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Rethinking adolescent risk-taking:
Perception of social risk impacts expected involvement in health-risk behaviour during
adolescence.

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Abstract

During adolescence the prevalence of certain health risk behaviours, such as binge drinking and illicit substance use, increases. Engagement in these behaviours has been attributed to immature self-regulation, heightened sensation seeking, and peer influence during adolescence. However, more recently, adolescence has been characterised as a time of risk sensitivity rather than universal increases in health-risk behaviour. For example, the extent to which individuals engage in health-risk behaviours may relate to their sensitivity to the social risk involved in engaging in the health-risk behaviour. In the present study we examined how individual differences in social risk perception relate to an individual's expectation of future involvement in risky behaviour during adolescence. One hundred and twenty-two participants (ages 11-17, mean 14 years) reported their expected involvement in a number of risk behaviours and degree to which they thought a) engaging in these behaviours would make people like them more, and b) not engaging in these behaviours would make people like them less. Social risk perception was operationalised as the perceived social benefit gained from engaging in a risk behaviour, from low (people would like you less), to high (people would like you more). We used linear mixed effects modelling to assess the contribution of social risk perception in predicting individuals expected involvement in health risk behaviours. We found that adolescents who perceived the social benefit associated with engaging in a risk behaviour to be high were more likely to report higher expected involvement in said behaviour. This was true for illicit substance use, aggressive and illegal behaviours, and risky drinking, but not for risky sex. Adolescents who reported a higher degree of peer victimisation showed a stronger relationship between the perceived social benefit of engaging in, and expected involvement in, these risk behaviours. Further, perceived social benefit moderated the relationship between sensation seeking and expected involvement in risky behaviours. Taken together, these data suggest that, across a number of health risking behaviours, adolescents incorporate perceptions of social risk when making decisions regarding their expected involvement. We argue that future investigations of adolescent health risking behaviours should incorporate social risk.

Key Word: Social risk, adolescence, sensation seeking, binge drinking, substance use, risky sex

Introduction

Health risk behaviours (HRBs), such as binge drinking and illicit substance use, cluster during the adolescent years (DuRant, Smith, Kreiter, & Krowchuk, 1999; van Nieuwenhuijzen et al., 2009). This increase in HRBs has fuelled the stereotype that adolescents generally take more risks than children or adults. However, recent studies have suggested that adolescence is a time of risk sensitivity (van Duijvenvoorde et al., 2015), rather than a time of universal increases in risk taking behaviour. Risk sensitivity is an individual difference characterised as the degree to which individuals are risk seeking or risk averse. In particular, it has been suggested that risk taking behaviours during adolescence are related to heightened social sensitivity, especially from peers (Blakemore & Mills, 2014). This theory predicts that an adolescent's perception of the social outcome of engagement in a particular risky behaviour will in part determine their likelihood of engaging in that behaviour. In this paper, we test this prediction by building a model of adolescent risk taking that accounts for the perceived social consequences of engaging in a variety of risky behaviours.

Current models of adolescent risk taking

Developmental scientists have proposed several theories as to why risk-taking behaviours increase during this period of life. Many of these theories have focused on the heightened degree of sensation seeking (Steinberg, 2008; Steinberg et al., 2018), reward value and peer influence (Chein, Albert, O'Brien, Uckert, & Steinberg, 2011). One of the most prevalent models that attempts to account for the increased risk taking seen during adolescence is the dual systems model (Steinberg, 2010). The general tenet of the dual systems model is that divergent patterns of motivational vs cognitive control systems contribute to increased risky decision making (Steinberg, 2010) and is largely based on psychological findings. However, a number of neuroscientific findings in the last decade are inconsistent with the dual systems model (Crone & Dahl, 2012; Pfeifer & Allen, 2012). For example, one study found that at an individual level there was wide variation in the presence of a developmental mismatch in the timing of development between subcortical regions (involved in motivational processes) and prefrontal regions (involved in cognitive control), with a number of individuals showing no evidence of a mismatch at all (Mills, Goddings, Clasen, Giedd, & Blakemore, 2014). Further, the extent to which this mismatch existed was unrelated to individuals retrospectively self-reported engagement in risky behaviour during adolescence (Mills et al., 2014). In contrast, in

recent years, the imbalance model (B. J. Casey, Jones, & Hare, 2008) has explicitly moved away from the dichotomy inherent in the dual systems model, and argued for a more nuanced understanding which accounts for variation in self-control across both content (e.g. emotions or actions) and context (e.g. in the presence of peers or parents) (B. Casey, Galván, & Somerville, 2016). Other recent models, such as a value-based choice account of adolescent decision-making (Pfeifer & Berkman, 2018), propose a single system integrates diverse value-laden inputs (which could include social risk perception) to inform choices.

The role of sensation seeking in accounting for this rise in risk-taking behaviour between childhood and adulthood has also been widely discussed (Romer, Reyna, & Satterthwaite, 2017a; Steinberg, 2008). One large cross cultural study has shown that across a number of countries self-reported sensation seeking peaks during adolescence, at 19 years of age, before declining thereafter (Steinberg et al., 2018) and previous work has documented a positive association between sensation seeking, substance use and sexual risk taking (Byck, Swann, Schalet, Bolland, & Mustanski, 2015; Quinn & Harden, 2013; Zhang, Zhang, & Shang, 2016). A recent model of adolescent risk taking, the Lifespan Wisdom Model, challenges the notion of a universal imbalance between the development of these brain systems and delineates adaptive and maladaptive risk taking during adolescence (Romer, Reyna, & Satterthwaite, 2017). This model argues that most risk-taking during adolescence is adaptive, allowing the individual to gain experience through exploration of the environment, particularly during ambiguous risk contexts (which is characterised by sensation seeking). In general however, when risks are known, risk taking declines monotonically from childhood to adulthood (Tymula et al., 2012). Maladaptive risk taking (which reflects lack of control and high impulsivity) is therefore characterised as risk taking within *known* risk contexts. The Lifespan Wisdom Model also argues for the incorporation of broader risk contexts such as ‘social conflicts’, with parents or peers, to be included in models of risk taking (Romer, Reyna, & Satterthwaite, 2017).

Risk taking and the peer environment

During adolescence, individuals undergo a period of substantial social-reorientation where they begin to spend more time with their peers (Lam, McHale, & Crouter, 2014; Nelson, Jarcho, & Guyer, 2016) and establish their position within a widening, and often unstable, social network of friends (Hartl, Laursen, & Cillessen, 2015). Importantly, adaptively navigating one’s social

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environment during adolescence, in order to attain social status and good quality of friendships, has been shown to have particular benefits for one's future social, psychological and physical health (Almquist, 2009; van Harmelen et al., 2017). One mechanism via which individuals may attain a beneficial position within a social group is through normative social influence, that is conforming to others in order to be accepted or liked.

Previous work that is consistent with this view has shown that belonging to a peer group that engages in smoking or drinking increases an individual's likelihood of smoking by 5.4 times and drinking by 1.9 times (Loke & Mak, 2013). Adolescents are also more likely to engage in HRBs such as excessive alcohol consumption, experimentation with illicit substances and smoking when with their peers, compared to when alone (Reniers et al., 2017). Data from across three US government surveys have also shown that the risk of car accidents is greater for young drivers when they have a passenger in the car (Chen, Baker, Braver, & Li, 2000).

Adolescence might be a period of particular susceptibility to peer influence due to sensitivity to the negative effects of social rejection. For example, following experimentally-induced social exclusion, 11-15 year olds report a greater decrease in mood compared to adults (22-47) (Sebastian, Viding, Williams, & Blakemore, 2010). Further, in a sample of 10-13 year olds, individuals with low resistance to peer influence were more likely to take risks on a simulated driving task, following social exclusion, compared to individuals with high resistance to peer influence (Peake, Dishion, Stormshak, Moore, & Pfeifer, 2013). Social rejection sensitivity has also been studied in relation to an incentivized risk-taking task, where individuals knock on a virtual door to earn points (McCormick, Perino, & Telzer, 2018). With each knock, the facial expression of the resident turns from happy to angry, however if the face becomes too angry the door slams and all points are lost. Moderate social sensitivity on this task was related to adaptive decision-making (McCormick et al., 2018).

Prior work has also revealed an association between engagement in substance use and victimization during adolescence. For example, in a sample of 12-17 year olds from South Africa, there was a significant association between substance use (e.g. tobacco, alcohol and marijuana) and prior victimization experiences (Morojele & Brook, 2006). Further, in a large sample of over four hundred thousand adolescents from California, USA, aged between 12 and 17, found that individuals who experienced high rates of victimization were twice as likely to frequently use substances such as tobacco, alcohol and marijuana (Gilreath, Astor, Estrada,

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Benbenishty, & Unger, 2014). The authors suggest that these results should be considered within the context of adolescence as a period crucial for developing peer relationships.

Taken together, these findings suggest that engaging in HRBs is influenced by the presence of social risk. Social risks can be defined as any decision or action that might lead to peer exclusion, lowering one's place in one's social hierarchy, embarrassment or loss of face (Allen & Badcock, 2003; Blakemore, 2018). We argue that these social risks need to be better incorporated into models of risk taking behaviour and that individual variation in the perception of social risk is a likely predictor of an individual's involvement in HRBs. This theory suggests that individuals who engage in HRBs, in order to avoid social risks, are making decisions that minimize their overall risk when both are taken into account.

Current study

Previous work has shown that positive outcome expectancies (e.g. pleasure, winning money, feeling good about oneself), are positively associated with drug use whilst both positive and negative outcome expectancies are associated with heavy drinking. However, engagement in risky sex was not predicted by outcome expectancies in a sample of young adults (mean age, 18) (Katz, Fromme, & D'Amico, 2000). In the present study, we examine how individual differences in social risk perception relate to an individual's expectation of future involvement in risky behaviour during adolescence. We investigated the extent to which an individual's perceptions of the social risk associated with a number of health risk behaviours. We did not investigate the relationship between individual's past engagement in these health risk behaviours, as perception of the social risk in the present may be conflated with previous social outcomes. Therefore, we use prospective measures of social risk associated with individual's prospective likelihood of engaging in HRBs to assess how their current perceptions of social risk impact their current expected involvement in a number of HRBs.

We hypothesise that individuals will incorporate perceptions of social risk into their expectations about engaging in HRBs, such that it will be related to the perceived social benefit of engagement (hypothesis 1). We predict that individuals who believe they will be liked more by engaging in a HRB will be more likely to expect to perform that behaviour, whilst individuals who believe that they will be liked less by engaging in said behaviour will be less likely to do so. Additionally, we anticipate that this relationship between perceived social

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benefit and engagement will be moderated by a number of characteristics. For example, we predict that individuals who report greater resistance to peer influence will show a diminished relationship between the perceived social benefit and engagement in risky behaviour (hypothesis 2). We further predict that individuals who report greater fear of negative evaluation, higher levels of peer victimisation, and lower levels of self-esteem will show a stronger relationship between perceived social benefit and engagement in risky behaviour (hypothesis 3-5). Finally, we hypothesise that social risk perception will moderate the relationship between sensation seeking and engagement in risky behaviours, such that individuals who perceive the social benefit of risk taking to be high will show a stronger relationship between sensation seeking and engagement in HRBs (hypothesis 6).

Methods

Participants

One hundred and eighty-three participants between the ages of 11 and 19 years were recruited as part of the *Teen Decision Study* (TDS; Research Component 1 of P50 DA035763) from the Eugene/Springfield, OR metropolitan area. The sample included in this project was drawn from three separate populations recruited for the TDS study. Of the 183 participants, 76 were recruited through contact with the Oregon Department of Human Services (DHS) (TDS 1), 97 were recruited in the local community (TDS 2), and 10 were recruited through their involvement with juvenile justice (TDS 3). The DHS-based sample participants were recruited because of their involvement with the Child Welfare System (e.g. in foster care) and were contacted through a DHS liaison. The community-based sample participants were recruited through distributed flyers, outreach events organized by the lab, online advertisement, tabling and word-of-mouth. The juvenile justice sample participants were recruited by re-contacting participants who had previously participated in another study conducted at the University of Oregon called the SHARP study (Research Component 2 of P50 DA035763). Caregivers of participants from TDS2 and TDS3, and caseworkers of participants from TDS1, provided informed consent, and all adolescent participants provided informed assent, in accordance with the University of Oregon Institutional Review Board and the DHS review board.

For the purposes of this analysis we removed the participants who were recruited through the juvenile justice system given the small number of participants in this group, and only included

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participants who had complete data for each variable of interest. This resulted in a total of 122 participants, between the ages of 11 and 17, of which 50 participants were from the DHS sample (TDS 1) and 72 were from the community sample (TDS 2). Across both samples the mean age of participants was 14 and there was an equal split of gender (61 females, 61 males). See table 1 for participant demographics split by sample.

Participant demographic information		
Group	TDS 1	TDS 2
<i>N</i>	50	72
Age	Mean 14.0 (Range 11.7 – 17.9)	Mean 14.1 (Range 11.1 – 17.6)
Gender	Male=29, Female=21	Male=32, Female=40
IQ	Mean 98.8	Mean 108.0

Table 1: Participant demographic information

Study Design

Data for this analysis was collected at two sessions, with the second session occurring roughly three weeks after the first session. The session in which each questionnaire was administered differed slightly between the DHS and community sample. This is outlined in supplemental table 1.

Materials

Cognitive appraisal of risky events (CARE)

We used items from the expected involvement (EI) subscale of the Cognitive Appraisal of Risky Events (Fromme, Katz, & Rivet, 1997) to assess expected involvement in the following domains of risky behaviour; aggressive and illegal behaviours, substance use, risky sex and risky drinking. All items were rated on a 7-point scale: 1=not at all likely to 7=extremely likely to engage in the specific health risking behaviour over the next 6 months. Scores were computed for each risk domain by averaging responses from items corresponding to each of the four risk domains of interest within the CARE (see supplemental material for the risk items included).

Social appraisal of risky events (SARE)

For each of the items tapped in the CARE, participants were separately asked to indicate how much people would like them if they (a) engaged in the behaviour (Social Benefit-Do), and if

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they (b) didn't engage in the behaviour (Social Benefit-Not). Items were rated on a 5-point scale: 1=a lot less, 2=less, 3=no difference, 4=more, 5=a lot more. Items posed in the negative (i.e., how much did people like them if they didn't engage in the behaviour) were reverse-scored, so that higher scores indicate higher perceived social benefit associated with engaging in risky behaviour. We computed an average score for each scale (Social-Benefit-Do/Not) by averaging the responses from items corresponding to each of the four risk domains of interest within the CARE.

Resistance to peer influence (RPI)

Resistance to Peer Influence (RPI). We scored each item on the 10-item RPI (Steinberg & Monahan, 2007) from 1 to 4 (reading left to right on the instrument) and reverse-scored items 2, 6, and 10. The mean score was calculated by summing the scores across the valid items and dividing them by the number of valid items.

Fear of negative evaluation (BFNE-S)

The Brief Fear of Negative Evaluation (BFNE) is a 12-item questionnaire used to assess fear of negative evaluation. Each item is rated on a 5-point scale, ranging from 0 (not at all characteristic of me) to 4 (extremely characteristic of me). We calculated a mean score across the eight straightforwardly-worded items because they have been reported to be "more reliable and valid indicators" (Weeks et al., 2005). This 8-item version is called the BFNE-S (Carleton, McCreary, Norton, & Asmundson, 2006).

Peer experiences questionnaire (RPEQ)

The Revised Peer Experiences Questionnaire (RPEQ) consists of 36 items that are scored on a 5-point scale: 1=never, 2=once or twice, 3=a few times, 4=about once a week, 5=a few times a week to assess bullying behaviour and experiences of victimization (Prinstein, Boergers, & Vernberg, 2001). For the current project we only used items that were worded such that the participant reports on being the victim, in order to get an indication of the participant's perceived sense of being victimized by peers. Average scores were computed from the items regarding individuals' overt and relational victimisation experiences and then combined in order to create a total victimisation score.

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Need threat scale (NTS)

Participants played Cyber ball (Williams, Cheung, & Choi, 2000), a virtual ball tossing game, in which they are excluded from the game by two other players. Participants were led to believe they were playing against two other players; however, these players were programmed by the experimenter to exclude the participant. Participants were then asked the Need-Threat Scale (NTS) and asked to indicate how they felt during the Cyber ball game. The NTS includes 12 items that are scored on a 5-point scale: 1=not at all, 3=moderately, 5=very much so. Only the Self-esteem subscale is included in the current analysis. The items included in the Self-esteem subscale are reverse-scored, so that higher scores correspond with experiencing greater threat to an individual's need for self-esteem.

Sensation seeking (BSSS)

The Brief Sensation Seeking Scale (BSSS) was adapted by Hoyle and colleagues from the Sensation Seeking Scale and tailored for adolescents (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002). It consists of 8 pairs of statements, with one of the two statements associated with sensation seeking behaviour, and participants are asked to select the statement that best describes their preferences from of each pair. Sensation seeking scores are calculated by summing together the total number of sensation seeking statement selected from the 8 pairs.

Statistical Analyses

We employed a linear mixed effects modelling approach to our data with the lme4 package in R (R Core Team, 2014). We take a model comparison approach whereby the model with the lowest Akaike information criterion (AIC) value that was significantly different ($p < .05$), as determined by a likelihood ratio test (LRT), from the less complex model was chosen. p values for model comparisons therefore represent likelihood ratio testing. Where we are interested in the interaction between two or more variables, we use LRT's to compare the interaction model against a simpler model where the interaction term of interest is entered as a fixed effect. Where omnibus tests and model parameters are reported, p values for F and t statistics are approximated with the Satterthwaite method, which approximates the degrees of freedom, given that the null distributions of parameter estimates and test statistics are unknown (Kuznetsova, Brockhoff, & Christensen, 2017). All models included age, gender, IQ and group (community: TDS2; child welfare services: TDS1) as fixed factors.

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The first aim was to examine our hypothesis that there would be a relationship between expected involvement in risky behaviour and the perceived social benefit of engaging in, or not engaging in, these risky behaviours. Expected involvement was measured with the CARE and the perceived social benefit of engaging in (Social Benefit-Do), or not engaging in (Social Benefit -Not) each of these behaviours was measured by the two questions asked in the SARE. In step one we find the best fitting model that predicts expected involvement using the SARE (see table 2 for models). In step two we were interested to see if an interaction between social benefit and risk domain, that is the type of risk behaviour (aggressive and illegal, substance use, risky sex or risky drinking), improved the model. We therefore compare our best fitting model from step one with a model incorporating the interaction with risk domain in step two.

We tested hypotheses 2-5 (see table 2 for models), that this relationship would be moderated by a number of individual characteristics, such as resistance to peer influence, fear of negative evaluation, peer victimisation and fear of negative evaluation. We did this by comparing our best fitting model arising from the results of our first hypothesis, to a model that incorporated the individual difference of interest. Where variables were testing similar constructs e.g. fear of negative evaluation and victimization, we Bonferroni corrected for multiple comparisons.

Our last hypothesis (6) investigated the relationship between sensation seeking and expected involvement in risky behaviours including the moderating effect of perceived social benefit on this relationship. We compared a model predicting expected involvement in risky behaviour with sensation seeking against our null model. We further compared a model incorporating an interaction between sensation seeking, social benefit, and risk domain with our simpler model.

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Models predicting expected involvement in risky behaviours			
Model Name	Fixed Effects	Random Effects	AIC
Hypothesis 1: Step one			
1 (null)	-	Subject ID	713.46
2	Age + Gender + IQ + Group	Subject ID	710.84
3	Age + Gender + IQ + Group + Social B-Do	Subject ID	682.98
4	Age + Gender + IQ + Group + Social B-Not	Subject ID	706.52
5	Age + Gender + IQ + Group + Social B-Do + Social B-Not	Subject ID	684.95
6	Age + Gender + IQ + Group + Social B-Do*Social B-Not	Subject ID	684.11
Hypothesis 1: Step two			
7	Age + Gender + IQ + Group + Social B-Do*Risk Domain	Subject ID	668.26
8	Age + Gender + IQ + Group + Social B-Do + Risk Domain	Subject ID	681.67
Hypothesis 2			
9	Age + Gender + IQ + Group + Social B-Do*Risk Domain*RPI	Subject ID	662.36
10	Age + Gender + IQ + Group + Social B-Do*Risk Domain + RPI	Subject ID	662.79
Hypothesis 3			
11	Age + Gender + IQ + Group + Social B-Do*Risk Domain*Negative Evaluation	Subject ID	668.30
Hypothesis 4			
12	Age + Gender + IQ + Group + Social B-Do*Risk Domain*Victimisation	Subject ID	657.83
13	Age + Gender + IQ + Group + Social B-Do*Risk Domain + Victimisation	Subject ID	663.23
Hypothesis 5			
14	Age + Gender + IQ + Group + Social B-Do*Risk Domain*Self Esteem	Subject ID	671.10
Hypothesis 6			
15	Age + Gender + IQ + Group + Sensation seeking	Subject ID	699.90
16	Age + Gender + IQ + Group + Social B-Do*Risk Domain*Sensation Seeking	Subject ID	648.02
17	Age + Gender + IQ + Group + Social B-Do + Risk Domain + Sensation Seeking	Subject ID	660.21

Table 2: Models predicting expected involvement in risky behaviours. Each model includes age, gender, IQ and group (TDS 1: child welfare sample and TDS 2: community sample) as fixed effects. Social B-Do refers to the SARE scale measuring the perceived social benefit of engaging in the risk behaviour. Social B-Not refers to the SARE scale measuring the perceived social benefit of not engaging in the risk behaviour.

Results

Hypothesis 1: Social benefit of risk taking

In step one, model 3, which included age, gender, IQ, group and Social benefit-do, best fitted the data. Across all models of interest, model 3 had the best model fit based on our AIC criteria. Model 3 provided a better fit to all simpler models; the null ($X^2(5)=40.48$, $p=<.001$) and a model (model 2) including just age, gender and IQ ($X^2(1)=29.85$, $p=<.001$).

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In step two, we added risk domain (substance use, aggressive & illegal behaviour, risky drinking, and risky sex) as an interaction term to our model. Model 7, which included age, gender, IQ, group and an interaction between social benefit and risk domain, explained more variance in expected involvement than model 3 ($X^2(6)=26.73, p < .001$).

We tested the significance of this interaction by comparing model 7 to a model where Risk Domain was entered, but not as an interaction (model 8). Model 7 outperformed model 8 ($X^2(3)=19.41, p < .001$), revealing the additional benefit of the interaction between perceived social benefit and risk domain in explaining expected involvement. Therefore, our best fitting model (model 7), included age, gender, IQ, group and an interaction between social benefit and risk domain.

Estimates for model 7 are found in table 3. Omnibus tests on model 7, revealed a main effect of age ($F(1, 123.06)=6.15, p = .014$), social benefit ($F(1, 380.46)=19.62, p < .001$), risk domain ($F(3, 350.60)=5.21, p = 0.001$) and an interaction of social benefit and risk domain ($F(3, 356.92)=6.67, p < .001$). To explore the interaction between perceived social benefit and risk domain we plotted the relationship for each risk domain (Figure 1) and used simple slope analyses. The perceived social benefit from engaging in aggressive and illegal behaviours ($\beta = 0.29, p < .001$), substance use ($\beta = 0.11, p = .03$) and risky drinking ($\beta = 0.30, p < .001$) predicted expected involvement in these respective risk behaviours, however this was not the case for risky sex ($\beta = -0.05, p = .52$) (table 3).

Figure 1
Relationship between perceived the social benefit and expected involvement in risk behaviour, broken down by risk domain.

Fixed effects	Estimate	SE	t	p
Intercept	0.32	0.4	0.80	.42
Age	0.05	0.02	2.48	.02
Gender	-0.08	0.06	-1.20	.23
IQ	-0.0	0.0	-0.92	.36
Group	-0.02	0.07	-0.31	.75
Social B-Do	0.29	0.07	3.98	<.001
Substance use	0.20	0.17	1.23	.22
Risky drinking	-0.07	0.17	-0.42	.68
Risky sex	0.67	0.21	3.20	<.001
Social B-Do*Substance use	-0.18	0.08	-2.11	.04
Social B-Do*Risky drinking	0.01	0.08	0.15	.89
Social B-Do*Risky sex	-0.35	0.11	-3.18	<.001
Total Observations = 434				
Random effects	Variance		S.D.	
Participant (intercept)	0.058		0.24	
Simple slopes	Estimate	SE	t	p
Aggressive and illegal behaviours	0.29	0.07	4.02	<0.001
Substance use	0.11	0.05	2.22	0.03
Risky drinking	0.30	0.05	6.25	<0.001
Risky sex	-0.05	0.08	-0.64	0.52

Table 3: Estimates for model 7, which included age, gender, IQ, group and an interaction between social benefit and risk domain.

Correlations between variables of interest

We computed a correlation plot depicting the relationship between each subsequent variable of interest (see Figure 2).

Figure 2: Correlation plot between all subsequent variables of interest (FNE = fear of negative evaluation, RPI = resistance to peer influence).

Hypothesis 2: Resistance to peer influence

A model including an interaction with resistance to peer influence (model 9) better fit the data compared to our simpler model (model 7) ($X^2(8)=21.90, p=0.005$). We further tested whether this model including the interaction with RPI explained more variance in expected involvement over a simpler model where RPI was entered, but not as an interaction (model 10). Model 9 provided a better model fit than model 10, revealing the additional benefit of the interaction between perceived social benefit, risk domain, and resistance to peer influence in explaining expected involvement. Therefore, model 9 which included the main effect of age, gender, IQ and group, as well as an interaction between social benefit, risk domain, and resistance to peer influence best explains the data. Omnibus tests on model 9 revealed a main effect of age ($F(1,$

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122.15)=11.17, $p = .001$) and social benefit ($F(1, 364.33)=5.92$, $p = 0.02$). All other fixed effects did not meet significance ($p > .05$).

Hypothesis 3: Fear of negative evaluation

The more simple model (model 7), which included age, gender, IQ, group and an interaction between social benefit and risk domain, provided a better fit than a model including an interaction with fear of negative evaluation (model 11). Therefore, fear of negative evaluation does not interact with social benefit and risk domain in association with expected involvement in risk behaviours.

Hypothesis 4: Peer victimisation

A model including an interaction with victimisation (model 12) outperformed our simpler model (model 7) ($X^2(8)=26.43$ $p < .001$) (Bonferroni corrected). We further tested whether this model including the interaction with victimisation explained more variance in expected involvement over a simpler model where victimisation was entered, but not as an interaction (model 13). Model 12 provided a better fit to our data than model 13 ($X^2(8)=21.40$ $p = 0.01$), revealing the additional benefit of the interaction between social benefit, risk domain, and victimisation in explaining expected involvement. Omnibus tests on model 13 revealed main effects of age ($F(1, 122.85)=7.12$, $p = .008$) and victimisation ($F(1, 370.85)=4.715$, $p = .03$), and a significant interaction between social benefit and victimisation ($F(1, 421.80)=8.60$, $p = .004$). All other fixed effects did not meet significance ($p > .05$). To explore the interaction between social benefit and victimisation we plotted the relationship (Figure 3) and used simple slope analyses. When victimisation was high (+1 SD) individuals showed a strong relationship between social benefit and expected involvement ($\beta = 0.39$, $p < .001$), however, when victimisation was low (-1 SD) the slope was not significant ($\beta = 0.06$, $p = .56$).

Figure 3

The moderating effect of victimisation on the relationship between social benefit and expected involvement in risk behaviours.

Hypothesis 5: Self esteem

The more simple model (model 7), which included age, gender, IQ, group and an interaction between social benefit and risk domain, provided a better fit to a model including an interaction with self-esteem (model 14). Therefore, self-esteem does not interact with social benefit and risk domain in association with expected involvement in risk behaviours.

Hypothesis 6: Sensation seeking

We built a model that predicted expected involvement in risky behaviours with sensation seeking (model 15). Model 15 provided a better fit than model 2 (which just included age, gender, IQ and group) ($X^2(2)=12.94$ $p < 0.001$). We then added an interaction with perceived social benefit and risk domain to the model (model 16), which improved upon model 15 ($X^2(14)=79.90$, $p < 0.001$). We tested the significance of including this three-way interaction by comparing model 16 to a simpler model (model 17). Model 16 outperformed model 17 ($X^2(7)=26.19$, $p < 0.001$), revealing the additional benefit of the interaction between sensation seeking, perceived social benefit, and risk domain in explaining expected involvement. Therefore, our best fitting model (model 16) included the main effect of age, gender, IQ and

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group, as well as an interaction between sensation seeking, perceived social benefit, and risk domain (see table 4 for the estimates of model 16). Omnibus tests on model 16, revealed a main effect of age ($F(1, 118.85)=4.51, p=.04$), a two way interaction of sensation seeking and risk domain ($F(3, 359.0)=5.55, p<0.001$) and a three way interaction of sensation seeking, social benefit, and risk domain ($F(3, 364.31)=6.20, p<0.001$) (Figure 4). Simple slope analyses revealed that when individuals perceived the social benefit of engaging in aggressive and illegal behaviours to be high (+1 SD) they show a strong relationship between sensation seeking and expected involvement ($b = 1.01, p=.01$), however when they perceive the social benefit to be low there is no significant relationship ($b = -0.2, p=.94$). This same pattern was observed for risky drinking. When individuals perceived the social benefit of engaging in risky drinking to be high (+1 SD) they show a strong relationship between sensation seeking and expected involvement ($\beta = 0.82, p<0.001$), however when they perceive the social benefit to be low (-1 SD) there is no significant relationship ($\beta = -0.23, p=.41$). Simple slopes for drug use were not significant ($p>.05$). Finally, when the perceived social benefit of risky sex was low (-1 SD) there was a strong relationship between sensation seeking and expected involvement ($\beta = 1.02, p<0.001$), however when they perceive the social benefit to be high (+1 SD) there is no significant relationship ($\beta = -0.13, p=.71$).

Figure 4: The moderating effect of social benefit on the relationship between sensation seeking and expected involvement in risk behaviours.

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Fixed effects	Estimate	SE	t	p
Intercept	0.80	0.47	1.71	.09
Age	0.04	0.02	2.10	.04
Gender	-0.10	0.06	-1.63	.11
IQ	-0.00	0.00	-0.65	.52
Group	-0.04	0.07	-0.60	.57
Sensation seeking	-0.71	0.50	-1.43	.15
Social Benefit-Do	-0.07	0.17	-0.40	.69
Substance use	-0.20	0.36	-0.55	.58
Risky drinking	-0.00	0.36	0.01	.99
Risky sex	-0.59	0.41	-1.43	.15
Sensation seeking*Social B-Do	0.62	0.28	2.24	.03
Sensation seeking*Substance use	0.67	0.66	1.01	.31
Sensation seeking*Risky drinking	-0.21	0.64	-0.33	.74
Sensation seeking*Risky sex	2.49	0.73	3.40	<.001
Social B-Do*Substance use	0.13	0.19	0.71	.48
Social B-Do*Risky drinking	0.03	0.19	0.18	.86
Social B-Do*Risky sex	0.33	0.23	1.46	.15
Sensation seeking* Social B-Do*Substance use	-0.54	0.33	-1.60	.11
Sensation seeking* Social B-Do*Risky drinking	0.01	0.32	0.02	.99
Sensation seeking* Social B-Do*Risky sex	-1.30	0.39	-3.34	<.001
Total Observations = 434				
Random effects	Variance		S.D.	
Participant (intercept)	0.057		0.24	
Simple slopes	Estimate	SE	t	p
Aggressive and illegal behaviours				
Social B-Do (-1 SD)	-0.2	0.24	-0.07	.94
Social B-Do (Mean)	0.5	0.19	2.56	.01
Social B-Do (+1 SD)	1.01	0.34	2.82	.01
Substance use				
Social B-Do (-1 SD)	0.04	0.27	0.16	.87
Social B-Do (Mean)	0.12	0.18	0.65	.52
Social B-Do (+1 SD)	0.19	0.22	0.88	.38
Risky drinking				
Social B-Do (-1 SD)	-0.23	0.28	-0.82	.41
Social B-Do (Mean)	0.30	0.19	1.56	.12
Social B-Do (+1 SD)	0.82	0.19	4.30	<.001
Risky sex				
Social B-Do (-1 SD)	1.02	0.30	3.37	<.001
Social B-Do (Mean)	0.44	0.21	2.08	.04
Social B-Do (+1 SD)	-0.13	0.34	-0.37	.71

Table 4: Estimates for model 16, which included the main effect of age, gender, IQ and group, as well as an interaction between sensation seeking, perceived social benefit, and risk domain.

Discussion

In this study we investigated the relationship between individual variation in social risk perception and expected involvement in HRBs in a sample of adolescents. We show that perception of social risk explains variance in an individual's expectations of engagement in aggressive and illegal behaviours, substance use and risky drinking, but not risky sex, during adolescence. More specifically, we find that individuals who perceived the social benefit of engaging in these risky behaviours to be high (increased likability) were more likely to expect to engage in said behaviour, whilst individuals who perceived the social benefit to be low (reduced likeability) were less likely to do so. This finding supports the theory that adolescents incorporate the social consequences when considering their likely engagement in a number of HRBs. This data supports the view that individual difference in risk sensitivity, in particular sensitivity to social risk, varies across adolescents – with some individuals placing greater weight on the social risk than others.

During adolescence, one's social and personal worth becomes increasingly dependent on peer relationships (O'Brien & Bierman, 1988). Therefore, engaging in behaviours that may lead to increased likeability, may lead to a positive impact on mental health. We observe that adolescents' expectations of engagement in HRBs are, in part, explained by how much they think others will like them for engaging (or dislike them for not engaging). Interestingly, we find this relationship to be true for all risk domains investigated except risky sexual behaviours. This finding is consistent with prior work showing that both positive and negative outcome expectancies did not predict engagement in risky sexual behaviour (Katz et al., 2000). One possible explanation for this observation is that whilst sex is of course a social behaviour, it is unlikely to occur in the presence of one's peer group, in comparison to the other risky behaviours investigated, and therefore carries with it a different set of social evaluative concerns. In addition, societal expectations of what is 'deviant' and what is not may be a contributing factor with regards to these findings. It is possible that risky sex is perceived as less deviant than the other HRBs presented by the CARE, which might relate to our observed finding that social consequences do not relate to expected engagement in risky sex.

We subsequently found that individuals with a higher degree of peer victimization showed a stronger relationship between the perceived social benefit of, and expected involvement in,

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HRBs. In previous studies, chronic peer victimization and experimentally induced social exclusion have both been related to increased risk taking behaviour on laboratory tasks (Peake et al., 2013; Telzer, Miernicki, & Rudolph, 2018). There is also evidence that feeling non-prototypical, or dissimilar to one's peers, augments adherence to group norms (Noel, Wann, & Branscombe, 1995), particularly in individuals who have a significant motivation for group acceptance (Steinel et al., 2010). Our data suggest that victimized individuals expect to make more socially risk-averse decisions, which may include placing greater weight on the social rather than the health consequences associated with a given decision, perhaps as a mechanism to attain likeability and peer acceptance. According to the social augmentation hypothesis (T. Dishion, Piehler, & Myers, 2008), victimization amplifies the role of deviant values in friendship formation. In support of this there is evidence that individuals who have experienced peer rejection are likely to form friendships with other rejected peers, who support deviant behaviours (T. J. Dishion, Patterson, Stoolmiller, & Skinner, 1991). This theory suggests that chronic victimization augments the value of peer interaction. Whilst we do not specifically ask about peers, the present findings support this idea that victimisation increases social evaluative concern, leading to a greater weight being given to the social risk involved in a decision.

Although our findings suggest that the social consequences of HRBs play an important contribution to one's expected involvement in a number of HRBs, one prevailing view is that HRBs during adolescence are in part explainable by a heightened degree of sensation seeking observed during this period of development. For our part, we show that the relationship between sensation seeking and expected involvement in HRBs is moderated by social risk perception. With respect to aggressive and illegal behaviours, as well as risky drinking, individuals who perceive the social benefit of engaging in these behaviours (and/or social risks of not engaging) to be high, show an increased positive relationship between sensation seeking and engagement in the risky behaviour. We find no such moderating effect for substance use, and an opposite effect for risky sexual behaviour. When individuals believe they will be liked less by engaging in risky sex, their expected involvement in risky sex is better explained by sensation seeking than when they believe they will be liked more. Collectively, these findings demonstrate that, engagement in risky behaviours is explained by an interaction between sensation seeking and concerns over the social risk associated with expected involvement in HRBs.

Limitations and Future Directions

Future work should build upon the findings reported here, to incorporate perceptions of social risk into measures of actual engagement in risk taking behaviour and experimental risk-taking tasks. The present study was unable to dissociate the effects of peer vs. parent contributions to social risk perception. In the present study, individuals were asked how much ‘people’ would like them, rather than specifically peers or parents, therefore conflating these different sources of influence. There is a growing literature showing that, as well as peers, parents continue to be an important source of influence in adolescents decision processes (Qu, Fuligni, Galvan, & Telzer, 2015; van Hoorn, McCormick, Rogers, Ivory, & Telzer, 2018). Therefore, future work is needed in order to delineate the contribution of peers and parents in social risk perception. In addition, the present study is unable to contribute to an understanding of how social risk perception impacts expected involvement in HRBs across the lifespan. Therefore, in order to understand developmental trends, future work should consider assessing the impact of social risk perception on risky decision making across age.

Whilst the data presented here was self-report, these findings have significant implications for public health interventions, specifically supporting the suggestion that interventions aimed at reducing risky health behaviours such as binge drinking and substance misuse in young people should focus on changing social norms around risk behaviour (Blakemore, 2018). However, interventions should be cautious of the possible iatrogenic effects of grouping deviant peers together (Gifford-Smith, Dodge, Dishion, & McCord, 2005). Rather, focusing on interventions that utilise a bottom-up, or peer-led, approach may have the most positive outcomes. This is evidenced by previous interventions that have utilised this approach reporting promising results for behaviours such as bullying (Paluck, Shepherd, & Aronow, 2016) and smoking (Campbell et al., 2008). More broadly, peers represent a potentially underused source of social change in current public health interventions; merely targeting the health consequences associated with a given risky decision ignores the broader social context that adolescents incorporate into their decisions regarding their engagement in (health) risk behaviours.

Conclusion

The findings from the present study demonstrate the importance of incorporating perceptions of social risk into models of engagement in HRB. Individual differences in the perception of the social risk associated with a number of HRBs predicted adolescents expected involvement in these behaviours. This was true for aggressive and illegal behaviours, substance use and risky drinking, but not risky sex. In addition, we find that this relationship is augmented in individuals with a history of victimisation and that social risk perception moderates the relationship between sensation seeking and expected involvement across a number of HRBs. This study provides an important contribution to the understanding of adolescent risk behaviour. Crucially, individuals, who are particularly sensitive to social risk, who engage in health risk behaviours, may in fact, not be engaging in risky behaviour per se but rather minimising their overall risk exposure when aggregating across social and health risks. When incorporating an understanding of the social risks involved in these behaviours, individuals may therefore be acting to attain social acceptance, and avoid social risk.

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Supplemental material

Measure	Acronym	TDS 1		TDS 2	
		Session 1	Session 2	Session 1	Session 2
Resistance to Peer Influence	RPI	x		x	
Cognitive Appraisal of Risky Events - Revised - Expected Involvement	CARE-EI	x			x
Social Appraisal of Risky Events	SARE	x		x	
Peer Experiences Questionnaire - Revised	PEQ - R		x		x
Brief Sensation Seeking Scale	BSSS		x		x
Need Threat Scale	NTS		x		x
Brief Fear of Negative Evaluation	BFNE		x		x
Wechsler's Abbreviated Scale for Intelligence	WASI		x		x

Table S1: Depiction of the timing of each assessment tool depending on the sample group

Risk behaviours

Risk behaviours from the CARE included in analyses. For each of these behaviours individuals reported their expected involvement (CARE) and how much people would like them if they (a) engaged in the behaviour and (b) didn't engage in the behaviour (SARE).

Illicit drug use

Trying drugs other than alcohol or marijuana

Smoking Marijuana

Aggressive and illegal behaviours

Driving after drinking alcohol

Damaging/destroying public property

Hitting someone with a weapon or object

Slapping someone

Punching or hitting someone with fist

Risky sexual activities

Sex without protection against pregnancy

Sex without protection against STD's

Sex with someone I have just met or don't know well

Risky drinking

Drinking more than 5 alcoholic beverages

Playing drinking games