The Effects of Control on Betting: Paradoxical Betting on Items of High Confidence With Low Value

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Theories of decision making emphasize the probabilities and values of possible outcomes, but decisions are not made in the abstract. Instead, they are based on general knowledge and personal experience. In this experiment, participants were asked to make their own decisions to general knowledge questions. They were then instructed to bet on their answers, with the cost of the bet defined as a probability of attrition. This process was repeated for several items, each with a different probability of attrition. The results showed that the probability of attrition was significantly correlated with the cost of the bet.

1 I thank Gabriel C. Cook, Clinton C. Williams, and two anonymous reviewers for their comments on an earlier draft. I am also grateful to.u'raeb.ici, ,U.',,j. ,n. u.,”.y r . u. .

References:

Confidence in Knowledge

To investigate the effects of perceived causality, in the present experiment I used common methods of assessing people’s confidence in their knowledge. A standard procedure in this domain is to ask participants many general knowledge questions (GQs) in a two-alternative multiple choice format and then to ask participants to assess their confidence in each answer on a half-scale (50%-100%) scale. It is sometimes explained that confidence should be assessed such that, for example, of answers assigned 90% confidence, 70% should prove to be correct. These effects have emerged most prominently in self-tests. First, the average assessed probability in greater than the proportion correct, which has been termed overconfidence, or poor calibration in the large (Czerwinski, 1993; Yates, 1982). Second, except in the lowest confidence categories, among answers assessed to have 80% chance of being correct, fewer than the 80% correct for most values of X which is termed poor calibration in the small. Third, questions that are answered correctly by the lowest percent tend to exceed the most overconfident, and those answered correctly most often flick the least overconfidence, which is termed the hard-easy effect. It should be noted, however, that significant effects have been addressed to these conclusions (e.g., Czerwinski, 1991; Hastie, Weimann, & Olson, 2008). The impact of these effects on the interpretation of all present experiments is discussed in the General Discussion section.

Yaffe, Griffith, Lin, and Ross (1990) remarked of their overconfident participants: "These subjects made errors of the sorts implied by their expression of subjective confidence; they would have fared poorly indeed" (p. 385). But they did not report any data to suggest whether participants would in fact make such errors. This question is crucial, as it has been signed rigidity (Gigerenzer & Goldstein, 1996; McKenry, 1990) that the importance of judgmental overconfidence should be assessed by the magnitude of such errors in context and that the alternative measures Enquist and Hohn in guidelines correct answers. The cost of overconfidence does not seem in correct answers, because calibration is largely independent of accuracy. The real cost is from accepting risky prospects that one wrongly beliefs are unpromising.

Report on Confidence

Does overconfidence at high probabilities lead to poor decisions? It is possible that the commonly observed overestimation of low probabilities (such as the probability of being wrong) when confidence in high probabilities is overconfident in a context-sensitive way to produce optimal decisions. This might be satisfied, though, by the finding that low probabilities are actually overweighted when learned through overconfidence, e.g. Nystrom, Banse, Wilier, & Erev, 2003; Heath and Tversky (1991) took a significant step in addressing heuristics on knowledge. Participants choose between two testing in the awareness of their answers and betting on a random event of probability equal to their confidence
by each item. Payoffs in the two bets were identical. Across a variety of settings, when betting on questions drawn from registrar demographics, the proportion of times participants chose to bet on their knowledge was a roughly increasing function of the probability of winning. This pattern held even when random bets were constructed to be less profitable than bets on knowledge under low-probability conditions and more profitable under high-probability conditions. Because confidence tends to exceed accuracy, a random bet with a probability of winning that is matched to confidence is more likely to win than the knowledge-based bet, and Meehl andamp; Pcteadered noted that the observed advantage of knowledge-based bets over random bets resulted in a 1.5% loss of expected winnings. These effects were subsequently replicated by Taylor (1983).

Hoek and Pcteadered (1993) bets were a test of ambiguity aversion under the special circumstance that the ambiguous item was a bet on their own knowledge, and their results show that ambiguous prospects under this circumstance are viewed and treated profitably differently from other ambiguous prospects. Participants were frequently ambiguity seeking, rather than ambiguity averse. More specifically, they sought ambiguity at the highest probabilities and avoided it at the lowest probabilities, with choice proportion of intermediate probabilities characterized well by a linear curve. This stands in contrast with the finding (Stanley, Hawkins, Smith, & Lukasz, 1993) that participants are generally ambiguity seeking at low probabilities and avoid ambiguity at high probabilities in judgment settings. This is in opposition to the pattern observed by Hoek and Pcteadered

Method and Overview of Experiments

The experiments made three kinds of questions, depicted in Figure 4, which also illustrate the format in which stimuli were presented to participants. The first kind of question, depicted in Figure 4A, is a yes-no forced-choice version of a CQD. The second kind of question (see Figure 4B) asked for an assessment of confidence in each CQD to be placed in one of the following categories: 50%-59%, 60%-69%, 70%-79%, 80%-89%, 90%-99%, and 100%-100%. Participants were instructed to think aloud and right some of the half circle on the purpose of such novelties in its elements, which was to allow the expression of certainty and near total uncertainty. Pilot postexperimental questionnaire data indicated that participants were not confused by either the half circle or the range of the confidence categories. For all analyses, confidence was taken in the midpoint of the selected confidence category. It is conventional to post-expressed confidence values into bins large enough to form meaningful inference counts, although still providing is usually done later in the process. This approach has the advantage of making the experiment's true structure more transparent to participants (Browning & Ortmann, 2001), although it carries the cost of ignoring last confidence values are distributed systematically across the bins. This assumption seems best likely to be violated in the highest confidence category (90%-100%).

Although the most extreme confidence categories were similar to the others, their use is justified by the fact that they were used more often than any other categories, consistently across the experiments reported here. Although a demand effect is present in the extreme values of these categories and one of others despite its small absolute size, it could not account for the large that was substantively present than use of the other categories.
which could imply that responses are more often between 97%–99% than 99%–100%. For example, if responses are uniformly distributed across an odds (rather than a percentage) scale, then their transformation to a percentage scale would skew them positively. However, the effect of this would be that true confidence is underestimated, and with it, overconfidence. Thus, both overconfidence and its deleterious consequences might be underestimated, but they are not unmeasured.

The third question (see Figure 1C) elicited acceptance or rejection of a bet for the basis of the answer given to the GRO. The structure of the bet differed between experiments, and is therefore described in detail under the individual experiments. In general, though, participants faced a two-alternative choice between a certain outcome and an uncertain bet with two possible outcomes, the successful one more favorable than the certain outcome (when the GRO choice was correct) and the unsuccessful one less so. The bet was always fair (ex ante value equal to the value of the certain outcome) if the participant was well calibrated. Its value was less than the value of the certain outcome if the participant was overconfident and greater than that of the certain outcome if the participant was underconfident.

In all experiments, the three question types were asked for each of the 150 GROs in two phases. In Phase 1, each GRO was presented and confidence assessed. After all questions were answered and confidence assessments provided, in Phase 2 the questions were repeated, with reminders of the participant’s answers but not of confidence ratings, and a bet was offered on the basis of the answer. Whether bets were accepted or rejected, the participant was provided with feedback that included the correct answer to the question, the chance (if any) in points, and the updated point total. If participants had full knowledge of the experimental structure before the experiment began, it would have been possible for them to understand their true confidence, to be offered more favorable bets, and, if that confidence was assessed, the participant did not know that any bets were eventually be offered, much less that the bets would be based on their confidence assessment.

Participants in all experiments were recruited from the college pool of the Psychology Department at the University of Georgia and were compensated with partial credit toward lower division courses. Participants were recruited from participating in more than one of the present experiments or any other related experiments.

Three experiments are reported. Experiment 1 replicates Experiment 1 in the phenomenon of paradoxical betting, characterized by having proportions that are an increasing function of confidence-stimulated decreasing odds. In Experiment 2, the payoff structure was altered to allow for a more direct test of the conditional independence of the two factors to discount effects of biases. To move extreme outcomes from the end of the conditions to the other, and to move more variable outcomes from less desired outcomes to more desired outcomes. The change in betting structure also had the effect of making the cost of paradoxical betting smaller. Paradoxical betting proved robust in this manipulation. Betting was never aligned with the value of bets in any simple or clear way. In Experiment 3, two matched control groups accepted or rejected bets that were statistically identical in those offered a third group having no knowledge, but not controlled by calibration, and these groups showed betting functions with significantly less steep slopes.
All experiments were performed under computer control, with a PC by software developed in the IBM (IBM, 1978) environment. Participants were randomly assigned to the conditions. Participants were instructed to respond using the computer keyboard, and their responses were recorded.

Results

The betting proportions are shown in Figure 2A, and reflect dramatically increasing risk taking as a function of probability under ambiguous with control. This is well described by a linear function *y = mx + b*.

The calculation curve, showing accuracy as a function of confidence, is reflected in the vivid colors of Figure 2B and reveals two effects. First, there is no overall over-confidence of 5.1%, with average confidence being 60.2% and average accuracy being 43.2%. Second, the underconfidence is expressed primarily in the higher confidence categories, with accuracy in lower confidence categories being relatively well calibrated. Also, there was no significant overconfidence within each confidence category. Accuracy among items with associated bets was higher than among items with associated bets that were ultimately rejected, and it was greater than the average in each confidence category. The general trend was observed, but the general accuracy of the data was not sufficient to argue that the trend was significant at a traditional level.

Because of the observed deviations from perfect calibration, the increasing trend in betting was eventually reversed as a function of the value of bets, which is depicted in Figure 3. The value of bets was calculated in four different ways, and all four show value systematically decreasing as a function of confidence. Figure 3 shows the average value of all bets in each confidence category, which is given by the function

\[ V = 100p - 100 \left( \frac{C}{1-C} \right) \left( 1 - p \right), \]

where *p* represents accuracy in confidence category *C*. The Alt-AV and Accepted-AV curves of Figure 3 illustrate these values with *p* reflecting accuracy within each confidence category and accuracy among questions whose associated bets were accepted. Points were lost by betting in highest confidence categories. The general trend was observed, but the general accuracy of the data was not sufficient to argue that the trend was significant at a traditional level.

Figure 4 also depicts values that adopt Koehler's (1982) power equation, *x = k* to model subjective utility, with their proposed exponent of 5/4 for gains and 3/4 for losses. Although the scale of losses is different (and less readily interpretable) than the AV values, the power curves (which were also calculated using all questions and those with bets that were accepted) depict primarily negative and systematically declining value of betting as a function of probability. Under any of the four

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*Note: The scatter plots from these results show the relationships between various factors and outcomes, indicating the strength and direction of the correlation. The diagrams illustrate the trends and changes observed in the data.*
PARADOXICAL BETTING

conceptions of value or utility well then, the value of bets was
strongly predicted by the lowest confidence categories, robustly
negative in the rest of the categories, and steadily declining
downwards. Accordingly, the average final point total was nega-
tive: -32.80. Only 22 of the 110 participants had non-negative
final point totals.

The linearly increasing betting function was reflective of most
participants' individual behaviors. The linear relationship between
confidence and betting was pervasive, with $b$ being greater than 1,
for half (50) of all participants, between 8 and 10 for 30, between
6 and 8 for 10, between 4 and 6 for 6, between 0 and 2 for 1, and
negative for 3. These values are expected to be artificially
suppressed in some cases, when participants used one or more
confidence categories as a shortcut that the reference classes to
which betting proportion refer are too small to be reliably sam-
ped. This would be expected to produce $b$ values that are biased
in the direction of zero.

Most participants were overconfident. Thirty-eight participants
(35%) were more than 10 percentage points overconfident, the
greatest overconfidence before 27.15. Thirty were between 5
and 10 percentage points overconfident, and 30 were between 1
and 5 percentage points overconfident. Eight participants were
within 1 percentage point of perfect calibration, and 19 were more
than 1 percentage point underconfident, the greatest underconfi-
dence being 9.6%.

Table 1 presents the means and standard deviations for points
correct, confidence, accuracy, overconfidence, betting proportion,
and points earned, as well as correlations among them. A number
of significant results emerged. Those who were more overconfi-
dent lost more points. Overconfidence was also positively related
to confidence and negatively related to accuracy (which is a
replication of the hard-easy effect). Those who were more selec-
tive about betting $b = 0$, who bet relatively infrequently earned
more points and were also less confident, less accurate, and less
underconfident. Accuracy was positively related to points, but con-
fidence was negatively related to points, although accuracy and
confidence were positively related to each other.

Discussion

Bet acceptance was a uniformly and strongly increasing linear
function of confidence. As a consequence of a calibration curve
that is typical of the literature, the value of betting was uniformly
(decreasing) function of confidence, by any of four measures that
were used. This effect, with its evident deleterious consequences,
even in a non-commercial setting, also, because it operates in a
country relationship not only to objective average value but also
to the power function that is widely accepted as representing
subjective utility, it appears that the betting pattern cannot be
attributed to psychological value but might be more fruitfully
attributed to the weighting of subjective probabilities in betting
decisions.

With regard to ambiguity aversion, these data support and
estended those of Hsu and Tversky (1991), yielding increasing
choice of an unambiguous option in subjective probability estimates.
This is consistent with the observation that ambiguity—
without conflict—is greatest at high probabilities and lowest at
low probabilities (Slovic et al., 1993). Hsu and Tversky referred to
this as an effect of competence, which is readily included within
the concept of control. Indeed, however, the experiment was not
a direct test of ambiguity aversion but rather of risk ambiguity.
The finding of greater accuracy and better calibration when
rejected bets were excluded is consistent with the idea (Budescu,
Evans, & Wallsten, 1993; Englund, Wallsten, & Budescu, 1994)
that random error is combined additively with functional judgments
that are real, with error on a particular bet being independent of
error on prior presentations of the same item. When participants
are allowed to omit answers that were previously attended by positive
error, both accuracy and calibration are improved. However, this
exception, although it reduces error/failure, does not eliminate
it, either outright or in individual confidence categories. This is also
consistent with the findings of Budescu, Wallsten, and Av (1997)
that representation effects due to case-specific random error do not
occur for omitted overconfidently. Heuristic error is also
consistent with the finding of the present experiment, that when
those judgments within the broad confidence category fell
relatively high in the categories, which one would also expect to be
those associated with greater accuracy than the confidence cate-
gory as a whole.

Experiment 2

Experiment 1 offered bets that included the possibility of both
profit and losses and used an liberal point total of 100, allowing for
cumulative bets that were either positive or negative. Because of
the liberal overconfidence, point totals were comparatively nega-
tive. Three learners were matched for students ofmatches. Gender
also, the three groups were matched for Experiments 1 may have
stronger linkages that contributed to the paradoxical pattern of
banning, which may not prevail in a game domain. Experiments
2 sought to overcome these biases by removing biases at basic
states and learning outcomes.

To remove the secrecy of losses on individual trials as well as
final positive point totals, and perhaps thereby reduce risk
shifting, I structured bets in Experiment 2. When only to explain
the possibility of loss on any bet, when Experiment 1 offered a
limited option of no change, for certain outcomes in this experiment
was a gain of 100 points. The incorrect option consisted of me
changing the answer in question was incorrect, and a gain of
100(better) or 0 point at the review was correct. This bet, like
those offered in Experiment 1, is fair if confidence is well cal-
culated, is of less value than the certain option of overconfidence.

Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Acc</th>
<th>Overconf</th>
<th>Betting</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>0.02</td>
<td>0.02</td>
<td>0.03</td>
<td>-0.02</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Acc</td>
<td>3.81</td>
<td>0.02</td>
<td>0.02</td>
<td>-0.02</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Overconf</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>-0.02</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Betting</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>-0.02</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>Points</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>-0.02</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Note: Acc = accuracy; Overconf = overconfidence; Betting = overall proportion of bets accepted; Points = total points earned; Core = average confidence

*p < .05.
prevails and is of greater value than the certain option when 
underconfidence prevails. But other dimensions of the bet are 
significantly changed. In addition to removing the possibility of 
loosing on any trial (or negative final values), the same extreme 
outcomes are associated with the large gains that are possible when 
confidence is low, which in previous experiments the most 
extreme outcomes were largely indecision when confidence was greatest. 

The least extreme outcomes, a Laplacian solution, avoided from the 
lowest confidence categories in the highest confidence categories. 
Also, the less favorable outcome varied between confidence cat-

Igories in Experiment 1, which could have made losses more 
salient. Here, the more favorable outcome varied.

Method

The Bet Calculation (B) was used to determine the 
response of the participants in Experiment 1, using the same assessment method 
and evaluation. The mix-up of bets was modified, as indicated above, 
and otherwise the design of the experiment was the same as Experiment 1.

Results and Discussion

Betting probabilities are depicted in Figure 4A and were 
uniformly increasing function of confidence, which is well de-
scribed by a linear function. It was 97.99 with the best fitting 
model. The fundamental changes in the structure of the bets, 
including the possibility of losing, and the choice of extreme outcomes, 
did not alter the strong, increasing linearity of the 
function.

Calibration curves are presented in Figure 4B and reflect the 
typical pattern overconfidence is all but the lowest confidence categories, which is distributed but not eliminated when condi-
tioned on bets acceptance. Average confidence was 80.8% and 
average accuracy was 72.9%, resulting in overconfidence of 5.9%. 
In order to quantify and disentangle overconfidence to identify 
what overconfidence is present despite average accuracy greater than 75%. With an elevated overconfidence of 5.9% and average accuracy of 72.9%, this experiment fulfills 
this challenge, although the stasis of overconfidence is not the 
main focus of this article. Base rate of use of the confidence categories were 19.6%, 19.6%, 21.5%, 21.8%, 18.6%, and 13.8.

The average final point total was 14,512. Only 7% of the 127 
participants had final point totals greater than the 15,000 
stock would be carried by requiring all bets. It bears noting that the 
average obtained points was 500 and what would occur if the certain option were always taken is much 
smaller than it was in Experiment 1, being -488 points as opposed 
in 32,906. Indeed, it would not have been possible for the 
betting outcome used in Experiment 2 to obtain a decrease in any 
large than 15,000 points, and this would occur only if every 
guest who was interviewed incorrectly, which is difficult to an-
swering even after correcting. In short, whereas Experiment 1 
avoided paradoxical betting when the costs of this strategy were 
relatively large, paradoxical betting was again observed in Exper-
iment 2 when the costs were relatively small.

Average bet values are depicted in Figure 5 and are charged in 
important ways by the default structure of the bets. Specifically, 
value is not larger in a uniformly decreasing function of probability, 
but is U-shaped instead. The U-shape venue is probabilistic in 
average point values and high probability in values assigned to 
a power function. The pattern of betting, which is the arises as had 
been observed in Experiment 1, is therefore less paradoxical under 
this betting structure than under others. The positive skew of the 
power curves does not account for the income in betting across 
confidence categories, however, as the linear component accounts 
for only 0.5% of variance. The absence of a uniformly decreasing 
function does much to the pattern of betting less contrary to its 
outcomes, but betting remains paradoxical in two senses. First, the 
subjective utility of the certain outcome under the power function 
in [9] = 21.54, which would suggest on its own that bets in any 
confidence category should be rejected, even at the highest confi-
dence, where subjective utility is highest because average subjec-
tive utility is less than 21.54 in all confidence categories. Also, the 
average value of bets in the lowest confidence categories were 
otherwise above the 100 points gained by rejecting all the bets, and 
the average value of bets in all other confidence categories was less 
that 200 points. The pattern of betting thus still maximally conforms 
to the maximum obtainable points.

The linear increasing betting function was reflective of most 
participants’ individual behavior. The linear relationship between 
confidence and betting was very strong, with 8 being greater than 
9 for 47 of 127 participants (35%), between 9 and 8 for 32.

Figure 4. A: Bets and calibration in Experiment 2. A: Betting proportions as a function of confidence. B: The 
examination curve, accuracy as a function of confidence.
between 0 and 8 for 35, between 2 and 6 for 12, between 0 and 2 for 1, and negative for 4. Again, these values are expected to be suppressed in some cases.

Most participants were overconfident, although the distribution was less favorable than in Experiment 1. Twenty-eight participants (27%) were more than 10 percentage points overconfident. The greatest overconfidence being 30%. Those who were between 5 and 10 percentage points overconfident, and 31 were between 1 and 5 percentage points overconfident. Sixteen participants were within 1 percentage point of perfect calibration, and 19 were more than 1 percentage point underconfident, the greatest underconfidence being 7.7%. Table 2 presents the means and standard deviations for points earned, confidence, anterior, overconfidence, betting proposition, and points earned, as well as correlations among them. In comparison with Experiment 1, two correlations were not larger statistically significant. Betting was no longer significantly related to overconfidence, and betting proportions with the more complex value functions, were no longer negatively related to points earned.

Experiment 3

In the first two experiments, control was not independently manipulated. In Experiment 3, we used conditions wherein bets were accepted or rejected, the feedback was unconfident bet in all regards except not being characterized by control, to assess whether control itself is responsible for the paradoxical betting observed in Experiments 1 and 2. Participants in uncontrolled conditions had an event that appeared random, not on their knowledge. The construction of elicited bets is not altogether straightforward, because many dimensions of the betting experience of those who win on their knowledge are experienced by the participants' responses. These include the distribution of subjective probabilities of winning for those betting on knowledge, the distribution of confidence, the objective probability of winning, that prevails at each level of attitude probability (accuracy in each confidence category), and any uses of betting on those dimensions (e.g., if overconfidence declines with experience, if accuracy declines with fatigue). Consequently, the first typified analytic were constructed from largely the same process as had that were consistently based

**Figure 5.** The wide of bets in Experiment 2. AV = average value, the amount of money on average. Power = average value resulting from application of power of the given to the 14 to 15 lessons.

**Table 2.** Descriptive Statistics and Correlations Between Variables in Experiment 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Ave.</th>
<th>Overall</th>
<th>Betting</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conf</td>
<td>32</td>
<td>0.08</td>
<td>0.09</td>
<td>0.40</td>
<td>0.30</td>
<td>0.60</td>
<td>0.10</td>
</tr>
<tr>
<td>Ave.</td>
<td>0.02</td>
<td>0.05</td>
<td>0.03</td>
<td>0.65</td>
<td>0.60</td>
<td>0.60</td>
<td>0.10</td>
</tr>
<tr>
<td>Overall</td>
<td>0.02</td>
<td>0.05</td>
<td>0.03</td>
<td>0.65</td>
<td>0.60</td>
<td>0.60</td>
<td>0.10</td>
</tr>
<tr>
<td>Betting</td>
<td>0.02</td>
<td>0.05</td>
<td>0.03</td>
<td>0.65</td>
<td>0.60</td>
<td>0.60</td>
<td>0.10</td>
</tr>
<tr>
<td>Points</td>
<td>0.02</td>
<td>0.05</td>
<td>0.03</td>
<td>0.65</td>
<td>0.60</td>
<td>0.60</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Note. Ave. = average; Overall = overall; betting = overall proportion of bets agreed. Points = total points earned. Conf. = average confidence.

*p < .05.
Method

One hundred forty-eight raw participants were recruited from the same population as previous experiments and were randomly assigned to the three groups: BOK (n = 40), subjective probability = confidence (SP = C; n = 50), and subjective probability < confidence (SP < A; n = 55). In short, the crossover effect evident in Figure 6A is real. These results suggest that the crossover effect at high confidence in Experiments 1 and 2 is not due to an overestimation of small probabilities under direct experience (Hertwig et al., 2002). All groups experienced the same low probabilities with the same direct experience, therefore this conclusion cannot explain the difference between groups.

Results and Discussion

Betting proportions for all three groups are depicted in Figure 5A. Betting proportions were once again uniformly increasing function of confidence, which is well described by a linear function for all three groups. For the BOK group, R = .98, for SP = C, R = .98, and for SP = A, R = .99. The best fitting slopes were 1.42, 1.90, and 0.09 for the BOK, SP = C, and SP = A groups, respectively. One use for an effect of context is whether the BOK slope is greater than the others. This was tested in several ways, all revealing that the BOK slope was greater than the others. An omnibus analysis of variance (ANOVA) revealed a statistically significant group effect, F(2, 145) = 8.30, p < .05. A specific contrast between the BOK group and the average of the other two was also significant, t(145) = 3.04, p < .05. Also, because of the flooring ceiling that is evident at high confidence, betting proportions were transformed into log odds format. This too revealed a significant omnibus ANOVA, F(2, 145) = 5.79, p < .05, and a significant contrast between the BOK group and the average of the other two, t(145) = 3.18, p < .05.

The betting curves reveal a crossover interaction, with BOK participants betting less than others at the low confidence levels but more than others at the highest confidence levels. Is this crossover general? It is obvious that the BOK group bet less than did other groups at the lowest confidence level, and inferential analysis using this test, F(2, 145) = 10.9, p < .05, for the contrast between BOK and the average of the other groups, t(145) = 1.35, p < .05. B, it less obvious, but nonetheless confirmed that the BOK group bet more frequently than did other groups at the highest confidence category, F(2, 145) = 4.95, p < .05, for the contrast between BOK and the average of the other groups, t(145) = 2.83, p < .05. For log odds, the omnibus ANOVA narrowly failed to a test of significance, F(2, 145) = 2.96, p = .055, but the contrast between BOK and the other groups was significant, t(145) = 2.23, p < .05. In short, the crossover effect evident in Figure 6A is real. These results suggest that the crossover effect at high confidence in Experiments 1 and 2 is not due to an overestimation of small probabilities under direct experience (Hertwig et al., 2002). All groups experienced the same low probabilities with the same direct experience, therefore this conclusion cannot explain the difference between groups.

Calibration curves are presented in Figure 6B. For the BOK group, average confidence was 78.3%, and average accuracy was 72.5%, resulting in an overconfidence of 5.8%. For the SP = C group, average confidence was 80.0%, and average accuracy was 73.0%, resulting in an overconfidence of 5.0%. For the SP = A group, average confidence was 77.9%, and average accuracy was 72.7%, resulting in an overconfidence of 5.2%. For all dependent measures (confidence, accuracy, and overconfidence), the differences among groups were nonsignificant (p > .10).

The inability increasing betting function for the BOK group was once again reflective of most participants' individual behavior. The linear relationship between confidence and betting was very strong, with A being greater than 0.9 for 21 of 45 participants (47%), between 0.8 and 0.9 for 11, between 0.6 and 0.8 for 10, between 0.2 and 0.6 for 2, between 0.2 and 0.0, and negative for 1. Again, these values are expected to be suppressed in some cases. In contrast, the positive linearity of the betting on seemingly random events was much less pronounced at the individual level. Combining the SP = A and SP = C groups, only 11 of 103 participants (11%) had R values greater than 9. The greatest number of participants (37 in the two groups) had R values between 0.2 and 5.

Once again, most participants were overconfident. Combining the three groups because all experienced the same confidence calibration task in the first place, 32 of 148 participants (22%) were more than 10 percentage points overconfident, the greatest overconfidence being 30.6%. Forty-two were between 5 and 10 percentage points overconfident, and 37 were between 1 and 5 percentage points overconfident. Fourteen participants were within 1 percentage point of perfect calibration, and 23 were more than 1 percentage point underconfident, the greatest underconfidence being 14.05.

Table 3 presents the means and standard deviations for points earned, confidence, accuracy, overconfidence, betting proportion.
Table 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>Ave</th>
<th>Overconf</th>
<th>Rating</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conf</td>
<td>0.75</td>
<td>0.03</td>
<td>0.64</td>
<td>0.29</td>
<td>0.50</td>
<td>0.10</td>
</tr>
<tr>
<td>Ave</td>
<td>0.75</td>
<td>0.03</td>
<td>0.64</td>
<td>-0.55</td>
<td>-0.26</td>
<td>0.60</td>
</tr>
<tr>
<td>Overconf</td>
<td>0.65</td>
<td>0.03</td>
<td>0.48</td>
<td>-0.28</td>
<td>-0.45</td>
<td>1.00</td>
</tr>
<tr>
<td>Betting</td>
<td>0.75</td>
<td>0.03</td>
<td>0.65</td>
<td>-0.19</td>
<td>-0.30</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Random events

| Var | Ave | Overconf | = Overconfidence | Betting = overconfident | Conf = overconfidence | BOR = betting on unknown group | Random events = overconfident betting or random events | P < 0.05 |

In these experiments, risk seeking was assessed, where the uncertain option was also ambiguous and characterized by control, defined here as a participant’s ability to change his or her probability of achieving a favorable outcome. It was found that when control was perceived, risk seeking was an increasing function of subjective probability, significantly different from the seemingly unrelated process. In Experiments 1 and 2, the pattern of betting was robust to manipulation of the structure of bets, eliminating both local and global factors, moving the most extreme possible outcomes from upper expected with high confidence to those with low confidence, and moving variable magnitude from less favorable outcomes to more favorable outcomes, which also had the effect of making the cost of potential betting smaller. These results are similar to previous experiments that found less risk aversion and ambiguity aversion at low probabilities and more of both at high probabilities. They are consistent, however, with the findings of Tversky and Shafir (1991) in finding more willingness to accept fair bets on one’s knowledge in direct domains at high confidence than at low confidence. The findings suggest that betting on events characterized by control may be different from fundamental ways from betting on events that are perceived as random.

It should be noted that the present experiments did not use external incentives such as money. It is possible that participants would have been less risk seeking if they had something of value to lose. However, whether this would affect the slope, elevation, or other properties, would likely depend on such factors as the size of the incentive, theremorse of losing that was offered, and participants’ wealth. Participants in the present study were undergraduates whose occupation was determined primarily by the pursuit of various kinds of prizes.

The observed pattern of betting was paradoxical in the following three ways. First, bets were more frequent of lower average value than the certain option, whether considered as average outcome or average subjective value, with subjective value being a power function of each outcome. Yet most bets were accepted. Second, bets in the highest confidence categories were always of lower value than their certain alternatives but were rarely accepted in all experiments. And third, the conclusion was clear, linear, increasing pattern of betting was not consistent across the steep, uniformly decreasing value of these bets as a function of probability in Experiment 1 and a monotonically decreasing value function in Experiment 2. The effect was consistent across a range of costs as well, from relatively large costs in Experiment 1 to relatively small costs in Experiment 2. It thus appears that overconfidence, particularly in high confidence, is not compensated for by underweighting low probabilities. This may be amenable, at least partly, to the fact that low probabilities are understood when they are learned through experience (Hertwig et al., 2002), as they were in other experiments. Would this pattern of betting be paradoxical if participants were well calibrated rather than overconfident? The question is important because the experiments reported here are particularly selected view questions which induce particularly pronounced overconfidence. Overconfidence is, however, not an effect that is always so sometimes obtained, by being questions that are randomly selected from lists, well-defined testing (e.g., Gigerenzer, Hoffrage, & Kleinbölting, 1994; Klein, 1994). Betting that accepted with probability to be less paradoxical than overconfidence, declined, as the declining value of bets becomes less dramatic. If confidence were perfectly calibrated both in the large and in the small, the value of bets would be constant and equal to the value of the certain alternative. However, the increasing pattern of betting, although no longer constant, in the large and confidence is consistently observed at low confidence, coupled with overconfidence and high confidence, both the finding is essentially impossible under plausible assumptions of low confidence judgments are formed. Thus, when bets are made for perfect calibration in the small, it will generally be of greater value to bet on low-confidence items than high-confidence items, making the increase in the taking a reliable pay strategy.
There is a sense in which these experiments were not a test of separability attitude because all options involved ambiguity. The certain option offered a precisely known, 100% chance of winning a certain number of points; but it also included six other possible outcomes with probabilities that are not precisely known: the thrill of being right, the delusion of being wrong, the thrill of having accepted a winning bet, the delusion of having rejected a bet that would have won, the delusion of having accepted a losing bet, and the thrill of having rejected a bet that would have lost. There is no telling how these incentives might combine subjectively. However, one can be reasonably sure that the outcomes are closer to equal (and therefore closer to diminishing ambiguity) with the certain option taken (i.e., where bet is not rejected). When the bet is accepted, the possible outcomes are the thrill of being right amplified by the thrill of accepting a winning bet, or else the delusion of being wrong amplified by the delusion of rejecting a losing bet. On the other hand, if the bet is rejected, these outcomes do not augment each other but mitigate each other. The participant gets either the thrill of being right mitigated by the delusion of rejecting a winning bet or the delusion of being wrong mitigated by the thrill of rejecting a losing bet.

Whereas the thrill of being right and the delusion of being wrong are not aspects of a conventional ambiguity experiment, the other four emotional outcomes are presently part of all ambiguity experiments. Whether these emotional outcomes affect ambiguity attitude would therefore be best tested within a conventional ambiguity-attitude framework. If these emotional outcomes contribute to ambiguity, then all ambiguity effects would be expected to disappear when they are included.

Modeling These Data Within a Prospect Theory Framework

Perhaps control is a fundamental dimension of risky decisions making, relatively independent of probability and value. However, its effects can be modeled within a prospect theory (Tversky & Kahneman, 1992) framework. Because being in a century relationship not only with objective average values but also with the power function that is widely accepted in representing the psychological representation of values, it appears that the decision function cannot be attributed to psychological values but might be more fruitfully attributed to the weighting of subjective probabilities in decision making.

These data suggest a probability weighting distribution under conditions of distress in prospect theory (Tversky & Kahneman, 1992) framework, because being in a century relationship not only with objective average values but also with the power function that is widely accepted in representing the psychological representation of values, it appears that the decision function cannot be attributed to psychological values but might be more fruitfully attributed to the weighting of subjective probabilities in decision making.

A perspective weighting function is usually modeled in decision models, because the weights of data taken from less on random events suggest primarily subjective weighting functions. But existing weighting models are equipped to reflect prospectively with only parametric models. No formal changes or additional specifications are needed.

Pelchat's (1998) weighting function, for example, contains a parameter 2 that generally evokes subjectivity. Pelchat defined 2 as falling between 0 and 1 and explicitly because separability is maintained within this range. However, the function is primarily separative if  \( a > 1 \). For example, if 2 is held constant at 1, then the curve crosses the diagonal from below between 0.0 and 0.09 for any value of  \( x \) major than 1.0. And the probability weighting function  \( f(x) \) does not depend on a moderate value of 2. If  \( a = 1.6 \), then the curve defined by Equation 1 crosses the diagonal from below at an ordinate value between 0.01 and 0.09 for any values between the range 0.46.45. Generalized and Wu's (1999) function also accommodates the possibility of progressive decision weights readily. Under their scheme Equation 3 is transformed to the form below and the function is primarily separative when  \( a > 1 \). For example, if 2 is held constant at 0.5, then the curve defined by Equation 2 crosses the diagonal from below at an ordinate value between 0.01 and 0.09 for any value of 2 in the range 0.25.

A third weighting function does not handle these data as well as does the others. Fox and Tversky (1998) suggested a simple power weighting function for ambiguous outcomes where the exponent is inversely related to the "salience of the worst" (p. 893) of uncertainty. This function is capable of receiving weights higher while weighting others lower and such flexibility of shape as well as invariance is needed to account for the present data. The models of Gonzalez and Wu (1999) and Pelchat (1998) accommodate this feature of the data readily, whereas that of Fox and Tversky (1998) does not.

Figure 7 shows how a progressive weighting function can account reasonably well for the psychological testing observed in these experiments. Figures 7A and 7B reflect the overall value of 2 in Experiments 1 and 2, respectively, with value computed as a function of the frequency with which the bet was accepted. The value function is taken as Tversky and Kahneman's (1992) power function with exponents of 0.7 for gains and 0.5 for losses. The weighting function is that of Gonzalez and Wu (1999); that is, 2 = 0.25. The median value they proposed, and for which the progressive function is taken as their anchor value of 0.44. The scale difference between the subjective and progressive functions is that the progressive function takes 1.4 as its value of 2. It is evident that this is sufficient to produce increasing subjective values of bets that are consistent with participants increasing willingness to accept bets. Also, the subjective utility of no betting is 0.5 in Experiment 1 (no betting caused no change in points with certainty), and was 0.25 in Experiment 2. It can be seen that under the progressive function, the value of betting crosses over from less than the certain option to more than the certain option, corresponding to the crucial point of crossing from predominant risk aversion to overwhelming risk seeking to confidence increased.

The Psychological Meaning of Certainty

Gonzalez and Wu (1999) were careful to avoid more modeling of choice data, arguing for psychological meanings of the two parameters they advanced. They interpreted the gamma parameter, which is primarily responsible for risk aversion and therefore relatively constant, as representing 'determinism' (p. 136). They also proposed specific uses to which discriminability might pragmatically vary, both between and within individuals. Between individuals, they suggested that experts might display greater literacy.
Figure 3. A: Subjective value of bets in Experiments 1 (A) and 2 (B) when both propositional and descriptive weighing functions were observed. Barring patterns more closely reflect objective value.

References

(within their domain of expertise) than nonexperts, by processing feedback that was consistent or inconsistent with values of gamma considerably less than 1. Within individuals, they proposed that "an option trade may exhibit more dissatisfaction for gambles based on option scaling rather than gambles based on outcome measures" (p. 138). The concept of perceived control proposed by Ruscio extends this explanation by beginning to reduce the conditions under which dissatisfaction is expected to increase or decrease.

Quantifying the effects of perceived control on bet valuation in terms of decision weight curves remains a crucial component in the field. Indeed, a task characterized by absolute control would frequently become a task not even characterized by uncertainty, because the person engaging in the task would see his or her absolute control to increase the likelihood of success in 100%. Rather, many tasks are characterized by partial control, which allows that steps may be taken to alter the probability of success, but within constraints. For example, Hirst, Le, and Zimbardo (1994) measured risk taking in the domain of racetrack betting and concluded that most human error risk at low probabilities and avoid it at high probabilities, which is qualitatively the same as is observed with random events. It may be the case, however, that even下的 steps have sufficiently little knowledge of horse racing, or more important, how to alter their likelihood of winning, and that betting on horse races is nearly a random uncontrollable prospect for them.

The role of control bears comparison with the work on regulatory focus pursued by Higgins (1987, 1994), which suggests that a promotion focus leads one to take risks to achieve an ideal self, whereas a prevention focus fosters that one's existing responsibilities are met. In particular, a promotion focus leads one to change, whereas a prevention focus leads one to change, whereas a prevention focus fosters that one's existing responsibilities are met.

The state with the option control, which is defined in terms of change, where one can change the probability of success, control, and partial, and a promotion focus may predict these. Where success and failure are uncertain and unchangeable, one's need for familiarity is a minimum. For example, a promotion focus may predict these. Where success and failure are uncertain and unchangeable, one's need for familiarity is a minimum. If changes are made, changes to risk-taking tasks have been shown to shift people's focus and with it their decisions. (Friedman, Shua, & Higgins, 1996; Idson, Higgins, & Pozares, 2000), whereas in the present experiments no comparable change was shown between the results of Experiments 1 and 2. In three experiments, risk-taking increased with confidence when participants bet on their own knowledge, despite bet that consistently (perhaps incorrectly) declined with confidence. This effect is termed perceived control and was shown to depend on the aspect of control, betting on one's own knowledge rather than a random event. It is proposed that a task characterized by control may induce weighting functions that are more progressive than has been commonly assumed—usually on the basis of people's attitudes toward bets on random events—when control prevails.