

Electronic Supplementary Materials
Reward currency modulates human risk preferences

Task setup



Figure S1: Behavioral task. (1) The experimenter showed the participant the safe option, and placed it on one side of the table (here, two quarters). (2) The experimenter covered the safe option with a bowl. (3) The experimenter placed a second (empty) bowl on the other side of the table, and occluded it. (4) The participant saw two possible risky outcomes (good and bad, here one dollar and one penny). Behind the occluder, the experimenter placed just one potential outcome under the risk bowl. (5) After removing the occluder, the experimenter reminded the participant of the safe value. (6) The participant could choose a bowl they preferred. Rewards shown are monetary rewards used in Study 3.

Study 1 supplemental analyses: Human risk preferences across currencies

In addition to the repeated measures ANOVA reported in the main text, where we analyzed mean preferences for the risky option across trials, we also used generalized linear mixed models (GLMM) to analyze choices as a binary outcome on a trial-by-trial basis. In particular, we used the *glmer* function from the *LME4* software package (Bates, 2010) in R v. 3.1.0 (R Development Core Team, 2014) to fit binomial models with a logit link function using maximum likelihood. We then used likelihood ratio tests to compare fit across models incorporating different factors (Bolker et al., 2008). To conduct post-hoc Tukey comparisons of model factors, we used the *glht* function in the package *multcomp* (Hothorn, Bretz, & Westfall, 2008).

We first fitted a basic model including random *subject* intercepts to account for repeated trials within subjects; *safe value* as a fixed factor (low, medium, or high); and *trial* (1 through 12) as a covariate to account for within-session changes in choice patterns. This model revealed that participants were less likely to choose the risky option as the value of the safe alternative increased, and also had a weak but significant propensity to choose the risky option more over trials. In the second model, we then added *condition* to assess the importance of our currency manipulation. The inclusion of condition as a predictive factor increased model fit compared to the basic model [$\chi^2 = 11.62$, $df = 2$, $p < 0.005$]. In particular, participants in the food and prize conditions were more likely to choose the risky option than those in the money condition (see Table S1 for all parameters from this best-fit model). In the third and fourth model, we then added an interaction term between *condition and safe-value*, or *condition and trial number*, respectively. This allowed us to assess whether individuals responded differently to safe value or trial number, depending on their reward currency condition. However, neither interaction term

increased model fit relative to the condition-only model [*condition-by-safe value model*: $\chi^2 = 3.39$, $df = 4$, $p = 0.49$, n.s.; *condition-by-trial model*: $\chi^2 = 1.49$, $df = 2$, $p = 0.48$, n.s.]. This suggests that while participants across all three conditions similarly modulated their choices according to the value of the safe alternative, and increased their selection of the risky option across the twelve trials, participants in the money condition were less likely to choose the risky option overall.

<i>Factor</i>	<i>Estimate</i>	<i>S.E.</i>	<i>Z</i>	<i>P</i>
Trial number	0.101	0.023	4.376	< 0.001
Safe value: Low - High	2.022	0.213	9.512	< 0.001
Safe value: Medium - High	0.830	0.183	4.543	< 0.001
Safe value: Low - Medium	1.192	0.209	5.715	< 0.001
Condition: Food - Money	0.868	0.289	3.005	< 0.01
Condition: Food - Prizes	0.000	0.291	0.003	0.99
Condition: Prizes - Money	0.867	0.288	3.016	< 0.01

Table S1: Best-fit GLMM model of human risky decisions across currencies.
Factors influencing human participant’s propensity to choose the risky option across when making decisions about food, money, or prizes in Study 1.

Study 1 supplemental analyses: Human and ape risk preferences for food

In addition to the repeated measures ANOVA reported in the main text, we also used GLMM analyses to examine the human and ape preferences on a trial-by-trial basis. We first fitted a basic model including random *subject* intercepts to account for repeated trials within subjects; and three covariates: *safe value* (1, 3, or 6, as all subjects tested with food faced made decisions about these safe value quantities); *trial number* (1 through 12 for humans and 1 through 18 for apes); and *preference score* (to index that individuals relative preference for the average payoff of the risky option versus the safe option, as described previously). We found that only safe value was a significant predictor of risky choices. In the second model, we then added *species*, which increased model fit compared to the basic model [$\chi^2 = 19.66$, $df = 2$, $p < 0.001$]. In particular, chimpanzees and humans were more likely to choose the risky option compared to

bonobos, but did not differ from each other (see Table S2 for all parameters from this best-fit model). In the third and fourth model, we then added an interaction term between *species* and *safe-value*, and *species* and *trial number*, respectively. This allowed us to assess whether the species responded differently to safe value or showed different patterns of learning within sessions. However, neither interaction term increased model fit relative to the species-only model [*species-by-safe value model*: $\chi^2 = 4.55$, $df = 2$, $p > 0.10$, n.s.; *species-by-trial model*: $\chi^2 = 4.20$, $df = 2$, $p > 0.12$, n.s.]. This suggests that all three species similarly modulated their choices according to the value of the safe alternative.

<i>Factor</i>	<i>Estimate</i>	<i>S.E.</i>	<i>Z</i>	<i>P</i>
Trial number	0.010	0.017	0.608	0.54
Safe value	-0.344	0.040	-8.501	< 0.001
Preference score	0.654	1.001	0.651	0.52
Species: Human – Bonobo	2.055	0.469	4.383	< 0.001
Species: Human - Chimpanzee	0.050	0.400	0.126	0.90
Species: Chimpanzee - Bonobo	2.005	0.479	4.183	< 0.001

Table S2: Best-fit GLMM comparing human, chimpanzee, and bonobos risky decisions for food rewards. Factors influencing individuals' propensity to choose the risky option across species, using human data from Study 1.

Study 2 supplemental analyses: Human risk preferences for money

In addition to the repeated measures ANOVA reported in the main text, we also used GLMM analyses to examine the human preferences on a trial-by-trial basis. We first fitted a basic model including random *subject* intercepts to account for repeated trials within subjects; *trial number* (1 through 12) as a covariate to account for within-session changes in choice patterns; and finally each individual's prize *preference score* (calculated the same was as the food preference score reported in Study 1) as a covariate, to account for any variation in desirability of the prizes across subjects. This model revealed that neither trial nor preference score were significant predictor's of the participants' decisions. In the second model, we then

added *condition* to assess the importance of our experimental manipulation (where participants could either keep the money or had to trade it for prizes). The inclusion of condition as a predictive factor increased model fit compared to the basic model [$\chi^2 = 5.80$, $df = 1$, $p < 0.05$]. In particular, participants were less likely to choose the risky option in the keep condition than the trade condition (see Table S3 for parameter models). In the third model, we added an interaction term between *condition and trial number*, but this interaction term increased model fit relative to the condition-only model [$\chi^2 = 0.98$, $df = 1$, $p = 0.32$, n.s.]. Overall these results indicate that individuals choose the risky option more when they knew they would trade the money for prizes, even when examining choices on a trial-by-trial basis and accounting for any individual differences in prize desirability.

<i>Factor</i>	<i>Estimate</i>	<i>S.E.</i>	<i>Z</i>	<i>P</i>
Trial number	0.036	0.028	1.287	0.20
Preference Score	0.659	2.092	0.315	0.75
Condition: Keep - Trade	-1.152	0.468	-2.460	< 0.05

Table 3: Best-fit GLMM Best-fit GLMM model of human risky decisions for money. Factors influencing human participant’s propensity to choose the risky when making decisions about monetary rewards they could keep, or had to trade in for prizes in Study 2.

Monetary risk questionnaire: Supplemental analyses

All participants then completed a hypothetical questionnaire about money (see Appendix 3). As with previous studies (Holt & Laury, 2002), participants were risk-averse, choosing the less-variable option even when it had less expected value relative to the riskier option.

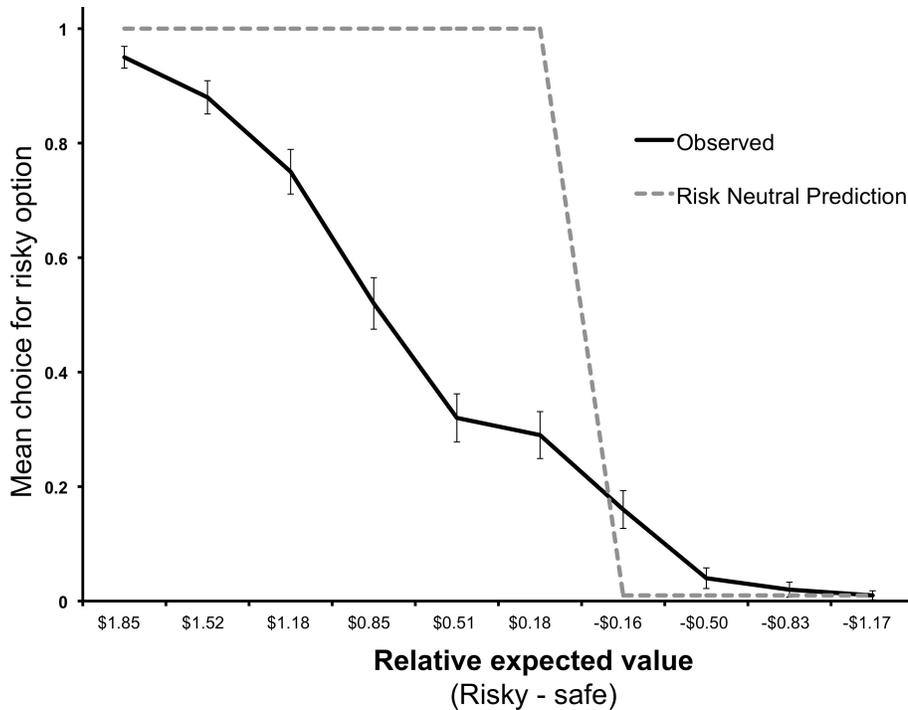


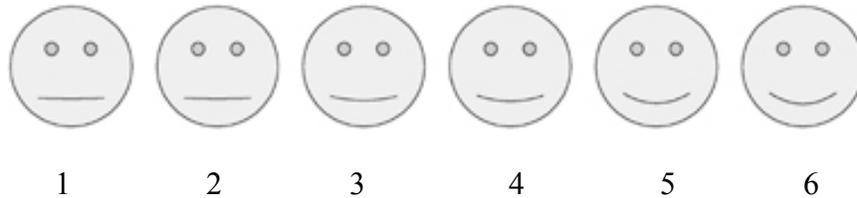
Figure S2: Overall risk choices in questionnaire. The solid line indicates the average choices of all 125 participants, and the dotted line indicates the predictions of risk neutrality (where subjects should simply choose the option with the higher expected value). Error bars indicate SE.

Appendix 1: Food and prize rating scales

Prior to receiving instructions for the main risk task, participants in the food condition (Study 1), prize condition (Study 2) and keep and trade conditions (Study 3) were asked to evaluate five food or prize items. Participants in the food condition evaluated Cheerios, Cheezit crackers, chocolates M&Ms, chocolate covered raisins, and pretzels. Approximately 10 per item were placed in transparent cups on the table with labels, and participants were encouraged to taste the items to ensure their ratings were accurate. Participants in the other three conditions evaluated a blank CD, eraser, notebook, paperclip and pen. One item each was arrayed on a table with labels, and participants were told they could pick them up to evaluate them.

Instructions: Please rank the available items in the two ways described below. There is no right or wrong way to complete the rankings—just do so according to your personal preferences.

1) First, indicate where each available item falls on the following scale. The same ranking can be assigned to multiple options if you prefer them approximately equally.



2) Second, please rank the available items in the order of your preference, using numbers from 1 to 5. Here, the number one item should be that which you would prefer to receive the most over any other item, the number two item should be the one which you would next prefer to receive, and so on.

Appendix 2: Experimental Script

The experiment read instructions to the participant for each phase of the study. The instructions were similar across conditions, with minor variations according to specifics of the condition (e.g., referencing food in the Food condition and prizes in the Prize, Keep, and Trade conditions). Instructions that are condition-specific are bolded and labeled. The experimenter demonstrated the task procedure while reading relevant parts of the instructions for the main behavioral task.

Reward ranking instructions (Food, Prize, Keep, and Trade conditions)

The first thing I am going to ask you to do is examine these five items. First I am going to ask you to rate how much you like each item. Here different items can receive the same rating. For example, if you like everything very much, you can give everything a six. Next, I am going to ask you to rank them in the order of your preference on this sheet of paper. For example, the item you prefer the most should be marked with a “one,” and the item you prefer the least should be marked with a “five.” [*Food condition*] **You can taste any of these items before making the rankings.** [*Prize, Keep, Trade conditions*] **You can touch or examine the items before making these rankings.** Once you finish the rankings, just return this paper to me and we will continue with the experiment.

Behavioral task instructions (after ranking phase)

This is an experiment about decision-making, and will take approximately one hour to complete. *[Food condition]* **In the experiment you are going to be able to make a series of choices about different types of food, and after each decision you can eat the food you choose.** *[Prize condition]* **different types of rewards, and after each decision you can keep the rewards you choose.** *[Money, Keep, and Trade conditions]* **money, and after each decision you can keep the money from the option you choose.** What you receive will depend on the decisions that you make. This part of the experiment will take no longer than 30 minutes. At the end of the experiment you will be asked to complete a series of questionnaire. These questionnaires will take about 30 minutes to complete. Do you have any questions at this point?

In the test, you get to make a series of choices between two different options. You will always know what one of the options will be before you pick it. However, for the other option there will be two possible outcomes. Sometimes you will receive one, and sometimes the other. In each trial, you will see me first place the known option under one cup like this *[demonstrates placement of safe option]*. Then I will show you a second, empty cup like this, and block your view of it with this barrier *[demonstrates placement of risky option and occlusion]*. Finally, I will show you the possible outcomes in a bowl like this *[shows participant risky bowl]*, and then behind the barrier I will place just one of the two options you saw under the second cup. Which of these two options is placed under the second cup will be randomly pre-determined on any given trial. *[Keep and Trade conditions]* **You should pay attention to what I put under the first cup and what I show you in the possible outcome container so you know how much respective money you might receive.** Do you have any questions at this point?

After I have placed the second option under the cup, I will remove the barrier and remind you what the known option is that I showed you initially *[experimenter demonstrates while talking]*. *[Food condition]* **Note that the known option can differ in amount. Sometimes you will see one item, sometimes three, and sometimes six. Therefore you should pay attention to what I put under this cup so you know how many items are in it.** *[Prize condition]* **Note that the known option can differ in amount. Sometimes you will see one item, sometimes two, and sometimes three. Therefore you should pay attention to what I put under this cup so you know how many items are in it.** *[Money condition]* **Note that the known option can differ in amount. Sometimes you'll see 4 dimes, sometimes you'll see 5 dimes, and sometimes you'll see 6 dimes. Therefore you should pay attention to what I put under this cup so you know how many items are in it.** Finally, I will ask you which of the two options you prefer, and you can then answer verbally or by pointing at your choice. Once you answer, I will uncover that cup to reveal what you have received on that trial. You can then retrieve your chosen option.

[Food condition] **Throughout the test, you must eat any food you wish to consume food before you can proceed to the next trial—that is, you have to eat it here during the test, and cannot take the food out of the test or save it for later. You can take as long as you'd like to eat the food if you choose to consume it. However, if you choose not to take the option you receive on a given trial, then you can place it in this bin. You will not be able to reclaim any options after you place them in this bin.** *[Prize condition]* **Throughout the test, you can save any rewards you receive in this container. However, if you choose not to take the option you receive on a given trial, then you can place it in this bin. You will not be able to reclaim any options after you place them in this bin.** *[Money condition]* **Throughout the**

test, you can save any money you receive in this container. Note that at the end of the study, we will exchange the coins you accumulate for dollar bills for you to keep after the test. [Keep and Trade conditions] Throughout the test, you can save any money you receive in this container.

If you chose the option you already know, I will not show you what you would have received had you chosen the alternative option. Each trial you complete will consist of one choice like this. The total number of trials was randomly predetermined, so the test could stop after any number of trials. Therefore just choose according to your preferences when I actually ask you. There is no right or wrong way to do this task. Finally, that's a glass of water that you should feel free to drink throughout the test if you get thirsty. Do you have any questions at this point?

[Trade condition] At the end of the study, you will then trade in all the money you have accumulated for these prizes over here. Each of the dollars you accumulate will be traded for a [participant's highest-preferred item], the pennies for a [participant's lowest-preferred item], and each 50 cent amount can be traded for a [participant's intermediate-preferred item]. You will need to trade in all the money for these prizes, and all the prizes will be yours to take with you when you leave the study. [Keep condition] At the end of the study, you will have the opportunity to trade the money you have accumulated for these prizes over here. Each of the dollars you accumulate can be traded for a [participant's highest-preferred item], the pennies for a [participant's lowest-preferred item], and each 50 cent amount can be traded for a [participant's intermediate-preferred item]. You can trade in as much or as little of the money for these prizes as you wish. That is, if you wish to keep all the money you accumulate in the test you can, and conversely if you wish to trade all the money for these items you can. The money and prizes will then be yours to take with you when you leave the study. Note that for any money you choose to keep, we will exchange the coins you accumulate for dollar bills for you to keep after the test.

Before we start the experiment there will be a practice period where you get to see how the procedure works and experience both options: choosing the option where you know what is under the cup, and choosing the alternative option where you do not. This practice period can then guide your decisions when you chose between the two options. Do you have any questions at this point? Ok great. Now there's going to be the practice period. Here you get to experience the option where you know what you will receive once, and the option where you don't know what you will receive beforehand twice. In this practice period I am going to demonstrate just on of the options, either the one where you have previously seen what is under the cup, or the option where you don't know which of two possible items I have placed under the cup. Once I complete the demonstration, I will then ask you how many items are in the cup.

[Food condition] Note that when you make choices the number of items associated with the known option can vary, although we will not go through every possibility in the practice period. Once you answer, I will reveal that option and you can eat it as in the real study. As in the real trials, if you do not wish to keep the option that is revealed, you can place it in the trash bin. [Prize condition] Note that when you make choices the number of items associated with the known option can vary, although we will not go through every possibility in the practice period. Once you answer, I will reveal that option and you can keep it as in the real study. As in the real trials, if you do not wish to keep the option that is revealed, you can place it in the trash bin. [Money condition] Note that when you make choices the number of coins associated with the known option can vary, although we will

1. Option A: 90% chance of winning \$1.60, 10% chance of winning \$2.00
Option B: 90% chance of winning \$0.10, 10% chance of winning \$3.85
2. Option A: 60% chance of winning \$2.00, 40% chance of winning \$1.60
Option B: 60% chance of winning \$3.85, 40% chance of winning \$0.10
3. Option A: 70% chance of winning \$3.85, 30% chance of winning \$0.10
Option B: 70% chance of winning \$2.00, 30% chance of winning \$1.60
4. Option A: 80% chance of winning \$1.60, 20% chance of winning \$2.00
Option B: 80% chance of winning \$0.10, 20% chance of winning \$3.85
5. Option A: 70% chance of winning \$0.10, 30% chance of winning \$3.85
Option B: 70% chance of winning \$1.60, 30% chance of winning \$2.00
6. Option A: 100% chance of winning \$3.85, 0% chance of winning \$0.10
Option B: 100% chance of winning \$2.00, 0% chance of winning \$1.60
7. Option A: 60% chance of winning \$1.60, 40% chance of winning \$2.00
Option B: 60% chance of winning \$0.10, 40% chance of winning \$3.85
8. Option A: 50% chance of winning \$3.85, 50% chance of winning \$0.10
Option B: 50% chance of winning \$2.00, 50% chance of winning \$1.60
9. Option A: 80% chance of winning \$2.00, 20% chance of winning \$1.60
Option B: 80% chance of winning \$3.85, 20% chance of winning \$0.10
10. Option A: 90% chance of winning \$3.85, 10% chance of winning \$0.10
Option B: 90% chance of winning \$2.00, 10% chance of winning \$1.60

Additional questionnaires

Participants completed a set of additional questionnaires after the main demographic and risk questionnaires, which were not analyzed as part of the current manuscript. First, participants in the Money condition (Study 2) and Trade and Keep conditions (Study 3) were asked to rate how they felt when they received the dollar, penny, and quarters/dimes in the main task (on five point scale: very upset, somewhat upset, neutral, somewhat happy, very happy). Second, participants completed an impulsiveness scale consisting of 30 questions with cognitive,

planning and motor subscales (Patton, Stanford, & Barratt, 1995), a risk attitude scale with 50 questions and ethical, financial, health, recreation, and social risk subscales (Weber, Blais, & Betz, 2002), and a decision-making style inventory with 45 questions examining analytical, intuitive and regret-based decision-making (Nygren & White, 2002).

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