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Verbal behavior and risky choice in humans: Exploring the boundaries of the description-experience gap

David J. Cox*, Jesse Dallery

University of Florida, Department of Psychology, United States

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ABSTRACT

The description-experience (DE) gap is a tendency to prefer uncertain over certain rewards when experienced compared to described. DE gap research typically intermixes choice between two gains with choice between two losses. Because preference for uncertain gains have been found to increase following experienced loss, preference for uncertain gains (and the DE gap) may decrease when gains are presented in isolation. Experiment 1 examined the DE gap when participants were presented choices between gains (points) in isolation. Experiment 2 examined the DE gap when participants were presented with gains in isolation and intermixed with point losses. When gains were first contacted in isolation, participants chose the uncertain gain more when it was described compared to experienced (a reversed DE gap). But, when gains were intermixed with losses, participants chose the uncertain gain more when it was experienced compared to described (typical DE gap). Additional exposure to intermixed following isolated choices led to a typical DE gap, and exposure to isolated following intermixed choices decreased the size of the typical DE gap. These results show how choice with experienced or described outcomes is influenced by intermixing gains with losses and may reveal how the DE gap can be manipulated.

1. Introduction

Choice is ubiquitous. All organisms must choose what to eat, where to take shelter, when to take risk, and when to play it safe. A fundamental objective for researchers interested in choice is to determine which variables influence choice and precisely how those variables do so. One variable that influences choice is the probability of an outcome (for a review, see McKerchar and Renda, 2012). Researchers have found that the value of a commodity decreases as a function of the odds against receiving the commodity (e.g., Rachlin et al., 1991), and that individuals differ in the degree to which uncertainty influences value and subsequent choice (McKerchar and Renda, 2012).

One interesting aspect of choice related to probability is the description-experience (DE) gap. In DE gap research, participants make one or more choices between outcomes that differ along two dimensions: the amount of money or points gained (or lost); and the probability the outcome occurs. For each choice, the participant typically selects between one option that occurs with a high probability but lower amount, and a second option that occurs with a low probability but higher amount (high and low are defined relative to the other option). For example, a participant may choose between a 100% chance of receiving $50 and a 40% chance of receiving $100. Description conditions present options by describing the amount and probability associated with each option. Experience conditions present the same options, but without any language describing the amount and probability. Instead, participants learn about the amounts and probabilities by choosing each option and directly experiencing the outcome. The DE gap refers to less preference for the low probability gain in description conditions compared to experience conditions (e.g., Hau et al., 2008).

Research on the DE gap has primarily examined choice with gains and losses randomly intermixed (e.g., Camilleri and Newell, 2011a,b; Hau et al., 2008; Hertwig et al., 2004; Ludvig and Spetch, 2011). For example, Ludvig and Spetch (2011) asked participants to make repeated choices between high probability and a low probability options in both experience and description conditions. In both conditions, half the choice trials required choosing between two options that led to point gain, and the other half of choice trials required choosing between two options that led to point loss. As with most research on the DE gap, participants preferred the low probability gain less when the outcomes were described compared to when the outcomes were experienced.

Intermixing gains with losses may impact preference across description and experience conditions. In conditions similar to the experience conditions in DE gap studies, humans have shown greater preference for a low probability gain when they have just experienced a loss and can gain points to compensate for the loss (i.e., the "break-even effect;" e.g., Canale et al., 2017; Thaler and Johnson, 1990). In

* Corresponding author at: University of Florida, Department of Psychology, 945 Center Drive, Gainesville, FL 32611-2250, United States.
E-mail addresses: david.j.cox@ufl.edu (D.J. Cox), dallery@ufl.edu (J. Dallery).

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addition, preference for the low probability option increases with losses compared to with gains of the same amount (i.e., loss aversion – McKerchar et al., 2013; Myerson et al., 2017). Thus, intermixing losses with gains might increase preference for experienced low probability gains. But, it is unknown how intermixing losses with gains influences choice in description conditions.

The purpose of Experiment 1 was to examine the DE gap when participants made choices between two options that only resulted in gains. The purpose of Experiment 2 was to examine the DE gap when participants experienced gains in isolation and when intermixed with losses using a within-subjects design.

2. Experiment 1

2.1. Method

2.1.1. Participants

Forty participants were recruited from the Psychology participant pool from a large public university in the southeast United States. The mean age of participants was 18.9 (range 18–23) and 71% of participants self-identified as female.

2.1.2. General procedures

All participants completed two conditions in an ABA reversal design. Each condition was coded in Visual Basic 2013 Community Edition and run on a desktop PC or laptop in a campus laboratory room. An inter-trial-interval (ITI) of 2 s was programmed into the experiment to prevent participants from rapidly clicking through the experimental trials. Responses were counted in bins of 10-trials to allow for easier programming of stability calculations and subsequent transitions between conditions (see below for stability criteria). Both description and experience conditions involved choice between the same high-probability-low-amount option and a low-probability-high-amount option. All conditions were completed in a single 30 min visit to the laboratory. All probabilities used were identical to previous research (e.g., Ludvig and Spetch, 2011; Madan et al., 2017).

2.1.3. Experience condition

Fig. 1 shows how the two choice options and point bank were presented on the screen to each participant (left panel). The blue button resulted in the bank increasing by 20 points every time it was selected. That is, 100% of responses made to this option resulted in 20 points (i.e., high probability option). The orange button resulted in the bank increasing by 40 points on a random-ratio-2 (RR 2) schedule – approximately 50% of responses made to this option resulted in points (i.e., low probability option). Both options had equivalent mean expected values. Each participant was exposed to the experience condition during the first and third conditions.

2.1.4. Description condition

Fig. 1 shows a screen shot of choice options present in the description condition (right panel). Responding in this condition resulted in points gained in an identical manner to the experience condition. However, there were three main differences between the experience and description conditions. First, both response options were gray. Second, a verbal description of the amount and probability of earning points was present on both options. The probability described for the larger amount was programmed to average 50% and randomly vary between 30% and 70% and both options had equivalent mean expected values. Finally, a text box was placed over the bank indicating the "Amount Earned Will Be Shown At End". This text box remained over the bank until the end of the condition. At this point, the text box disappeared, and the participant could observe how many points they earned. Points earned were only shown at the end to isolate the influence of described choices from experienced point gain. Each participant was exposed to the description condition during the second condition only.

2.1.5. Repeated trials

Each participant completed a minimum of four, ten-trial blocks (i.e., 40 responses) in every condition. Beginning after the 40th response, the computer was programmed to calculate the stability of responding over the previous three 10-trial blocks (i.e., previous 30 responses). The transition between 10-trial blocks was not signaled to the participant in any way. Stability was assessed by first calculating the mean number of times the low probability option was chosen per 10 trials over the previous 30 trials. The three previous ten-trial block proportions were then compared to that mean. If the number of responses made to the low probability option in each 10-trial block was within 1.5 responses of the mean, the program would present the final trial (information on final trial below). If the stability criterion was not met, another 10 trials were presented to the participant. This pattern of stability calculation following every 10-trials continued until either (a) the stability criterion was met or (b) 200 total trials had been completed.

2.1.6. Final trial

Once participant responding was stable, a final trial was presented on the screen. This trial was presented to allow comparison with previous research on the DE gap where a single trial was used to compare preference for the low probability option. This trial included the same response options present within the preceding condition (i.e., blue and orange buttons if the final trial of an experience condition and gray buttons with text if a description condition). The response options on the final trial were accompanied by the following text: "This is the final choice trial for this condition. If you had only one chance to make only one choice, which button would you choose?" Following selection of either option, both options disappeared, a new text box appeared indicating the condition was over and to wait while the next condition loaded, and a 20 s inter-condition interval began. At the end of the 20-s inter-condition interval, a button appeared with the text "Start Next Condition". The next condition loaded on the screen and the previous condition closed when the participant clicked this button.

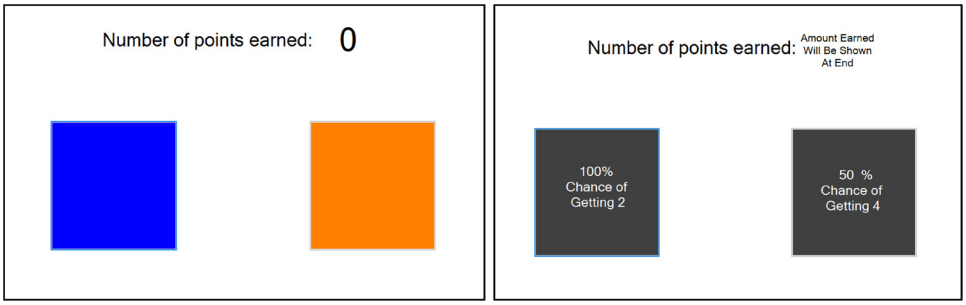

Fig. 1. Screen shots of the experience (left) and description (right) conditions. The left set of stimuli were presented during the first and third conditions. The stimuli on the right were presented during the second condition.

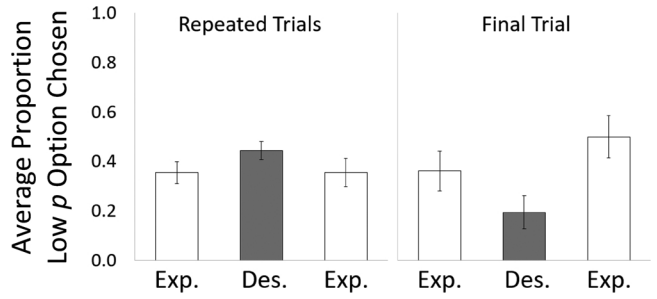

Fig. 2. Average proportion the low probability option was chosen by the participants in Experiment 1 across the repeated choice trials (left panel) or the proportion of participants that chose the low probability option on the single, final trial (right panel). "Exp." = experience; "Desc." = description. Error bars represent SEM.

2.1.7. Data analysis

We compared the proportion of trials each participant chose the low-probability option over the final 30 trials in each condition as one measure of the DE gap. This measure allowed us to compare our results with previous research using repeated choice procedures (e.g., Ludvig and Spetch, 2011). We also calculated the proportion of participants who chose the low probability option on the final trial as a second measure of the DE gap. This measure allowed us to compare our results with previous research using sampling procedures (e.g., Hau et al., 2008; Hertwig et al., 2004). Lastly, all statistical analyses were conducted using IBM SPSS Statistics, version 24.0 (IBM Corporation, 2016).

2.2. Results and discussion

The left panel in Fig. 2 shows repeated choice data at stability. Each bar represents the mean proportion of trials the low probability option was chosen over the final 30 trials for all participants (i.e., the proportion of choices for the low probability option once responding was stable). Participants reached stability in an average of 47.4, 46.3, and 47.4 trials in the first through third conditions, respectively.

We observed a DE gap at the group level. A repeated measures ANOVA indicated a significant difference in preference for the low probability option between experience and description conditions ($F(2, 78) = 4.25$, $p = 0.02$, $\eta p^2 = 0.10$). Post hoc tests using a Bonferroni correction revealed the difference in preference for the low probability option centered on the 1st experience condition and the description condition ($p = 0.05$). However, no difference in preference for the low probability option was observed between both experience conditions ($p = 0.77$) or between the 2nd experience condition and the description condition ($p = 0.20$). That is, the participants chose the low probability option more when point gain was described compared to when it first was experienced directly. This observation is opposite to previous research on the DE gap (Ludvig and Spetch, 2011; Madan et al., 2017; Gonzalez and Mehlhorn, 2016; Lejarraga et al., 2016). Stated differently, we observed a reversed DE gap for point gain using a repeated trials procedure.

Inspection of individual participant data indicates a more nuanced picture than the averaged values (Fig. 3). To analyze the DE gap at the individual level, we subtracted the mean number of times the participant chose the low probability option in each experience condition from the description condition during the final three 10-trial blocks. Nineteen of the 40 participants chose the low probability option on 10% or more of trials in the description condition compared to both experience conditions (left panel of Fig. 3). Of the remaining participants, 7 participants showed a reverse pattern (middle panel of Fig. 3). They chose the low probability option on 10% or more of trials in both experience conditions compared to the description condition. The remaining participants showed some combination of the above two patterns ($N = 9$) or no difference in preference ($N = 5$) between described and experienced outcomes (right panel of Fig. 3). In total, these data suggest some pre-experimental history likely plays a role in choices between two probabilistic options in DE gap studies (Skinner, 1957).

The right panel in Fig. 2 shows the proportion of participants that chose the low probability option for the single, final choice. A McNemar test of paired proportions indicated the proportion of participants that chose the low probability option on the final trial was different between the 1st experience and description conditions ($p = 0.05$) and the 2nd experience and description conditions ($p = 0.004$). Interestingly, the direction of the DE gap was the same direction as previous research for the final, single-trial choice. That is, the direction of the DE gap in Experiment 1 differed across a repeated trials measure of preference and a single-shot measure of preference.

A logistic regression analysis was conducted to predict individual participant choice on the final trial using the number of times the larger outcome was observed in each 10-trial block. Prediction success was 63.9% and 72.2% for the first and second experience condition, respectively. Nagelkerke's R^2 of 0.03 indicates no relationship between prediction rate and choice during the final 30 trials at stability. Wald criteria suggests that, independently, none of the final three 10-trial blocks were significant predictors of choice on the final trial for either experience conditions (1st experience condition – $p = 0.65$, 0.94, and 0.38; 2nd experience condition – $p = 0.43$, 0.43, and 0.88). Participant preference at repeated and stable responding was not predictive of their choice on the single, final trial.

To determine whether choice for the low probability option or experience with the large outcome influenced subsequent choice, a comparison of correlation coefficients was conducted to determine the influence of the contact rate of the large outcome on subsequent choice (Table 1). This analysis was completed by first calculating the number of choices for the low probability option for each 10-trial block, and the number of times the low probability option resulted in the large point gain for each participant. Pearson's product-moment correlation coefficients were calculated between (a) the number of times the low probability option resulted in large point gain and the number of times the low probability option was chosen in that same 10-trial block; and

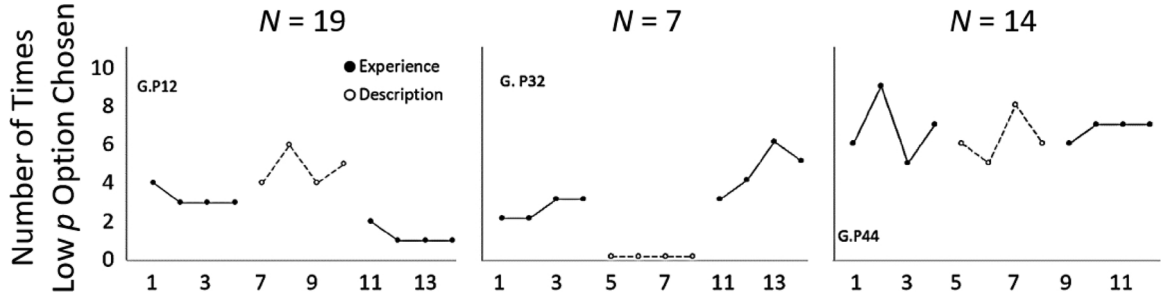

Fig. 3. Individual participant plots that demonstrate the three patterns of responding observed in Experiment 1. Closed markers represent choices made during an experience condition. Open markers represent choices made during a description condition.

Table 1
Pearson correlations between the number of low probability outcomes experienced and the number of times the low probability option was chosen in the same and the next 10-trial block. All were significant correlations of $p < 0.001$.

Condition	Pearson Correlation Same 10-Trial Block	Pearson Correlation Next 10-Trial Block
1st Experience	0.89	0.64
2nd Experience	0.9	0.79

(b) the number of times the low probability option resulted in the large point gain per 10-trial block and the number of times the low probability option was chosen in the next 10-trial block. Correlations for the same 10-trial block were greater than correlations for the next 10-trial block for 1st and 2nd experience conditions. This suggests that outcomes directly experienced in each 10-trial block had a greater influence on choice in the same 10-trial block than on choice in the next 10-trial block.

Finally, experienced probabilities were calculated for the first and second experience conditions for each participant. The probability experienced by each participant was directly related to the number of times the low probability option was selected. Based on the programmed function for presenting the random ratio in Visual Basic, participants needed to select the low probability option a minimum of 7 times before the experienced probability was above 43%. The overall experienced probability subsequently remained between 45% and 57% for any number of times the low probability option was chosen beyond 7. Median experienced probabilities in the first experience point gain and the second experience point gain were 50% (range, 0%–57%) and 47% (range, 0%–57%), respectively. Removing the participants from the analysis that experienced a probability below 43% did not alter the above results.

In summary, we observed a reversed DE gap using a repeated trials measure of stable preference for a low probability option. However, the direction of the DE gap changed when preference was measured using a single, final choice trial. The reversal occurred through reduction in preference for the low probability option in the description condition (Fig. 2). This is a rather puzzling observation we are unable to explain. Patterns of preference on repeated trials were not due to participants experiencing different probabilities than were programmed by the researchers. And, participant choice on repeated trials was not predictive of choice on the single, final choice trial. Finally, 19 of 40 participants demonstrated a DE gap consistent with the group averages. However, a sizable portion demonstrated a DE gap in the opposite direction ($N = 7$) DE gaps in both directions ($N = 9$), or no DE gap ($N = 5$). Overall, these data highlight conditions under which the DE gap changes or is not observed.

3. Experiment 2

In Experiment 1, we observed a reverse direction in the DE gap compared to previous research using a repeated trials procedure, similar probabilities, and similar outcome amounts (Ludvig and Spetch, 2011 – Exp. 1; Madan et al., 2017). One difference between Experiment 1 and previous research was that participants experienced only point gain in our study whereas previous studies intermixed gains and losses. Experiment 1 suggests that experiencing gains in isolation decreased preference for the lower probability option compared to experiencing gains intermixed with losses. But, preference for the lower probability described option was not impacted by choosing between gains in isolation. Thus, the DE gap may be sensitive to gain and loss manipulations through changing preference in experience conditions, but not description conditions.

Some support for the above conclusion is gained by looking at the data across the different studies. The mean proportion of trials the low probability option was chosen was similar for the description condition in Experiment 1 and the studies by Ludvig et al. (2011, 2017). The difference in participant preference between studies occurred in the experience conditions. This suggests experiencing both gain and loss contingencies within the same condition leads to different preference for the low probability option than when gain contingencies are experienced in isolation.

Interestingly, different risk preference was not observed in the description conditions. The mean proportion of trials the low probability option was chosen was similar across the present experiments and the studies by Ludvig and colleagues (Ludvig and Spetch, 2011; Ludvig et al., 2014). That is, no difference in preference for the described low probability option was observed if gains were presented alone or if gains and losses were intermixed. This highlights one way that described and experienced outcomes may influence choice differently. Preference in experienced outcome conditions may be influenced more by the contingencies arranged within the experiment. Preference in described outcome conditions may be influenced more by pre-experimental experiences with probability labels applied to different events.

Experiment 2 was designed to test if the DE gap direction could be reversed by presenting gains in isolation, and intermixing gains with losses. To do this, participants completed three DE comparisons using an ABA or BAB design. One comparison involved procedures nearly identical to Experiment 1 (A – isolated condition). In the isolated condition, participants completed repeated choice trials in experience and description conditions where all choice options resulted in gaining points only. The second DE comparison involved procedures similar to Ludvig and Spetch (2011; B – intermixed condition). In the intermixed condition, participants completed repeated choice trials in experience and description conditions where choice between two gains were randomly intermixed with choice between two losses.

3.1. Method

3.1.1. Participants

One-hundred and eleven participants were recruited from the Psychology participant pool from a large public university in the southeast United States. The mean age of participants was 19.2 (range 18–25) and 74% self-identified as female.

3.1.2. Isolated gains

All participants completed three sets of DE procedures. In the isolated gains set, participants completed DE conditions that were identical to Experiment 1 – with three exceptions. First, the total number of trials was fixed at 50. We used a fixed number of 50 trials because most participants in Experiment 1 demonstrated stable preference by 50 trials and transitioning at stable responding did not seem to impact the DE gap direction in Experiment 1. Second, participants completed only one experience condition followed by one description condition (i.e., we did not reverse back to a second experience condition as in Exp. 1 – see *Within Subject Design* section below for rationale). Third, the colors of the buttons were changed from blue and orange to red and yellow, respectively. These colors for the gain choice options were identical to those used by Ludvig and Spetch (2011).

3.1.3. Gains intermixed with losses

The second set of DE procedures presented were similar to those used by Ludvig and Spetch (2011). Participants completed 80 trials where the outcome amounts and probabilities were experienced directly following a choice, and 80 trials where the outcome amounts and probabilities were described only.

Fig. 4 shows the different buttons presented to participants during the experience procedures where gains were intermixed with losses. Participants began with 24 forced option trials where only one button was visible. Sixteen of the forced option trials presented a gain button and 8 presented a loss button. Half of the forced option gain trials

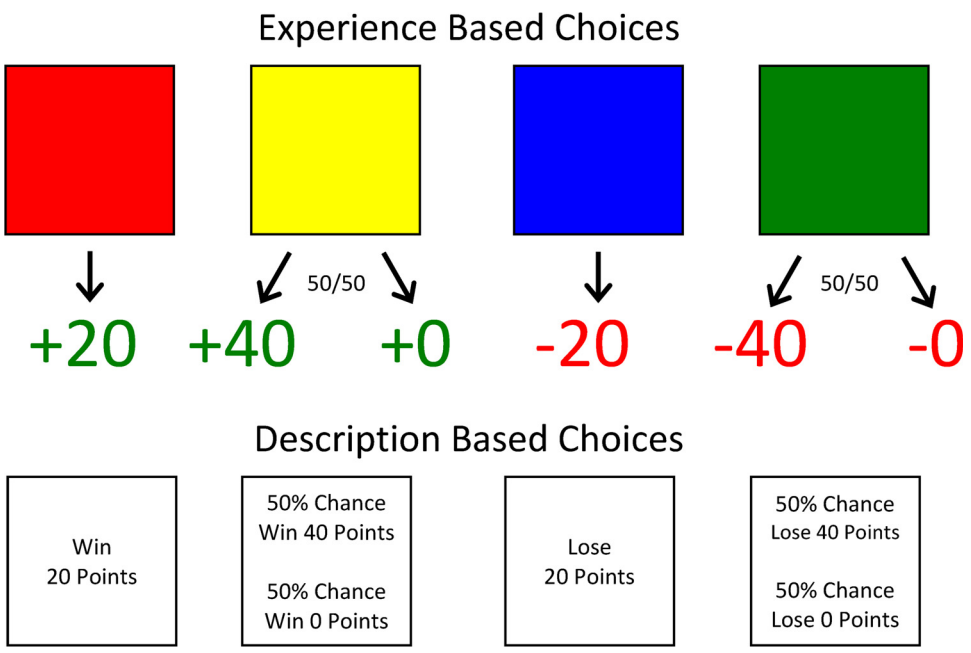

Fig. 4. Buttons used during experience (top) and description (bottom) trials for the intermixed gains and losses procedures in Experiment 2. The colored point amounts below the experience based choices (e.g., green "+20") are the outcome that followed selection of that button. This feedback corresponded with an associated change in the participant's bank amount on the screen (for interpretation of the references to color in this figure legend, the reader is referred to the web version of this article).

presented the red button (+20 points) and the other half presented the yellow button (50% chance of +40, else 0). Similarly, half the loss trials presented the blue button (−20) and the other half presented the green button (50% chance of −40, else 0). When the participant clicked the button, a number appeared in the center of the screen denoting how many points were earned or lost according to the probabilistic schedule in effect for the button. In addition, a cumulative bank at the upper portion of the screen changed based on the points earned or lost. The 24 forced option trials ensured the participant contacted the programmed outcome amounts and probabilities for each button before entering the choice trials. Note that the two gain options were identical in point amount and probability as the two options in the procedures where gains were presented in isolation.

Following the forced option trials, participants completed 56 more trials. Sixteen of these trials presented a choice between the red and yellow buttons (i.e., two gains); 16 trials presented a choice between the blue and the green buttons (i.e., two losses); 16 trials were catch trials and presented one gain and one loss button (yellow and green buttons); and the remaining 8 trials were forced option trials (2 of each button). The gain choice, loss choice, catch, and forced option trials were presented randomly to participants during these 56 trials.

After participants completed the 80 trials where they experienced the outcomes following each button click, they then completed the same number and types of trials within the description condition ("Description Based Choices" – Fig. 5). That is, participants completed 24 forced option trials (16 gain, 8 losses) followed by 56 trials where 16 presented a choice between the two gain buttons, 16 presented a choice between the two loss buttons, 16 were catch trials (i.e., one gain and one loss), and 8 were forced option trials.

3.1.4. Within subject design

All participants completed three sets of DE procedures. Half the participants completed the isolated gains procedures first (A), then the procedures where gains were intermixed with losses (B), and ended with trials presenting gains in isolation (A – i.e., an ABA reversal design). The other half of the participants first completed procedures where gains were intermixed with losses (B), then gains were presented in isolation (A), then ended with gains intermixed with losses (B – i.e., a BAB reversal design).

Fig. 5 shows the sequence of tasks completed for each group in Experiment 2. Note that participants only completed one experience condition followed by one description condition in each *isolated gains* and *gains intermixed with losses* sets. We chose not to use a reversal of DE conditions within a set for two reasons. First, an additional 180 trials would be added to the experiment by reversing back within each DE set. The tradeoff in time and potential participant fatigue did not seem justified considering the presence of a DE gap using a within subject reversal design has been replicated across four known experiments and two research labs (Experiment 1; Ludvig et al., 2011, 2017). Second, the primary question in Experiment 2 was whether presenting gains in isolation or intermixed with losses impacted the direction of the DE gap. We were therefore interested in completing an ABA or BAB reversal design across the primary independent variable of gains in isolation or intermixed with losses. Presenting a single experience and single description condition within each isolated and intermixed condition allowed participants to complete Experiment 2 in a single 30 min visit to the lab.

3.1.5. Participant removal

We removed participants from the data analysis if they did not choose the gain option on more than 60% of the catch trials in the experience condition. Ten participants were removed for not accurately responding to catch trials. This led to 54 participants completing the isolated-intermixed-isolated reversal, and 47 participants completing the intermixed-isolated-intermixed reversal.

3.1.6. Data analysis

All statistical analyses were conducted using IBM SPSS Statistics, version 24.0 (IBM Corporation, 2016).

3.2. Results and discussion

3.2.1. Isolated gains first

The top panel of Fig. 6 shows the mean proportion of trials the low probability option was chosen by participants who contacted gains in isolation first. We first conducted a two-way repeated measures ANOVA using gains presentation (gains in isolation or gains intermixed with losses) and condition type (experience or description) as the two factors. This allowed us to examine if these variables independently influenced how often participants chose the low probability option.

Overall, participants chose the low probability option more when gains were intermixed with losses than when gains were presented in

GROUP 1: |----------Isolated----------| |---------Intermixed---------| |----------Isolated----------|
Experience → Description → Experience → Description → Experience → Description

GROUP 2: |---------Intermixed---------| |----------Isolated----------| |--------Intermixed---------|
Experience → Description → Experience → Description → Experience → Description

Fig. 5. Sequence of conditions contacted by the participants in Experiment 2. Half the participants (Group 1) experienced choice between gains on all trials ("Isolated"), followed by trials where gains and losses were randomly intermixed ("Intermixed"), and then ended with only gain trials. The other half of participants (Group 2) experienced "Intermixed" first, followed by "Isolated", and ended with "Intermixed". Note that participants always completed one experience followed by one description condition within each "Isolated" or "Intermixed" trial sets.

isolation (top panel Fig. 6). That is, participants chose the low probability option less when they were making repeated choices between two gains (≈25% of trials) compared to when they made repeated choices between the same two gains but these choices were randomly intermixed with choices between two losses (≈42% of trials; $F(2, 106) = 25.27$, $p < 0.001$, $\eta p^2 = 0.32$). We did not observe an overall difference in choice between description and experience conditions ($F(1, 53) = 0.01$, $p = 0.93$, $\eta p^2 = 0.00$). However, this was likely due to an interaction between gain presentation and condition type ($F(1.56, 82.80) = 16.20$, $p < 0.001$, $\eta p^2 = 0.23$). That is, the effect of describing or experiencing outcomes on choice depended on whether gains were presented in isolation or were intermixed with losses. This interaction is most easily observed by looking at the large difference between the first and second experience conditions in the top panel of Fig. 6. On average, there was no difference between experience and description conditions. But, the absence of a main effect for description vs. experience condition on choice clearly does not tell the whole story.

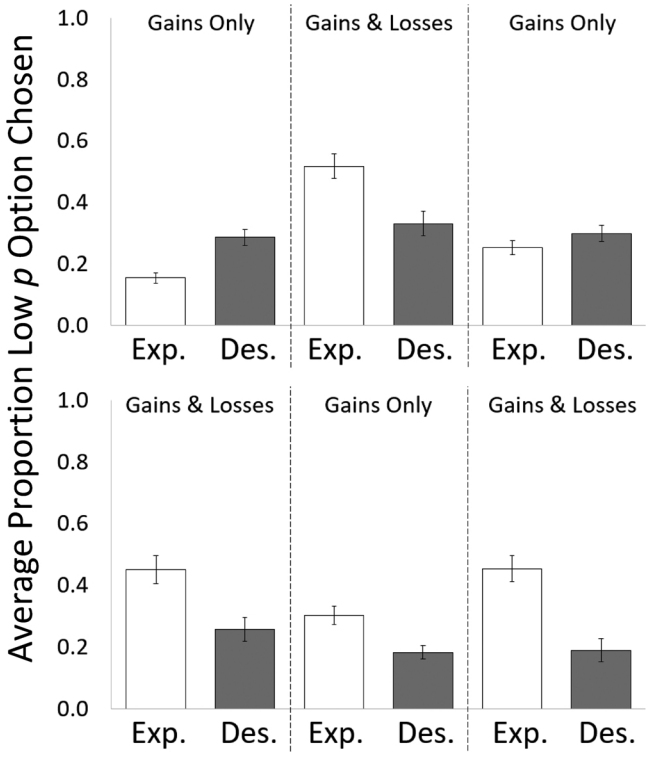

Fig. 6. Average proportion the lower probability option was chosen by the participants in Experiment 2. The top panel shows data from participants who made choices with gains in isolation first, followed by intermixed, and then isolated. The bottom panel shows data from participants who made choices with gains intermixed with losses first, followed by isolated, and then intermixed. "Exp." = experience; "Desc." = description. Error bars represent SEM.

As such, we can take a closer look at this interaction beginning with the leftmost "Gains Only" data in the top panel of Fig. 6.

We replicated the reversed DE gap finding from Experiment 1. Participants who began with gains presented in isolation chose the low probability option more in the description condition compared to the experience condition ($p = 0.05$; leftmost "Gains Only" in top panel of Fig. 6). However, when these participants then made choices between two gains that were intermixed with choices between two losses, we observed a DE gap in the same direction as previous research ($p = 0.02$; "Gains & Losses" in top panel of Fig. 6). That is, the low probability option was chosen more in the experience condition compared to the description condition. As predicted, the change in direction of the DE gap occurred through increased selection of the low probability option in the experience condition ($p < 0.001$); whereas, selection of the low probability option was the same across description conditions ($p = 1.00$). These data suggest repeated choices with experienced outcomes are impacted by the surrounding choices that are also being made (Ludvig et al., 2014). In contrast, repeated choices with described outcomes do not seem to be impacted by anything other than the language used to describe the outcome amounts and probabilities.

Interestingly, we did not observe a DE gap when we reversed from intermixing gains and losses back to presenting gains in isolation ($p = 1.00$; rightmost "Gains Only" in top panel of Fig. 6). We did observe a reduction in overall selection of the low probability option from the second to the third experience condition ($p < 0.001$). But, selection of the low probability option in the experience condition only reduced to levels similar to those observed in the description conditions.

The absence of a DE gap in the final "Gains Only" condition could have been the result of participants' having just experienced gain and loss trials intermixed (i.e., a carryover effect). However, previous research has also found that preference across experience and description conditions tends to become similar as the total number of trials becomes large (e.g., Hau et al., 2008). Thus, the absence of the DE gap may have been the result of experiencing over 250 trials by the time the participants made choices in the second "Gains Only" condition. Data from the second group of participants helps rule out this latter hypothesis.

3.2.2. Gains intermixed with losses first

The second group of participants first made repeated choices between two gains or two losses randomly intermixed, followed by repeated choices between two gains, and ending with gains intermixed with losses (lower panel Fig. 6). Overall, participants in this group also chose the low probability option more when gains were intermixed with losses (≈34% of trials) than when gains were presented in isolation (≈25% of trials; $F(2, 92) = 4.27$, $p = 0.02$, $\eta p^2 = 0.09$). We also observed greater preference for the low probability option in experience conditions compared to description conditions ($F(1, 46) = 34.51$, $p < 0.001$, $\eta p^2 = 0.43$). Lastly, we did not observe an interaction between how gains were presented and the condition type ($F(2,$

Table 2
Number of participants that demonstrated the different directions of the DE gap or no difference in preference between description and experience conditions.

DE Gap Direction	CONDITION ORDER					
	Isolated	Intermixed	Isolated	Intermixed	Isolated	Intermixed
Experience < Description	25	10	11	10	6	4
Experience > Description	5	32	16	28	21	31
Experience ≈ Description	24	12	27	9	20	12

92) = 2.80, $p = 0.07$, $\eta p^2 = 0.06$).

We next examined pairwise comparisons for these six conditions. Looking first at the leftmost "Gains & Losses" in the lower panel of Fig. 6, we see that participants chose the low probability option more when the outcomes were experienced directly ($p = 0.02$). This DE gap direction is similar to previously published research as well as the first group of participants above when gains and losses were intermixed. However, we again did not observe a DE gap when the same participants transitioned from intermixed gains and losses to repeated choices between two gains only ($p = 0.07$; middle "Gains Only" in lower panel Fig. 6). But, the same direction of the DE Gap was again present when we reversed back to presenting gains intermixed with losses ($p < 0.001$; rightmost "Gains & Losses" in lower panel Fig. 6). This pattern of choice suggests selection of the low probability option over repeated choices with gains is somehow altered if the person has previously made choices with gains intermixed with losses (i.e., a carryover effect). Future research should determine how many trials of losses intermixed with gains are needed before the DE gap is impacted for choices only with gains, and the duration carryover effects might last.

As with Experiment 1, we were also interested in the extent to which individual participant responding matched the observations at the group level. Table 2 shows these data. Similar to Experiment 1, the majority of participants demonstrated a DE gap consistent with the group averages show in Fig. 6. However, a sizeable portion demonstrated a DE gap in the opposite direction to the rest (approximately 20% of comparisons). This again suggests analysis of the variables that influence risk preference at the individual level is important for future research.

4. General discussion

In two experiments, we assessed preference for a low probability option when the outcomes were experienced directly compared to described only. Experiment 1 examined how preference for a low probability option changed across repeated choices as well as a single, final choice. The direction of the description-experience (DE) gap depended on the number of choice trials. This was intriguing as the direction of the DE gap for repeated choices was opposite to previous publications. We hypothesized the reversed DE gap in Experiment 1 was the result of examining choice between two gains rather than intermixing choice between two gains with choice between two losses – as in most previous DE gap research. Experiment 2 tested this hypothesis. We found a reversed direction of the DE gap when participant's chose between two gains in isolation followed by choosing between two gains intermixed with choices between two losses. However, there was no evidence of a DE gap when participants transitioned from choice between intermixed gains and losses to making choices between two gains only.

The two experiments reported on here are important to research on the DE gap for three reasons. First, these experiments suggest the direction and size of the DE gap can be manipulated. One way we manipulated the DE gap was through the number of choice opportunities (Experiment 1). Increasing the number of choices between two gains led to greater preference for the low probability option in the description condition. But, restricting choice to a single trial led to greater preference for the low probability option in the experience condition. A second way we manipulated the DE gap was by surrounding choices between two gains with choices between two losses (Experiment 2). When choices between two losses were randomly interspersed on a trial-by-trial basis, the DE gap reversed compared to when gains were presented in isolation. When choices between two losses were presented in the block of trials preceding repeated choice between gains in isolation, the DE gap was absent.

A second reason these experiments are important is they highlight that choice in experience conditions is more sensitive to other contingencies in effect than is choice in description conditions. Ludvig et al. (2014) previously demonstrated that the surrounding choice context impacts preference for a low probability option when outcomes are experienced directly. We replicated these findings but also found that the surrounding choice context does not appear to impact preference for the low probability option when the outcomes are described. One hypothesis for this observation is that choice in experience conditions is impacted more by the experimental contingencies whereas choice in description conditions is impacted more by the participants' pre-experimental history with the stimuli associated with probability descriptions. This hypothesis is somewhat supported by previous research finding that increasing the number of trials will significantly reduce the size of the DE gap (e.g., Hau et al., 2008, 2009; Ungemach et al., 2009). As one's history with arbitrary colored buttons becomes similar in length to the history with verbal descriptions, preference for the low probability option becomes similar between the two conditions.

A final reason these experiments are important is they suggest the processes leading to individual risk preferences are understudied in DE gap research. The present two experiments are the first known studies to report on individual patterns of risk preference in DE gap conditions. A sizable portion of participants in both experiments demonstrated DE gaps in the opposite direction of the group pattern. Theories seeking to describe the processes that lead to the DE gap have primarily used preference aggregated at the group level (e.g., Erev et al., 2010). These theories may be helpful to researchers if the primary goal is to influence proportions of group behavior (e.g., setting excise taxes on cigarette products – U.S. National Cancer Institute and World Health Organization, 2016). But, without identifying the variables that lead to individual differences in behavior, the underlying processes controlling the DE gap are unlikely to be found (Smith and Little, 2018; Staddon, 2001 – p. 95).

5. Conclusion

The present experiments add to the growing body of research on the description-experience (DE) gap. In particular, these experiments are the first to show that the direction and size of the DE gap can be manipulated. Experiment 1 demonstrated that the number of choice trials a participant has will impact the direction of the DE gap when choosing between a low probability of gaining a large amount and a high probability of gaining a small amount. Experiment 2 demonstrated that surrounding the same two gain options with choices between two loss options will reverse the direction of the DE gap or eliminate the DE gap altogether – depending on how many trials it has been since the losses were intermixed. Finally, although the majority of participants demonstrated a preference for the low probability option in a manner

consistent with the group aggregate data, a noticeable portion of participants demonstrated a DE gap in the opposite direction to the rest of the group. A complete understanding of the processes that lead to the DE gap will need to include analysis of choice at the individual level.

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References

Camilleri, A.R., Newell, B.R., 2011a. Description- and experience-based choice: does equivalent information equal equivalent choice? Acta Psychol. 136, 276–284. https://doi.org/10.1016/j.actpsy.2010.11.007.

Camilleri, A.R., Newell, B.R., 2011b. When and why rare events are underweighted: a direct comparison of the sampling, partial feedback, full feedback, and description choice paradigms. Psychon. Bull. Rev. 18, 377–384. https://doi.org/10.3758/s13423-010-0040-2.

Canale, N., Rubaltelli, E., Vieno, A., Pittarelly, Billieux, J., 2017. Impulsivity influences betting under stress in laboratory gambling. Sci. Rep. 7, 10668. https://doi.org/10.1038/s41598-017-10745-9.

Erev, I., Ert, E., Roth, A.E., Haruvy, E., Herzog, S.M., Hau, R., et al., 2010. A choice prediction competition: choices from experience and from description. J. Behav. Decis. Making 23, 15–47. https://doi.org/10.1002/bdm.683.

Gonzalez, C., Mehlhorn, K., 2016. Framing from experience: cognitive processes and predictions of risky choice. Cogn. Sci. 40, 1163–1191. https://doi.org/10.1111/cogs.12268.

Hau, R., Pleskac, T.J., Kiefer, J., Hertwig, R., 2008. The description-experience gap in risky choice: the role of sample size and experienced probabilities. J. Behav. Decis. Making 21, 493–518.

Hau, R., Pleskac, T.J., Hertwig, R., 2009. Decisions from experience and statistical probabilities: why they trigger different choices than a priori probabilities. J. Behav. Decis. Making 23, 48–68. https://doi.org/10.1002/bdm.665.

Hertwig, R., Barron, G., Weber, E.U., Erev, I., 2004. Decisions from experience and the effect of rare events in risky choice. Psychol. Sci. 15, 534–539.

IBM Corporation, 2016. IBM SPSS Statistics for Windows, Version 24.0. IBM Corp, Armonk, NY.

Lejarraga, T., Pachur, T., Frey, R., Hertwig, R., 2016. Decisions from experience: from monetary to medical gambles. J. Behav. Decis. Making 29, 67–77. https://doi.org/10.1002/bdm.1877.

Ludvig, E.A., Spetch, M.L., 2011. Of black swans and tossed coins: Is the description-experience gap in risky choice limited to rare events? PLoS One 6, e20262.

Ludvig, E.A., Madan, C.R., Spetch, M.L., 2014. Extreme outcomes sway risky decisions from experience. J. Behav. Decis. Making 27, 146–156. https://doi.org/10.1002/bdm.1792.

Madan, C.R., Ludvig, E.A., Spetch, M.L., 2017. The role of memory in distinguishing risky decisions from experience and description. Q. J. Exp. Psychol. 70, 2048–2059. https://doi.org/10.1080/17470218.2016.1220608.

McKerchar, T.L., Renda, C.R., 2012. Delay and probability discounting in humans: an overview. Psychol. Rec. 62, 817–834.

McKerchar, T.L., Pickford, S., Robertson, S.E., 2013. Hyperboloid discounting of delayed outcomes: magnitude effects and the gain-loss asymmetry. Psychol. Rec. 63, 441–451. https://doi.org/10.11133/j.tpr.2013.63.3.003.

Myerson, J., Baumann, A.A., Green, L., 2017. Individual differences in delay discounting: differences are quantitative with gain, but qualitative with losses. J. Behav. Decis. Making 30, 359–372. https://doi.org/10.1002/bdm.1947.

Rachlin, H., Raineri, A., Cross, D., 1991. Subjective probability and delay. J. Exp. Anal. Behav. 55, 233–244.

Skinner, B.F., 1957. Verbal Behavior. Coply Publishing Group, Acton, MA.

Smith, P.L., Little, D.R., 2018. Psychonomic Bulletin Revview. ePub ahead of print. https://doi.org/10.3758/s13423-018-1451-8.

Staddon, J.E.R., 2001. Adaptive Dynamics: The Theoretical Analysis of Behavior. MIT Press, Cambridge, MA.

Thaler, R.H., Johnson, E.J., 1990. Gambling with the house money and trying to break even: the effects of prior outcomes on risky choice. Manage. Sci. 36, 643–660.

U.S. National Cancer Institute and World Health Organization, 2016. The economics of tobacco and tobacco control. National Cancer Institute Tobacco Control Monograph 12. NIH Publication No. 16-CA-8029A. U.S. Department of Health and Human Services, Bethesda, MD.

Ungemach, C., Chater, N., Stewart, N., 2009. Are probabilities overweighted or underweighted when rare outcomes are experienced (rarely)? Psychol. Sci. 20, 473–479.