peers may have a similar influence on behaviour (Weigard et al., 2014). Moreover, the quality of peer relationships has been shown to influence risk-taking behaviour with increased conflict (Telzer, Fuligni, Lieberman, Miernicki, & Galvan, 2014) and low support (Brady, Dolcini, Harper, & Pollack, 2009; Telzer et al., 2014) being associated with increased risk-taking and this should be taken into consideration for future studies. Nevertheless, risk-taking generally takes place in the presence of familiar individuals (Gardner & Steinberg, 2005); as such we believe the current task has captured the dynamics of peer influenced risk-taking behaviour (Lejuez et al., 2002).

It is important to note that the current study design did not test causality. The study is cross-sectional and as such associations between variables can be identified. In order to test the predictive properties of variables and the therewith associated mediation, a longitudinal design should be employed. Participants in the current study performed both tasks (alone and peers condition) and were present to observe and encourage their peers when they completed the task. Therefore, predictor (peer observation and encouragement) and outcome (peer-related change in risk-taking and risk-taking when in the presence of peers) variables were partly dependent. In addition, even though no difference in performance of participants who performed the peers condition first, second or third within their triad was observed for the first set of participants (n=102) and all participants received the same instructions before the

start of the task (including visual demonstration), it is plausible that there was a learning effect of having observed the task twice before performing it in comparison to only having observed it once or not at all. To avoid any dependency or possible learning effect, future studies should separate groups of individuals who perform the tasks from those who observe and encourage. Alternatively, the use of nested multilevel analyses could be explored. There is evidence of a potential order effect on task performance in the current study, particularly for those who showed a peer-related increase in risk-taking behaviour. It should be taken into account that the sample of participants who performed the peers condition first is much smaller than the sample of participants who completed the alone condition first (n=48 versus n=152), but the possibility of an order effect presents a serious limitation of the current study. Even though practice effects on the BART have been observed (Reynolds et al., 2013), there is also evidence for acceptable test-retest reliability (White et al., 2008). Furthermore, peer-related increases in risk-taking behaviour as observed in the current study have been found even when task order was counterbalanced across participants (Chein et al., 2010) and when participants only performed one of the two conditions (Gardner & Steinberg, 2005). While this provides some support for the current findings, future research should further explore the extent to which practice effects have an impact and counterbalance order of task performance to eliminate any possibility of order effects.

Bursting a balloon on the BART-Y was associated with a loss of points that were built up for that trial but had not been awarded yet. Therefore, it was assumed that no direct punishment was incurred and the association between sensitivity to punishment (BIS subscale of the BIS/BAS scales) and performance on the BART-Y was not examined. It needs noting though that even though no actual points were lost from the overall total, not being awarded the anticipated points may still be felt as a punishment, especially after many pumps. It is important for future research to not only focus on the added reward that peers may bring to a

situation (as was the focus of the current study) but to also include assessment of the sense of punishment that failure in a peer-related situation may bring.

As discussed above, only a small amount of variance in the path model (9% and 2% of the variance in reward responsiveness and in risk-taking in the presence of peers respectively) was explained, leaving room for many other factors to exert their influence on risk-taking when in the presence of peers. One important and obvious factor is one's level of risk-taking when alone. This forms a baseline for individual differences to which a relative increase or decrease in risk-taking when with peers can be compared. While the focus of the path model was to investigate the relative impact of reward responsiveness, age and resistance to peer influence on risk-taking when with peers, risk-taking when alone could potentially have explained a substantial amount of variance in risk-taking when with peers. However, multicollinearity problems arising between risk-taking when with peers and when alone prevented addition of risk-taking when alone as another observed variable in this path model. In addition, only half of the participants completed the UPPS-P (n=102) while the other half completed the BIS-11 (n=98). While assessment of different types or forms of impulsiveness was of interest, this has prohibited the use of an impulsiveness variable in the path analysis.

The age range of participants recruited for this study was 18-24 years. On the one hand, this gives confidence in the generalisability of the findings for individuals who fall within this age group but on the other hand it limits generalisability to the wider developmental context. The mean score of resistance to the influence of peers in the current sample (median age 19.8 years old) was 2.8 (SD = 0.35) which is lower than the average of the 19 and 20 year old community sample that was recruited by Steinberg and Monahan (2007) (M = 3.4, SD = 0.39 and M = 3.4, SD = 0.41 respectively) and the antisocial youth sample recruited by Monahan et al. (2009) (M = 3.3, SD = 0.50 and M = 3.3, SD = 0.51 for 19

and 20 year olds respectively). While the differences in scores between the samples may be explained by differences in demographics, the lower level of resistance to peer influence reported by the participants in the current study would suggest a direct association with CHANGE which was not observed. However, a lack of a direct association between resistance to peer influence and performance on the BART is not uncommon (Cavalca et al., 2013). It could be that participants devalued the risks associated with the task as there was no risk for punishment (participants could only loose points that had not been awarded yet) and the difference between the small prize and bonus prize (£2.50 versus £10) was relatively small. Alternatively, participants may have had different situations in mind when responding to the items on the RPI than the current lab based task which may have impacted the association between RPI scores and risk-taking when with peers. The RPI assesses resistance to the influence of peers in general terms while task performance in this study assessed peer influence in the specific context of risk-taking for financial gain. Behaviour in this specific context may not be generalisable to other situations in which peers are influential. As with any self-report measure, it needs to be assumed that the given responses are consistent with participants' real-life behaviour. Likewise, although the BART-Y has good ecological validity, participants in the current study received the actual amount of money they won during performance of the tasks and received this sum immediately after completion of the study, no laboratory experiment can fully simulate real life (Gardner & Steinberg, 2005). Even though the BART has an acceptable level of test-retest reliability (White et al., 2008) and random fluctuations in performance may therefore be unlikely, they cannot be completely ruled out as an explanation for the current findings.

Taken together, this study confirmed and advanced recent findings on the influence of peer presence on risky driving (Chein et al., 2010) and suggestions of heightened response to reward when with peers (Chein et al., 2010; Steinberg, 2008). Responsiveness to reward

plays an important part in risk-taking behaviour and is subject to the influences of peers. A deeper understanding of the mechanisms underlying these processes has direct implications for prevention and intervention efforts and placing risk-taking behaviour within varying (social) contexts with eye for differences in developmental rates, personality and emotions provides ample scope for future research.

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Table 1

Sample characteristics

Measure		**n**	**Median**	**Range**	**Mean**	**SD**
BART-Y	Risk-taking alone	200	759.0	236-1074	743.3	151.2
BART-Y	Risk-taking with peers	200	808.5	262-1091	805.5	137.9
	Age	200	19.8	18.2-24.0	19.9	1.2
RPI	Resistance to peer influence	200	2.8	2.0-3.9	2.8	0.3
BIS/BAS	Drive for reward	200	9.5	4-16	9.5	2.1
	Fun seeking	200	10.0	4-16	9.8	2.8
	Reward responsiveness	200	13.0	5-20	12.4	5.1
	Behavioural inhibition	200	18.0	9-28	19.2	5.2
UPPS-P	Premeditation	102	2.1	1.1-3.3	2.1	0.4
	Negative urgency	102	2.3	1.3-3.7	2.4	0.5
	Positive urgency	102	1.7	1.0-3.9	1.8	0.5
	Sensation seeking	102	2.7	1.2-3.9	2.7	0.5
	Perseverance	102	2.0	1.2-3.4	2.1	0.4
BIS-11	Attention	98	10.0	5-18	10.7	2.8
	Cognitive instability	98	6.0	3-11	6.6	1.8
	Motor	98	15.0	7-28	15.5	4.0
	Perseverance	98	7.0	4-13	7.5	1.9
	Self-control	98	12.0	6-22	13.3	3.5
	Cognitive complexity	98	11.5	6-18	11.6	2.7

Note. Participants' performance on the BART-Y and self-report measures. BIS/BAS, Behavioral Inhibition System/Behavioral Activation System scales; RPI, Resistance to Peer Influence scale; UPPS-P, Urgency, Premeditation, Perseverance, Sensation seeking impulsive behavior scale; BIS-11, Barratt Impulsiveness Scale; SD, standard deviation.

Table 2

Goodness of fit tests and indices

Model	**Parameters**	**Goodness of fit measure**					
	(estimated)	χ^2(df), *p*	RMSEA (90% CI)	CFI	TLI	SRMR	AIC
Model 1	10 (7)	$\chi^2(3)=21.899$, $p<0.001$	0.178 (0.113-0.251)	0.124	-0.753	0.1081	35.899
Model 2	10 (7)	$\chi^2(3)=3.625$, $p=0.305$	0.032 (0.000-0.128)	0.971	0.942	0.0423	17.625

Note. df , degrees of freedom; RMSEA, Root Mean Squared Error of Approximation; CI, confidence interval; CFI, Bentler's Comparative Fit Index; TLI, Tucker-Lewis Index; SRMR, Standardised Root Mean Square Residual; AIC, Aikaike's Information Criterion.

Table 3

Standardised direct, indirect and total effects for predicting risk-taking in the presence of peers

			Direct effects	**Indirect effects**				**Total effects**
					S.E.	**95% C.I.**		
						Lower	**Upper**	
1.	Predictor	Resistance to peer influence	-0.076	0.041	8.883	1.394	35.949	-0.035
	Mediator	Reward responsiveness	0.158	-				0.158
2.	Predictor	Age	0.063	-0.030	2.131	-8.324	-1.118	0.034
	Mediator	Reward responsiveness	0.151	-				0.151

Note. The measures correspond to the models presented in Figure 2.2. S.E., standard error; C.I., confidence interval.

Figure 1. Path model (model 2) exploring the association between risk-taking in the presence of peers, reward responsiveness, resistance to the influence of peers and age.

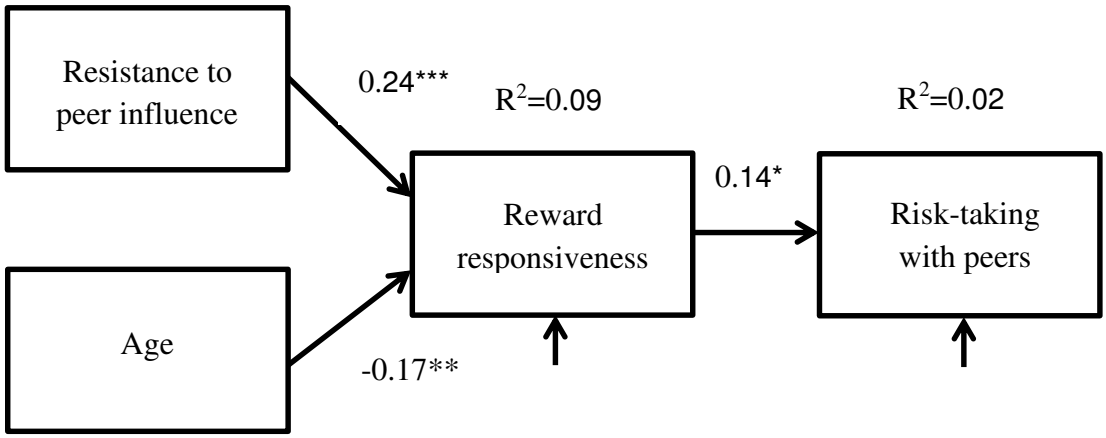
Note. * $p<0.05$; ** $p=0.01$; *** $p<0.001$.

Boxes represent observed variables. Long, solid arrows represent regressions. Short arrows represent residual error variances. Numbers indicate the standardised regression weights and R^2 indicates the amount of variance explained by the model.

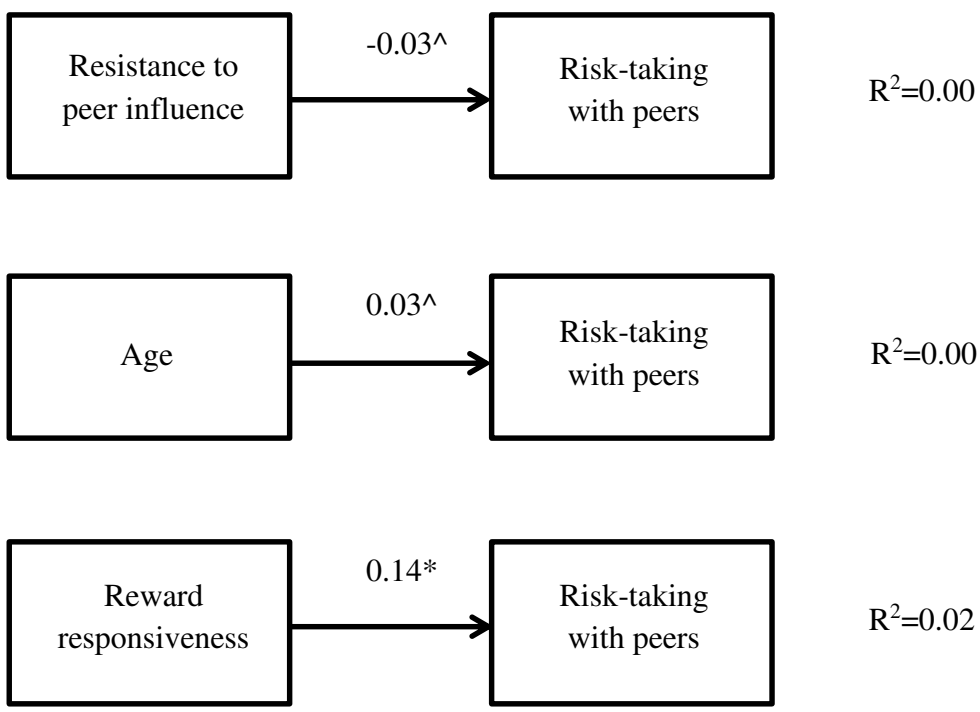
Figure 2. Path models investigating the direct and indirect associations between resistance to peer influence and reward responsiveness, and age and reward responsiveness.

Note. ^ $p>0.05$; * $p<0.05$; ** $p=0.005$; *** $p<0.001$.

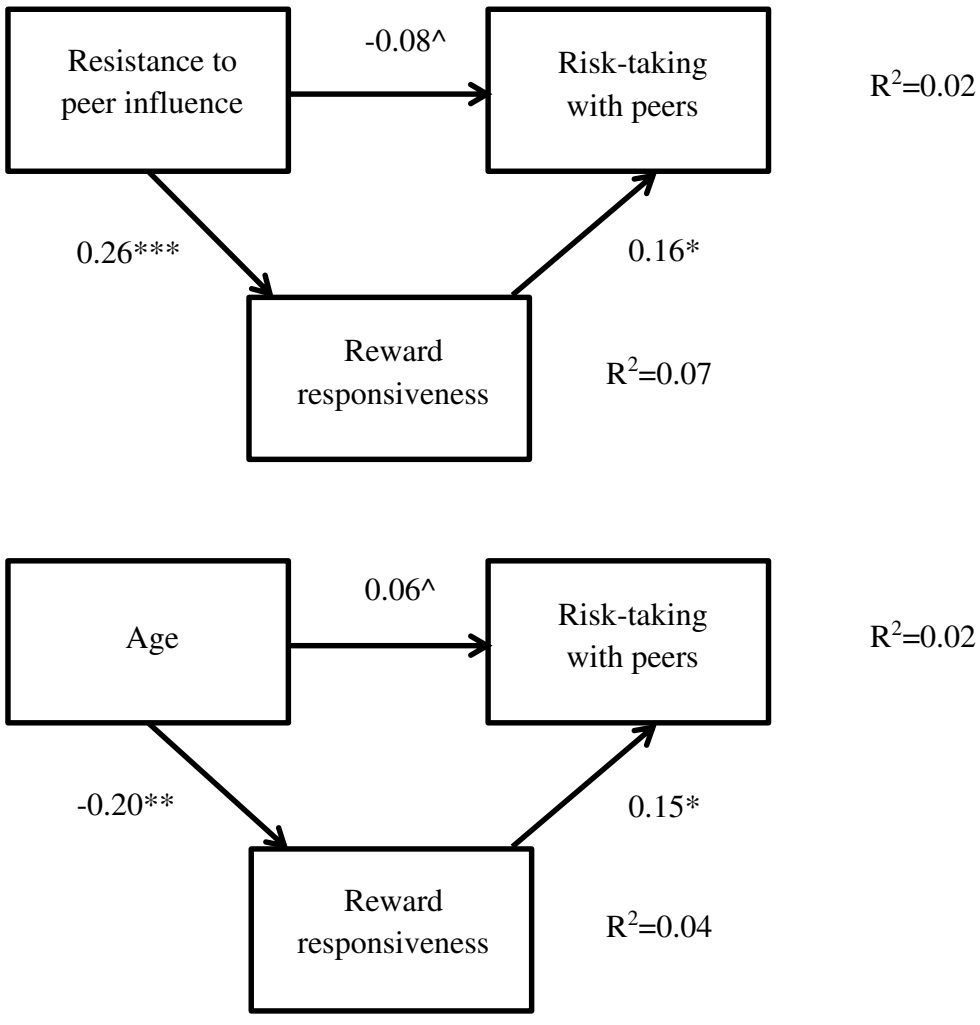
Boxes represent observed variables. Long, solid arrows represent regressions. Short arrows represent residual error variances. Numbers indicate the standardised regression weights and R^2 indicates the amount of variance explained by the model.


Resistance to peer influence
0.24***
R^2=0.09
R^2=0.02
0.14*
Reward responsiveness
Risk-taking with peers
Age
-0.17**

1.


Resistance to peer influence
-0.03^
Risk-taking with peers
R^2=0.00
Age
0.03^
Risk-taking with peers
R^2=0.00
Reward responsiveness
0.14*
Risk-taking with peers
R^2=0.02

2.


Resistance to peer influence
-0.08^
Risk-taking with peers
R^2=0.02
0.26***
0.16*
Reward responsiveness
R^2=0.07
Age
0.06^
Risk-taking with peers
R^2=0.02
-0.20**
0.15*
Reward responsiveness
R^2=0.04