Supplemental Materials

Consequences for Peers Differentially Bias Computations About Risk Across Development

by K. Powers et al., 2017, *Journal of Experimental Psychology: General*

http://dx.doi.org/10.1037/xge0000389

Methods

Observed Power

Posthoc analyses were conducted to quantify observed power based on the design and effect sizes in the current study. A series of Monte Carlo simulations were carried out using the simr package in R (Green & MacLeod, 2016a; 2016b), which accommodates complex designs involving mixed effects models. Two sets of simulations (n=1,000 simulations each; alpha = 0.05) were conducted to calculate power to detect the key developmental effects within the adolescent sample: shifts towards risk aversion during friend loss and shifts towards risk seeking during friend gain. Simulations were based on the mixed effect models reported in the main text. Results revealed the following levels of observed power to detect significant shifts in risk aversion: friend loss condition (observed power = 95.50%, CI=[94.02, 96.70]); friend win condition (observed power = 68.20%, CI=[65.21, 71.08].

Parameter recovery simulations for risk aversion (α)

Simulation exercises were conducted to evaluate model performance by determining whether the choice set is sufficient to reliably estimate model parameters. Sets of choice data were simulated across a wide range of parameter values (for α: 0-2, by increments of 0.1) at low, medium and high levels of inverse decision noise (i.e., μ, the other free parameter in the model that captures the degree to which an individual's choices are driven by randomness (low) vs. value (high)). One hundred sets of simulated choice data were generated for each unique combination of these parameters. We then fit the model to each simulated choice data set using a maximum likelihood procedure as described in the main text to obtain estimates of each parameter. Recoverability was assessed by calculating the similarity between the values of the parameters inputted to generate the simulated choice data and the values of the estimated parameters derived from fitting the simulated choice data, using a Pearson correlation. Indices of similarity (mean r-values and accompanying standard errors for α across all simulations) for each level of inverse decision noise are reported in Table S1.

The results from this set of simulations demonstrate that risk aversion parameters can be recovered with very high accuracy using the two-parameter expected utility model. Though it is more difficult to reliably recover risk aversion when there is a lot of noise and randomness present in a participant's decision-making strategy, participants characterized by such a decision-making strategy are not included in the reported analyses (see p. 10-11 of the main text). That is, these parameters can be recovered with confidence within the final, usable sample.

Alternative model exploration – nonlinear probability weighting

According to prospect theory and prior empirical work (e.g., Gonzalez & Wu, 1999; Tversky & Kahneman, 1992; Hsu et al., 2009), nonlinear weighting of probabilities represents a key feature of human decision bias. Though the choice set in the present study was optimized according an expected utility framework (Tymula et al., 2012) not a prospect theory framework, we also fit an alternative model with a third estimated parameter and conducted simulation analyses to determine whether a probability weighting function could be reliably estimated. A standard version of a single-parameter weighting function was incorporated into the model, where γ controls the weighting of probabilities (*p*):

$$w(p) = \frac{p^{\gamma}}{(p^{\gamma} + (1-p)^{\gamma})^{1/\gamma}}$$

The rest of the model fitting procedure proceeded according to the description in the main text.

Parameter recovery simulations for probability weighting (γ)

Simulation analyses were conducted as described above for two additional models: one estimating probability weighting (γ) independently and one estimating both risk aversion (α) and probability weighting (γ) simultaneously, using the following range of parameter values for γ: 0 – 1, by increments of 0.1. The results of these simulations (see Table S1) demonstrate that the choice set used in the present study does not permit sufficiently reliable estimation of a probability weighting parameter either independently or jointly with the risk aversion parameter, at any noise level. Together, these results support the use of a two-parameter expected utility model without a weighting function in conjunction with the present choice set, as has been used in prior work (e.g., Gilaie-Dotan et al., 2014; Levy & Glimcher, 2011; Levy et al., 2012).

Measures of risk attitudes

Partway through data collection we added measures to the study protocol with the goal of extending the study to answer questions about how having knowledge of a friend's beliefs about risk might affect choice behavior. Participants completed the Domain Specific Risk Taking questionnaire (DOSPERT; Blais & Weber, 2006), which is a self-report scale assessing an individual's likelihood of engaging in a series of risky scenarios. Young adult participants completed the Adult version of the scale and adolescent participants completed the Adolescent version, which is still in the process of being validated. Participants completed the scale twice: once based on their own risk attitudes (as the scale intends) and a second time based on how likely they believe *their friend* would be to engage in the risky scenarios. Scores from the "friend" measure could then be compared against the friend's actual risk attitude to identify whether the participant viewed their friend as more or less risk tolerant than they actually were. N=143 participants (101 adolescents, 42 young adults) completed the original DOSPERT scale and N=116 participants (74 adolescents, 42 young adults) completed the modified "friend" version of the scale. Calculations comparing these two measures (i.e., risk bias scores) could only be derived for dyads in which both scores were present (N=114 participants; 72 adolescents, 42 young adults). The goal was to use these questionnaire scores as potential moderators of task performance.

Results

Comparisons of friend observation conditions

To further explore the significant age x friend monitoring interaction that emerged from analyses testing for shifts in risk aversion evoked by the prospect of friend win, we conducted additional targeted pairwise tests that directly compared each pair of the three friend observation conditions. Results parallel the contrast-based analyses presented in the main text.

Young adults were marginally more risky when being actively watched by their friend (*friend monitoring*) relative to when the friend was present but not watching (*friend present*; $M_{DIFFERENCE} = 0.27$, CI=[-0.01, 0.54], p=0.057) and significantly more risky when the friend was not in the room (*alone*; $M_{DIFFERENCE} = 0.32$, CI=[0.06, 0.58], p=0.010). There were no differences between the *alone* and *friend present* conditions ($M_{DIFFERENCE} = 0.05$, CI=[-0.21, 0.31], p=1.000). In contrast, adolescents made consistently riskier choices when helping a friend win, irrespective of the physical location of the friend (*alone* vs. *friend present*: $M_{DIFFERENCE} = 0.06$, CI=[-0.11, 0.23], p=1.000; *alone* vs. *friend monitoring*: $M_{DIFFERENCE} = 0.08$, CI=[-0.09, 0.24], p=0.819; *friend* *present* vs. *friend monitoring*: $M_{DIFFERENCE} = 0.01$, CI=[-0.15, 0.18], *p*=1.000). Full descriptive statistics of task behavior for all conditions are presented in Table S2.

Relationship between task performance and risk attitudes

Initial analyses tested whether beliefs about friends' attitudes towards risk changed with age. Within the adolescent sample, there was no relationship between age and baseline perceptions of friends' risk attitudes (*B*=0.10, CI=[-0.18, 0.43], *p*=0.48), perceptions of friends' risk attitudes decreased marginally with age across the adult cohort (*B*=-0.33, CI=[-0.70, -0.03], *p*=0.052). We also examined whether participants' perceptions of their friends' risk attitudes differed from the actual risk attitude reported by the friend. Young adults were quite accurate in their estimations of their friends risk attitudes, showing a strong coherence between these two measures (*B*=0.51, CI=[0.26, 0.76], *p*<0.001). On the other hand, adolescents' reports of their friends' riskiness were not associated with the friend's actual risk attitude (*B*=0.04, CI=[-0.16, 0.23], *p*=0.73). Though they neither consistently overestimated nor underestimated riskiness, their estimates were not accurate.

Based on these initial results we then tested whether participants' beliefs about their friends' riskiness moderated changes in risk aversion during the task. The first set of mixed effects models focused on the friend loss condition with both perceived risk attitudes of the friend and age included as predictors. There were no significant main effects of perceived risk attitudes of friends on participants' task performance for the adolescents (*B*=-0.0009, CI=[-0.06, 0.05], *p*=0.976) or the young adults (*B*=0.05, CI=[-0.06, 0.15], *p*=0.390). There were also no significant interactions between perceived risk attitudes of friends and age on task performance for either age group (adolescents: *B*=0.01, CI=[-0.02, 0.05], *p*=0.478; young adults: *B*=-0.07, CI=[-0.18, 0.05], *p*=0.293). Similarly, in the friend win condition, there were no significant main effects or interactions between perceived risk attitudes of friends on participants' task performance for either the adolescents (ME: *B*=-0.007, CI=[-0.07, 0.06], *p*=0.821; interaction: *B*=-0.02, CI=[-0.05, 0.02], *p*=0.337) or the young adults (ME: *B*=0.001, CI=[-0.21, 0.21], *p*=0.993; interaction: *B*=0.04, CI=[-0.20, 0.28], *p*=0.736). In sum, in the present study, we did not find evidence that beliefs about a friend's risk attitudes moderated participants' task performance. In adolescence, this could be because participants held inaccurate views of their friends' actual risk attitudes. In addition, task performance was not moderated by the participant's own risk attitude (adolescents: all *p*s>0.187; young adults: all *p*s>0.223) or by the degree to which the participant over or underestimated their friend's risk attitude (adolescents: all *p*s>0.299; young adults: all *p*s>0.111).

These preliminary results are offered as a foundation to help ensure future studies are adequately powered to address such questions and should be interpreted with appropriate caution. Because this scale was only collected for a subset of participants, it is possible that we were not powered to conduct this analysis of individual differences due to the reduced sample size. It is also possible that the scale used, which is still in the process of being validated, is not sufficiently sensitive to risk preferences for the subtle questions examined here.

References

Gonzalez, R., & Wu, G. (1999). On the shape of the probability weighting function. *Cognitive Psychology*, *38*(1), 129-166.

Green, P., & MacLeod, C. J. (2016a). SIMR: an R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution*, *7*(4), 493-498.

Green, P. & MacLeod, C. (2016b). simr: Power Analysis for Generalised Linear Mixed Models by Simulation. R package version 1.0.3, CRAN.R-project.org/package=simr.

Hsu, M., Krajbich, I., Zhao, C., & Camerer, C. F. (2009). Neural response to reward anticipation under risk is nonlinear in probabilities. *Journal of Neuroscience*, *29*(7), 2231-2237.

Table S1

Summary results of parameter recoverability from simulation exercises

	Level of inverse decision noise		
	low	*medium*	*high*
Risk aversion (α) recoverability *independent*	r = 0.28 (0.22)	r = 0.80 (0.11)	r = 0.90 (0.09)
Probability weighting (γ) recoverability *independent*	r = -0.004 (0.32)	r = 0.63 (0.24)	r = 0.62 (0.24)
Risk aversion (α) recoverability *simultaneously with γ*	r = 0.13 (0.07)	r = 0.27 (0.06)	r = 0.37 (0.06)
Probability weighting (γ) recoverability *simultaneously with* α	r = 0.01 (0.07)	r = 0.27 (0.06)	r = 0.37 (0.06)

Note: Values represent mean similarity (r) and standard error for each parameter across all simulations. Cells with underlined text represent the model and usable sample reported in the main text.

Table S2

Descriptive statistics of shifts in risk aversion for all friend outcome and friend observation conditions

	Shifts in risk aversion evoked by friend loss			**Shifts in risk aversion evoked by friend win**		
	alone	*friend present*	*friend monitoring*	*alone*	*friend present*	*friend monitoring*
Adolescents	-0.23 (0.20)	-0.24 (0.15)	-0.26 (0.19)	0.11 (0.18)	0.17 (0.19)	0.18 (0.25)
Young adults	-0.17 (0.15)	-0.27 (0.33)	-0.30 (0.14)	0.26 (0.45)	0.31 (0.35)	0.57 (0.44)

Note: Values represent mean difference scores (standard deviations).

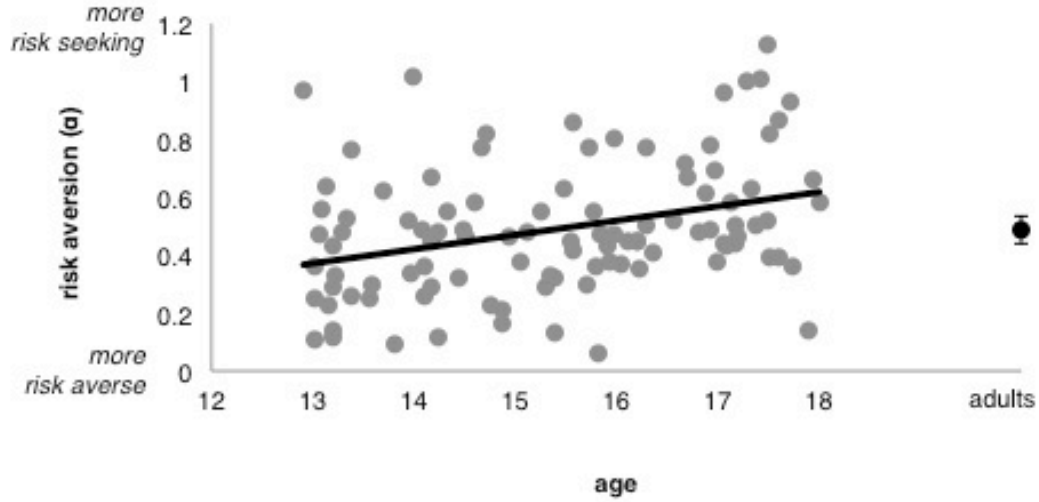

Figure S1. Baseline risk preferences. Graph depicts risk aversion parameters (α) obtained from baseline (*friend 0)* models for adolescent participants. Mean adult behavior is plotted as a single reference point (bars indicate standard error of the mean).