The skill element in risky decision making: Control, competence or both?

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Running Title: CONTROL AND COMPETENCE IN RISK TAKING

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Abstract

Although most decision research and theory has relied on uncertain decisions based on random events, most natural decisions contain an element of skill, which has shown to affect decisions. Modern conceptions of the skill element include control (Goodie, 2003) and competence (Heath & Tversky, 1991). In Experiments 1-4, perceived control increased risk taking markedly with all statistical properties held constant. In Experiments 5-6, decisions made in domains of varying difficulty, and by individuals of varying ability, yielded qualified support for the role of competence. In Experiment 7, the role of control was replicated, and participants' perceptions of the differences in group treatments were more aligned with control than with competence. Support was thus obtained for the control hypothesis across a range of competence, and also for the competence hypothesis. Implications for applied and natural decisions are discussed.

KEY WORDS: control, competence, decision making, choice, betting, risk, overconfidence, college students

A surprising paucity exists within the basic decision making literature on how people approach decisions under uncertainty when the uncertainty depends on their own ability. A great deal is known – and a corresponding quantity of theorizing has been done – about the terms of risk that people will accept and reject on random events such as the drawing of a lottery number, rolling a die, or pulling a poker chip from a bookbag; but much less is known about how individuals accept or reject risk when they are betting on their own golf putts, stock picks, organizational decisions or answers to trivia questions. There are clear advantages to building models of decision making around risky decisions based on random events. Much decision research is analogous to psychophysical perception research, relating psychological events to objective criteria. A bookbag with 70 percent white and 30 percent red poker chips is a clear objective criterion to which subjective perceptions may readily be compared. Sinking a free throw does not present such a clear criterion with regard to its associated probabilities. In short, it is easier to know the probabilities in effect when they are based on random events than when they are based on skilled actions, and so it is understandable that the bulk of data and theorizing has centered around decisions based on random events.

Nevertheless, the existing evidence suggests that skill, ability, competence or control – there are important differences between the concepts, but all depend in an essential way on a skill component in determining an uncertain outcome – have an impact on subjective probability assessment and decision making. For example, in demonstrating the "illusion of control," Langer (1975) showed that people respond differently to vague likelihoods when certain superficial characteristics of the prospects were distorted, and argued that the changes in the appearance of a skill component forced changes in responses. Confidence ratings, bet acceptance and bet amounts were all affected by apparent control. Similarly, Chau and Phillips (1995) varied participants' control over elements that were seemingly skill-relevant and seemingly skill-irrelevant (all manipulations had no actual effect on the probability of winning) and found that participants bet more with the skill-relevant manipulation, but participants did not bet more with the skill-irrelevant manipulation.

Burger and Schnerring (1982) found that participants high in desire for control bet more than those low in desire for control on events over which they had falsely perceived control. Those high in desire for control bet less than others on events over which they did not have illusory control. These findings are part of a broader trend toward demonstrating effects of factors beyond the likelihood and magnitude of possible outcomes when making uncertain decisions. For example, Rettinger and Hastie (2001) showed that statistically identical bets were accepted at different rates, depending on the specific content of the risky event. Indeed, probability assessments themselves carry different meaning, depending on the content domain (Bender, 1998).

There exists a systematic divide on the skilled-to-random dimension between the artificial tasks on whose basis decision theory has primarily been developed, and the natural tasks that decision theory is intended to explain. Natural decisions typically contain at least some element of ability. This is true across domains, including business-related decisions such as those in organizational management (Forlani, 2002; Hiller & Hambrick, 2005), marketing (White, Varadarajan, & Dacin, 2003), and investment (Fellner, Guth, & Maciejovsky, 2004); personal decisions such as mate selection (Hinsz, Matz, & Patience, 2001) and child rearing (Pridham, Denney, Pascoe, Chiu, & Creasey, 1995); health-related decisions such as dieting, exercise, diagnosis and treatment; and law-related decisions such as regulation and jury decision making (Weinstock & Flaton, 2004). The idea has been extended to some unexpected domains, such as union leaders assessing random events, fictional elections and real elections (Maffioletti & Santoni, 2005). In all these cases, skill matters: some individuals can make systematically better decisions than others, with more favorable consequences; and each individual can take steps to make better decisions. In contrast, decision research is dominated by real or hypothetical bookbags and poker chips, lotteries, dice, cards and other devices that are notable for their purely stochastic properties. Often, the device is left unstated, and subjects simply choose, for example, between an 80 percent chance of X and a 40 percent chance of Y. They are not permitted even to contemplate that the mechanism by which the operative probabilities are generated contains an element of skill.

Control and competence. In the modern literature, two conceptions of the role of skill have been advanced: competence (Heath & Tversky, 1991) and control (Goodie, 2003). These can be viewed as partially overlapping conceptions, and their commonalities are at least as important as their differences. They share in common an emphasis on the role that the skill component of a task plays in shaping risky decision making, apart from the probability and magnitude of possible outcomes. They differ in the conditions under which a skill component is posited to operate, with control prevailing when the task is such that a person could increase the rate of success, and competence prevailing only when the person has increased the rate of success, relative to some standard. In other words, the control hypothesis claims that people bet differently when skill makes a difference; the competence hypothesis claims an effect only when people believe that they possess the skill that makes the difference. Control is a property of the task: if the task is a skill that can be learned, then it is characterized by control, even if the skill hasn't been learned by a particular participant. Competence, on the other hand, is an interactive characteristic of both the task and the person: there is competence only if the person perceives both that the task can be learned (the task component) and that it actually has been learned (the person component).

The state of the empirical literature. Heath and Tversky (1991) argued that people prefer to bet on questions about topics in which they feel competent rather than incompetent, giving participants the opportunity to bet on their knowledge. In their studies, participants chose either to bet on the correctness of their answers to general knowledge questions, or to bet on a random event whose probability matched their previously-stated confidence, for each item. Payoffs in the two bets were identical. Across an assortment of situations, when betting on questions drawn from intermixed domains, the proportion of times that participants chose to bet on their knowledge was a steeply increasing function of the probability of winning (Experiments 1 and 3). This effect held even when bets on random events were created to be less profitable than the parallel bets on knowledge under low-probability conditions, and more profitable under high-probability conditions. Because accuracy was exceeded by confidence in these experiments, betting on a random event (whose probability of winning was equal to confidence) was more likely to win than betting on the belief that referred to confidence, and Heath and Tversky (1991) noted that the acceptance of knowledge-based bets over random bets resulted in a 15% loss of expected earnings. These effects from these experiments have been replicated (Taylor, 1995).

They then (Experiment 4) tested the competence hypothesis by drawing questions from discrete domains in which participants believed themselves to be either competent or incompetent. They observed that, when subjective probability was held constant, participants displayed a pattern of ambiguity attitude that was constant across levels of subjective probability: bets in a domain of competence were preferred to bets on random events, which in turn were preferred to bets in a domain of incompetence. They concluded that ambiguity was sought after in domains of competence but avoided in areas of incompetence.

Heath and Tversky (1991) conducted tests of ambiguity attitude The literature on ambiguity, a state where relevant probabilities are not known in their exact quantities, suggests that people generally prefer unambiguous risky options (i.e., those where the exact probabilities are known), with an important exception at very low probabilities, where ambiguity is preferred. Heath and Tversky's findings were noteworthy for being contrary to the early ambiguity findings with random events: when evaluating bets on vaguely probable events with a skill component, participants preferred the vague (skilled) option at high probabilities, but preferred the unambiguous (random) option at low probabilities. Fox and Tversky (1995; Fox & Weber, 2002; see also Chow & Sarin, 2001) presented a successor to the competence hypothesis, the comparative ignorance hypothesis, positing that relative knowledge has its impact most strongly when the contrast between the more and less competent conditions is brought to the decision maker's attention.

Goodie (2003), in addition to pointing to a role of control rather than competence, also differed from Heath and Tversky (1991) in assessing risk attitude rather than ambiguity attitude. Thus, the alternative to betting on a knowledge item was no bet at all, rather than a bet on a random event of equivalent probability. Bets on knowledge items were constructed to be fair, having zero average marginal value if confidence was well calibrated. In two experiments, participants showed a sharply increasing proportion of accepting bets on their knowledge, which bears a striking resemblance to the comparable data obtained by Heath and Tversky (1991) when using similarly mixed-domain questions. In Experiment 3, participants were divided into groups that differed from each other in whether they appeared to be betting on random events or their knowledge. One group answered, assessed confidence in, and considered bets on knowledge items. The other groups answered and assessed confidence in the same items, then considered bets on events that appeared random, but were constructed to be identical in every statistical way to bets on knowledge. The anticipated cross-over effect was observed, with participants accepting more bets on random events at low probabilities, and more bets on their knowledge at high probabilities.

In Goodie's (2003) results, an interesting relationship between betting patterns and obtained value was observed. Bets were favorable if underconfidence prevailed, and unfavorable if overconfidence prevailed. As is usual in confidence assessment tasks (and arguably inevitable, Erev, Wallsten, & Budescu, 1994), underconfidence was observed at low confidence levels, and overconfidence at high confidence levels. Thus, bets at low confidence levels were favorable, and bets at high confidence levels were unfavorable. Thus betting that decreased as confidence increased would have maximized points earned. Yet, betting sharply <u>increased</u> as confidence increased, leading to reliably negative point totals, a finding that was dubbed “paradoxical betting” due to the inverse relationship between betting patterns and point maximization.

The present experiments. The empirical goals of this paper are: a) to extend the risk-attitude findings (Goodie, 2003) to single-domain formats, a manipulation that made a considerable difference in the ambiguity-attitude findings of Heath and Tversky (1991); b) to compare across single domains wherein people have different degrees of competence, in order to observe the degree to which variation in competence makes a difference in risk attitude; and c) to begin to assess the degree to which participants' perceptions of competence and control guide their decisions under uncertainty. The present experiments begin to test the competence hypothesis against the conception of control in the domain of risk attitude, by eliciting betting decisions within domains of varying difficulty, and among participants of varying ability. The distinction between competence and control is most evident in a skill-based task in which a particular participant has little skill. When people bet differently on their own knowledge than they do on random events, is it their competence within the domain that alters their risk attitude, as Heath and Tversky (1991) suggested, so that paradoxical betting is observed only when a particular participant has competence in the domain? Or is it the control that can be exerted over winning and losing, as Goodie (2003) suggested, such that differential betting is observed at all levels of ability so long as the task is one that could be learned? Or, do control and competence both play a role in decisions with a skill element?

General Method

Seven experiments are reported, which expand on the methods developed by Goodie (2003; Campbell, Goodie, & Foster, 2004). The basic task of fair bets on knowledge use three kinds of questions, administered in two phases.

Phase 1. General knowledge and confidence assessment. The first question type was a two-alternative forced choice question. In prior studies (Goodie, 2003), questions were adapted from a collection (Nelson & Narens, 1980) that sampled from diverse domains. In the present studies, questions were drawn representatively from well-defined domains that were transparent to participants. Five question populations were used. Three of these question populations selected two U.S. states at random and asked for a binary comparison on one statistic: population, land area, or population density. (When more than one statistic was used, the manipulation was between-subjects. Each participant answered questions about only a single attribute.) The other two question populations randomly selected two of the 50 largest U.S. cities and elicited a comparison on either population or driving distance to Athens, Georgia.[1]

The second question type asked for an assessment of confidence in each question, to be placed in one of the following categories: 50-52%, 53-60%, 61-70%, 71-80%, 81-90%, 91-97%, and 98-100%. Confidence was taken as the midpoint of the selected confidence category. This question type was adopted without alteration from that used by Goodie (2003; Campbell, Goodie, & Foster, 2004).

Phase 2. Betting on answers. Vallone, Griffin, Lin, and Ross (1990, p. 585) remarked of their overconfident participants: "Had subjects made wagers giving the odds implied by their expressions of subjective confidence, they would have fared poorly indeed." But Vallone et al. reported no data to suggest whether participants would in fact make such bets. This is a vital issue, as it has been maintained (McKenzie, 1994; Gigerenzer & Goldstein, 1996) that the importance of judgmental errors should be assessed according to the magnitude of their costs in correct answers or, even better, the consequences that accompany correct answers. The cost of overconfidence does not come in fewer correct answers, as good calibration is distinct from accuracy, and does not increase accuracy. The cost of overconfidence would arise from accepting risk that one wrongly thinks is beneficial.

The third question elicited acceptance or rejection of a bet on the correctness of the answer that was given. In all conditions, participants faced a two-alternative choice between a certain outcome and a bet. The bet was always fair, having zero average marginal value, if the participant was well-calibrated. Its marginal value was negative if the participant was overconfident and positive if the participant was underconfident. After the participant chose to accept or reject the bet, feedback was provided, including the correct answer to the question, the number of points gained or lost (or a message that no points were gained or lost), and the cumulative point total. All feedback was presented whether the bet was accepted or rejected.

<u>The betting formats.</u> Two bet formats were used in these experiments: the Confidence-Odds format and the Gains-Only format. In the Confidence-Odds format, the certain option was no change in points, and the bet provided for a gain of 100 points if the answer was correct, and a loss of 100* *confidence*/(1-*confidence*) points if the answer was incorrect. It is easy to demonstrate that the average outcome of this bet was zero if *p(correct)=confidence*, negative if *p(correct)< confidence* (i.e., if overconfidence prevails), and positive if *p(correct)>confidence* (i.e., if underconfidence prevails). In the

Gains-Only structure, the certain option was a gain of 100 points. The bet offered a gain of 100 /*confidence* points if the answer was correct, and no gain if the answer was wrong. As with the Confidence-Odds structure, the average outcome of this bet was equal to the certain option (a gain of 100 points) if *p(correct)=confidence*, less than the certain option if *p(correct)< confidence*, and greater than the certain option if *p(correct)>confidence*.

"Answers" and "Random" groups. In Experiments 1-4 and 7, participants were randomly assigned to two groups that differed in whether they believed they were betting on their knowledge or on a random event. The "Answers" group bet on their answers, using either the Confidence-Odds or Gains-Only format in different experiments. The "Random" group's bets were designed to differ only in appearing to rely on random events rather than participants' answers. The construction of such bets is not altogether straightforward, because many dimensions of bets on knowledge are determined by the participants' responses. These include the distribution of subjective probabilities of winning (determined by confidence); the frequency of winning (determined by accuracy); and any order effects on these dimensions (for example, if overconfidence declines with experience, or accuracy declines with fatigue, or any number of other possibilities). Brandstatter and Schwarzenberger (2001) reported greater risk seeking in domains characterized by control, but attributed this to the more favorable outcomes that are possible under conditions of control. The purpose of experiments in this series is to find the role of control that is independent of changes in the probability distribution of favorable outcomes.

Consequently, bets that appeared stochastic were constructed using a process that relied on participants' answers and confidence assessments on the trivia questions. In the betting phase, each answer was converted into a bet on a seemingly random event, with the stated probability of winning equal to assessed confidence in a corresponding answer, and outcome determined by correctness of the corresponding answer. For example, if a participant expressed 75% confidence in her answer to the first question, then the first bet she encountered in the betting phase instructed: "A number will be chosen at random between 0 and 100, and to win the bet, the Chosen number must be less than or equal to the Magic Number. The Magic Number this time is: 75. If the chosen number is LESS THAN or equal to the Magic Number, you gain 100 points. If the chosen number is greater than the Magic Number, you lose 300 points." If the participant rejected the bet, then no points were won or lost. The bet, if it was accepted, was won if the participant’s answer was correct and lost if the answer was wrong. The chosen number was actually selected randomly from within the winning range if the corresponding answer was correct, and selected randomly from within the losing range if the answer was incorrect. The Magic Number, the magnitude of the gain if the bet was won, and the determination of whether the bet was won or lost, were changed on each betting trial to reflect the confidence expressed in the corresponding question from the first phase and whether it was answered correctly. (This example draws on the Confidence-Odds format, which was used in Experiments 1, 2 and 7. A corresponding version was created with the Gains-Only format, which was used in Experiments 3 and 4.)

Other general facets. The order in which the three question types were asked across trials is of consequence. First, in Phase 1, 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 the confidence ratings, and a bet was offered on the basis of each answer. If bets had alternated with confidence assessments, it would have been possible for participants to under-report their true confidence in order to be offered more favorable bets.

In all experiments, participants were recruited from the Research Pool of the Psychology Department at the University of Georgia and compensated with partial credit toward lower-division courses. Participants were prevented from participating in more than one of the present experiments, or in any additional related experiments. All experiments were approved by the University of Georgia Institutional Review Board. All stimuli were presented, and responses recorded, on a personal computer using software developed in the Delphi™ environment. Participants were run in groups of up to three in a room with individual computer stations separated by five-foot-tall partitions. Participants' data were omitted from analysis if they did not use more than three confidence categories, and also showed evidence of not attending to the task (exclusive betting acceptance or rejection, and radical over- or underconfidence).

Experiments 1-4

In the first four experiments, the differential impact of a skill component was assessed using items from single, well-defined domains, comparing some participants betting on their answers with others betting on random events. The different experiments used different question populations and betting formats.

Method

In Experiment 1 (N=76; 37 in Answers and 39 in Random), participants answered binary choices comparing two states in population, and faced bets that were constructed in the Confidence-Odds format. In Experiment 2 (N=67; 33 in Answers and 34 in

Random), participants compared cities in population, with bets again in the Confidence-Odds format. In Experiment 3 (N=48; 23 in Answers and 25 in Random), participants compared states in population, and faced bets in the Gains-Only Format. In Experiment 4 (N= 35; 17 in Answers and 18 in Random), participants compared cities in population, and faced bets in the Gains-Only format.

Results

Confidence, accuracy and calibration. It was anticipated that no difference between groups should be observed in confidence, accuracy, or over/underconfidence. This is because all answers and confidence assessments were provided prior to beginning the manipulation of the appearance of bets. And indeed, these measures were substantially equivalent across groups in all four experiments. Confidence calibration curves are given in Figure 1, and average confidence, accuracy and over/underconfidence are given in Table 1. One of 12 comparisons between the Answers and Random groups was significant, which is approximately what would be expected under the null hypothesis, although it may be noted that a second comparison narrowly missed statistical significance.

Overall bet acceptance. The principal finding of these experiments is that, using representative sampling in single domains, and with all statistical properties of bets held constant between groups, participants consistently accepted more bets when betting on their answers than they did when betting on random events. These results are presented in Table 2 and show dramatically greater rates of bet acceptance in the Answers group in all four experiments, which were statistically significant in all cases. Averaged across all four experiments, those betting on their answers accepted .758 of all bets, and those betting on random events accepted .555 of all bets.

Bet acceptance curves. The rates of betting, conditionalized on confidence, in the four experiments are shown in Figure 2. A consistent pattern was found of higher betting rates when participants bet on their own knowledge, compared with bets that are identical in every statistical way but appear to hinge on random events. At all confidence levels in all experiments, those betting on their answers bet more frequently than those betting on a random event. This difference was statistically significant by a chi-square analysis in 24 of these 28 comparisons. Comparisons at the 85% confidence level in Experiment 2 and the 65% confidence level in Experiment 3 were marginally significant ($.05<p<.10$); and those at the 99% confidence level in Experiment 1 and the 94% confidence level in Experiment 2 were non-significant. Because average confidence did not differ between groups, the distribution of responses among confidence categories did not differ systematically between groups. Because accuracy did not differ significantly between groups, neither group experienced a systematically greater proportion of won bets. And because overconfidence did not differ significantly between groups, neither group benefited from a systematically more favorable outcome for betting. The comparison of the betting curves is thus an appropriate reflection of the different appearance of betting on knowledge versus betting on random events, rather than a reflection of differing probabilities or magnitude of possible outcomes.

The findings in bet acceptance mark a considerable change from what Goodie (2003, Experiment 3) observed with arbitrarily selected items, where participants chose to bet on their knowledge relatively seldom at low levels of confidence, and increasingly often as confidence increased. In the present experiments, rates of bet acceptance are higher for bets on answers at all levels of confidence, though it is important to note that there is still an increasing rate of bet acceptance as confidence increases. These comparisons, between the present experiments with single domains and past experiments with mixed domains, resemble the trend across experiments in Heath and Tversky (1991), where a narrowing focus among questions yielded an increasingly consistent preference to bet on items where participants had competence, not contingent on level of confidence.

Discussion

The principal finding of these experiments is that control affects risk attitude, when extended to the important case of a single domain. This supports the conclusion of Goodie (2003) that control affects risk attitude, but these findings suggest that the nature of that effect may be different within single domains than it is in mixed domains. Whereas in mixed domains participants showed betting proportions that were lower at low judged probabilities and higher at high judged probabilities (when compared to participants who bet on random events), participants who bet on their answers in this experiment accepted risk more often at all levels of confidence than those who bet on random events.

There is reason to believe that the results observed here, with questions drawn from single domains, have more external validity than those based on mixed domains, and thus generalize more to natural and applied decisions. This is because the present experiments satisfied the requirements of representative sampling (e.g., Gigerenzer, 1991). In addition to using a well-defined population of questions, this population was understood the same by researchers and participants; questions were selected randomly from the question population; and the random selection process was transparent to participants. This is a solution to the reference class problem, which arises when participants understand probability statements to apply to a different reference class than researchers' understanding, or when participants lack any clear understanding of the reference class.

Goodie (2003) discussed the possibility of modeling the impact of control in terms of the probability weighting function proposed by Gonzalez and Wu (1999). This weighting function includes two parameters that are notable for their psychological plausibility: elevation, which reflects the overall attractiveness of risk; and curvature, which reflects the discriminability of different levels of probability. Goodie (2003), interpreting the betting proportions that increased with judged probability, speculated that the data could be accounted for by positing diminished regressivity under conditions of control. The present data suggest that, at least under representative sampling, perceived control increases the elevation of the probability weighting function and also diminishes its regressivity.

It may be observed that overconfidence in these experiments was considerably less than in the prior experiments (Goodie, 2003) on risk attitude under conditions of control. In those studies, overconfidence averaged 7.1 percentage points. In these experiments, overconfidence averaged just 3.5 percentage points. Juslin, Winman, and Olsson (2000) have claimed that overconfidence is an artifact of disproportionately difficult question sets, pointing out a scarcity of data sets that simultaneously demonstrate overconfidence and accuracy in a two-alternative format greater than 75%. The current results are strikingly consistent with this reasoning. Two groups out of eight showed overconfidence greater than .06, and they were the only two groups with accuracy less than .70. Two other groups showed overconfidence between .05 and .06, and they were the only two with accuracy between .70 and .72. Among the three groups with accuracy greater than .75, the average overconfidence was -.003.

Experiments 5-6

In Experiments 1-4, the primary aim was to manipulate control to determine its impact on risky decisions in single domains. In Experiments 5 and 6, we sought to observe differences in competence both through experimental manipulation and correlationally, and to measure the impact of these differences on performance measures. One way to obtain diverse degrees of competence is to rely on naturally occurring variability in competence among participants, observing performance differences that depend correlationally on demonstrated knowledge in the content area. Another way is to observe differences that arise between groups when different groups are given questions that differ in difficulty. We did this by using the five question populations that were described previously – comparisons between pairs of U.S. states on population, land area and population density; and between pairs from among the fifty largest U.S. metropolitan areas on population and driving distance from Athens, Georgia. We assumed that some of these question populations would be more difficult than others, and could be identified by showing a sizable degree of variability in average accuracy between groups. We also assumed that some participants would be more competent in each content area than others, and these differences could be identified by variability in average accuracy within groups. Would people display different patterns of betting on a task characterized by control when they have different degrees of competence? If they did, then the competence hypothesis would be supported.

Heath and Tversky (1991) explained their conception of competence by saying "...people prefer to bet in a context where they consider themselves knowledgeable or competent than in a context where they feel ignorant or uninformed. We assume that our feeling of competence in a given context is determined by what we know relative to what can be known" (p. 7). In many important settings, such as subjective judgments or predicting future events, what participants perceive as knowable and as known depends on any number of subjective and objective considerations. In the case of answering questions about existing facts, however, the matter is more straightforward. The domains are completely knowable, and what is known is readily identified by means of correct answers.

Method

In Experiment 5, participants (N=112) were randomly divided into five groups, which differed in the domain of questions they were asked. Three groups answered questions seeking comparisons between pairs of randomly selected U.S. states on the dimensions of population (n=25), land area (n=25) and population density (n=25). The other two groups made binary comparisons between U.S. cities on the dimension of metropolitan area population (n=18) and driving distance from Athens, Georgia (n=19). The Confidence-Odds betting format was used in Experiment 5; Experiment 6 used the Gains-Only betting structure. Participants in Experiment 6 (N=152) were randomly divided into the same five groups as in Experiment 5: state population (n=32), land area (n=32) and population density (n=32), and city population (n=28) and driving distance (n=28).

Results

Confidence, accuracy and calibration. Confidence, accuracy and overconfidence values for both experiments are given in Table 3. Unlike in Experiments 1-4, differences in accuracy and confidence were not only expected, but were essential as a manipulation check for the impact of differential competence on betting. And indeed, the differences among groups were considerable, with average accuracy ranging from .706 to .856 in Experiment 5, and from .691 to .840 in Experiment 6. Average confidence ranged from .741 to .887. In a binary choice task, where the proportions are constrained to [.5,1], this overall accuracy range of .165 is considerable. The differences among groups were also statistically significant. In Experiment 5, for accuracy, F (4,171)=22.2, p<.05; for confidence, F (4,171)=22.6, p<.05. In Experiment 6, for accuracy, F(4,145)=18.9, p<.05; for confidence, F(4,145)=15.0, p<.05. Overconfidence was also found to be significantly different among groups in both experiments (in Experiment 5, F(4,171)=3.37, p<.05; in Experiment 6, F(4,145)=4.32, p<.05). Although theorists such as Juslin et al. (2000) would anticipate differences in overconfidence among groups that differ in accuracy, the obtained values do not show overconfidence systematically declining with accuracy.

Overall bet acceptance. Bet acceptance is presented in Figure 3 as a function of groups, shown in descending order of accuracy among groups. It can be seen that overall bet acceptance is closely correlated with accuracy at the group level – in Experiment 5, r=.98; in Experiment 6, r=.96. Such a correlation is the essential claim of the competence hypothesis, and so these very strong correlations constitute prima facie evidence for the competence hypothesis. It must be remembered that in such settings of betting on knowledge, betting frequency correlates positively with confidence. This is reflected in increasing betting curves. Accuracy also correlates with confidence, as can also be seen in Figure 3 – in Experiment 5, r=.88; in Experiment 6, r=.84. In short, when participants have competence, they also have high confidence, and this may account for the increased bet acceptance. Consequently, as Heath and Tversky (1991) did in their Experiment 4, domains must be compared at equivalent levels of confidence. We performed this analysis by comparing curves relating bet acceptance curves to confidence.

Bet acceptance curves. Betting proportions across confidence categories for the five groups in both experiments are shown in the two panels of Figure 4, and reflect increasing risk seeking as a function of subjective probability in all groups. Darker symbols reflect domains of greater accuracy. In general, the competence hypothesis predicts darker symbols to appear above lighter symbols, and this prediction receives relatively little support. It is clear that any differences between groups are small (for example, in comparison with the effect of confidence on bet acceptance). Each participant's curve was fitted to a linear function, and the resulting best-fit slopes and y-intercepts were analyzed for between-groups differences. The competence hypothesis predicts higher y-intercepts for higher accuracy, and differences in slope would also be of interest. The results of these analyses are shown in Figure 5. In Experiment 5, the main effect of group on intercept was significant ($F(4,171)=2.70$, $p<.05$), and the effect on slope was marginally significant ($F(4,168)=2.19$, $.05<p<.10$), but it is clear that the differences among groups were not systematically related to accuracy. In Experiment 6, neither effect was significant (both Fs<1). It would appear that the strong correlation between accuracy and overall bet acceptance is due, to a significant degree, to the facts that higher confidence attends higher accuracy, and increased betting attends increased confidence.

Individual variation. We also tested correlationally for the impact of individual variation in competence on bet acceptance curves. In each experiment, a partial correlation was computed for the slope and intercept of participants' best fitting linear betting curves, controlling for group assignment, as a function of accuracy. In Experiment 5, neither slope ($r(170)=.089$) nor intercept ($r(170)=-.038$) correlated significantly with accuracy. However, in Experiment 6, accuracy did correlate positively and significantly with intercept ($r(147)=.183$, $p<.05$), as predicted by the competence hypothesis.

Discussion

The results of these two experiments provide qualified support for the competence hypothesis. The correspondence between group-level accuracy and betting proportions is strikingly close. This was not the whole story, though, as the correlations between accuracy and confidence, and between confidence and betting proportion, needed to be taken into account. This was handled by constructing best-fitting curves for each participant and comparing the average between groups of participants' best fitting intercepts. This analysis did not provide much support for the competence hypothesis, but it was a test that was relatively sensitive to small variations in the data. In particular, the linear regressions used the bet acceptance rates within all seven confidence categories. If a confidence category were used infrequently by a particular participant, it could contribute considerable variability to the regression analysis. For example, if a confidence category were used only two times, its associated bet acceptance rate could be only 1.00, 0.50 or 0.00. If it were used only once, its bet acceptance rate could be only 1.00 or 0.00. For this reason, the intercept analyses may have been undesirably stringent, and the striking correlation at the group level between overall accuracy and bet acceptance, which is evident in Figure 3, should not be disregarded. The correlation between accuracy and overall betting was stronger than that between overall betting and confidence, so it is not reasonable to conclude that the latter accounts entirely for the former. Furthermore, at the individual level, the partial correlation between accuracy and betting curve elevation was significant in Experiment 6, though not in Experiment 5.

Experiment 7

In Experiment 7, we sampled subjective measures of both competence and control. In the previous experiments, competence was defined objectively as accuracy among existing facts, and control as probability alterability. In this experiment, we replicated the methods of the earlier experiments, but sought further to examine how participants' perceptions of their competence and control correlated with performance measures.

Method

In this experiment, 185 new participants were recruited. Only one question domain (state population comparisons) was used, and the Gains-Only betting format was used. Participants were divided into Answers (n=92) and Random groups (n=93), which considered bets that were constructed as their counterparts' were in Experiments 1-4. In the first two phases, then, this study was a replication of Experiment 3. In a third phase, the following survey questions were asked of all participants:

1. How competent do you feel you are at this task?
2. How do you think your abilities at this task compare to others?
3. How much control do you feel you had over this task?
4. If you were to do this task again one week from now, how much could you do between now and then to improve your performance?

All responses were made on a seven-point scale. The first two questions were intended to reflect responses respectively to the term "competence" and to a definition of competence. The last two were correspondingly intended to reflect responses to the term "control" and the definition of control utilized by Goodie (2003). It may be noted that the definition of competence conveyed in Question 2 reflects just one of multiple possible definitions, which is social in nature – comparing one's competence with that of others. For both Heath and Tversky (1991) and Fox and Tversky (1995), this is optional. Both series of studies operationalized competence sometimes by comparisons with others, and sometimes by noncomparative judgments. We framed the survey question in a social-comparative way because non-comparative questions appeared to offer little more than synonyms of "competence."

Results and Discussion

Calibration, overall bet acceptance and bet acceptance curves. Average confidence across both groups was .759, average accuracy was .751, and average overconfidence was .007. The difference between the two groups was less than .007, and statistically non-significant, for all three measures. Calibration curves are given for the two groups in Figure 6a.

Once again, those betting on their own knowledge bet considerably more frequently than those betting on events that were identical in every statistical way but appeared random. The Answers group accepted 71.9 percent of all bets, whereas the Random group accepted only 45.6 percent of all bets. This difference was statistically significant ($t(183)=4.46$, $p<.05$). Recall that, like Experiments 1-4 but unlike Experiments 5-6, average confidence was equivalent between groups, so these values are directly comparable. The large effect of perceived control was thus replicated. Betting proportions across confidence categories for all three groups are shown in Figure 6b and reflect greater risk acceptance in all confidence categories when control prevails. The difference between the groups' linear betting curves at the individual level were significant for both intercept ($t(183)=4.46$; $p<.05$) and slope ($t(183)=2.61$; $p<.05$).

Survey results. Survey results are depicted in Figure 7. On the seven-point scale that we used, there was a large difference between the groups in the perception of control as defined here (Question 4, $t(183)=11.68$, $p<.05$). There was also a marginally significant effect on responding to the term "control" (Question 3, $t(183)=1.78$, $p=.077$). There was also a small but statistically significant difference between the groups ($t(182)=2.30$; $p<.05$) in perceptions of "competence" (Question 1), but in the opposite direction to that predicted by the competence hypothesis, with the Random group perceiving more competence than the Answers group. There was no difference between groups in perceptions of the social-comparative definition of competence (Question 2). It would appear from these survey data that, in the minds of our participants, the concept of control as defined here is prominent in explaining the effect of the control manipulation on risk taking. The term "control" proved less compelling a description of the difference for our participants. The term “competence,” however, and its social-comparative were not able to account for how the groups perceived their conditions.

General Discussion

In seven experiments, risk attitude was assessed where the risky alternative was not only risky but ambiguous, and not only ambiguous but based on ability rather than a random event. This is a special case in the decision making literature, which has been treated both in terms of competence (Heath & Tversky, 1991) and control (Goodie, 2003). Control has been defined as a characteristic of the task wherein steps exist that could improve one’s performance. Competence is an interactive property of both the task and the individual, wherein differential performance is possible, and the participant has attained a sufficient degree of advantageous performance, relative to either an absolute or a social standard. For example, if a participant did poorly on a general knowledge quiz, she could study almanacs before trying another such quiz. According to the competence hypothesis, effects on betting might occur only after such improvement has taken place. According to the control hypothesis, it is the possibility of improvement that makes a difference. Experiments 1-4 sought to ascertain the existence of a control effect within single domains, much as Heath and Tversky (1991) had done with competence. Experiments 5-6 sought evidence for a role of competence in risk attitude. Experiment 7 sought to determine whether performance measures covaried with participants’ perceptions of the terms “control” and “competence,” or with their meanings.

Summary. In Experiments 1-4, using representative sampling in single domains, and with all statistical properties of bets held constant between groups, participants consistently accepted more bets when betting on their answers than when betting on random events. At all confidence levels in all experiments, those betting on their answers bet more frequently than those betting on a random event. These results provided strong support for the role of control in decision making.

In Experiments 5-6, overall bet acceptance was closely correlated with accuracy at the group level. Such a correlation is the essential claim of the competence hypothesis, and so these very strong correlations constitute prima facie evidence for the competence hypothesis. Comparing best-fitting linear intercepts to control for the correlation between confidence and bet acceptance, higher degrees of accuracy did not in all cases correlate significantly with more elevated bet acceptance curves between groups. However, within groups there was a significant correlation between accuracy and intercept in Experiment 6.

In Experiment 7, as in Experiments 1-4, those betting on their own knowledge bet considerably more frequently than those betting on events that were identical in every statistical way but appeared random. There was a large difference between the groups in the perception of control as defined here, and a marginally significant effect on responding to the term "control." There was no difference between groups in perceptions of the term "competence" or its social-comparative definition.

<u>Competence, control or both?</u> Do the present data reflect support for the control hypothesis, the competence hypothesis, or both? We believe the answer is: both. Experiments 1-4 and 7 all showed strong effects of a skill element on risk acceptance. Importantly, those experiments used the question domains of city population and state population, which proved to be among the domains with the lowest accuracy in Experiments 5-6. Across all the experiments, the average accuracy using these two

question domains with binary response options was less than .75, and lower than other domains. Yet, participants consistently chose to bet on them much more frequently than on an equivalent random event. This provides evidence for an effect of control even when competence is relatively low.

Furthermore, in Experiment 7, the perceptions of participants suggested that the manipulation that had a profound impact on bet acceptance also affected probability alterability and, to an extent that was only marginally statistically significant, the term “control.” Any effect of either the term “competence” or the concept of competence as defined in that experiment was in the direction opposite to that predicted by the competence hypothesis. This may be attributable at least in part to low accuracy; it is plausible that in a similar setting but with easier questions, competence may have been rated higher among those betting on their own answers. The conclusion remains, however, that control increases risk taking, even when competence is relatively low.

The present findings do not constitute strong evidence against the competence hypothesis, only evidence that control exerts an effect across a range of levels of competence. We also found clear evidence to favor the competence hypothesis – that is, that people accept risk more often when they perceive themselves to be competent than when they do not. In Experiments 5 and 6, bet acceptance at the group level correlated extremely closely with accuracy, which is the essential prediction of the competence hypothesis. It was noted that bet acceptance and accuracy both correlate with confidence. When confidence was controlled for by examining bet acceptance curves, there was no group-level correlation between the intercept (overall elevation) of the betting curves and average accuracy within groups. This was an extremely stringent test, however. When tested at an individual level, with a partial correlation between accuracy and intercept controlling for group, a significant effect was observed in Experiment 6.

Finally, there is a major difference between these studies, using questions from single domains, and those of Goodie (2003), which used questions from mixed domains. In those studies, bet acceptance was found to be low (Experiments 1 and 2), and lower than bet acceptance on matched random events (Experiment 3) at low levels of confidence. As Heath and Tversky (1991) noted in discussing the differences between single and mixed domains, low confidence items in mixed-domain populations will systematically include more questions from low-competence domains. When these low competence domains are removed in tests using single domains, bet acceptance at the lowest levels of confidence increases. The comparison between the present experiments and those of Goodie (2003) thus supports the competence hypothesis.

We propose that control and competence both have a real impact on risk attitude, perhaps such as is depicted in Figure 8. Control (a skill element) has a main effect on risk acceptance, such that people accept risk more with control than without it. Among tasks characterized by control, participants accept risk more readily in tasks on which they feel more competent. As depicted in the dashed line, however, extremely low degrees of competence may diminish risk taking more than control increases risk taking, so that participants accept more bets on random events than they do in low-competence skilled domains.

<u>Why did these studies find less strong evidence for the competence hypothesis?</u> The evidence to support the competence hypothesis was less strong in these studies than in those of Heath and Tversky (1991). Perhaps the most striking finding of those studies

came in Experiment 4, where participants who perceived themselves as competent in one domain but incompetent in another consistently preferred to bet on a random event rather than an event of matched probability in the domain of incompetence. We didn't observe such an effect in these studies – any time participants could bet on their answers, they were considerably more prone to do so than bet on a random event, even when their answers were not especially competent.

Why the difference? We suspect that the answer may relate to a special feature of Heath and Tversky's sample. They sought participants who felt themselves of above-average competence in either football or political prediction, and also of below-average competence in the other domain. Of 110 participants they screened, 25 (23 percent) fit this criterion and constituted the sample. (Two of the 25 declined to participate.) If participants were well calibrated in evaluating their own abilities, and if these ratings were independent of each other, then half of all screened participants would fall on opposite sides of the median on the two measures. But less than a quarter satisfied the criterion. Most of the screened participants self-evaluated on the same side of the median for both tasks and were thus excluded. The data reflected only the rather small minority who placed themselves on opposite sides of the median for the two tasks. This could reveal participants who feel particularly weak competence in the weak area, which would be reflected in the dashed line of Figure 8. The larger effect observed by Heath and Tversky could also be attributable to their use of within-subjects designs, which may highlight comparisons among the three kinds of bets they employed to a degree that does not commonly occur in natural decision contexts.

It could be argued that our domains were all essentially similar, exclusively asking questions about demographic characteristics of U.S. cities and states. Indeed, it may well be that, had we used domains of lesser competence, the reversal depicted in the dashed line of Figure 8 would have prevailed. Still, our selected domains encompassed a wide range of mean accuracy levels, including some that fell below 75%. And even the most difficult of these induced more bet acceptance than random events did.

Probability weighting and control. Goodie (2003) suggested that, within the framework of prospect theory (Kahneman & Tversky, 1979), the impact of control on decision making might most fruitfully be attributed to an impact on the probability weighting function, considered within the formal model offered by Gonzalez and Wu (1999). In those studies, risk acceptance under conditions of control interacted with confidence, compared with conditions of no control, such that bets were accepted less often with control at low probabilities, and more often with control at high probabilities. Goodie (2003) attributed this to an impact on the discriminability of probabilities. In the current experiments, there was no such interaction: bets were accepted more often with control than without, across the entire spectrum of subjective probability. Thus, in the terms of Gonzalez and Wu's (1999) model, the effect may be better attributed to attractiveness. In short, people accept more risk under conditions of control than under conditions of no control. The idea of making weighting functions sensitive to properties of the setting other than perceived probability is not new. Kilka and Weber (2001) suggested that the probability weighting function should be "source dependent," which in their study reflected the degree of competence participants perceived in the domain of the uncertain judgment.

March and Shapira (1987) famously cautioned decision theorists that organizational managers view the risks they take as being fundamentally different from gambling. To the extent this is true, it diminishes the applicability to applied management settings of the wealth of empirical decision research using real or hypothetical lottery pulls, rolls of dice, or drawing poker chips from bookbags. They noted prior literature pointing to the perceived controllability of risk (which is defined as altering the odds of success), though for the case of organizational managers they ultimately reject this as a fundamental source of their decisions. Instead, they conclude, a bit cynically, that the distinction is a matter of “managerial conceit.” Managers suppose that the risks they take are different from (and better than) gambling because they are trained by societal norms to think so, and also because among managers whose decisions have coincidentally succeeded, just as among a convention of lottery winners, the relative rate of winning is greater than the odds that are built into the game.

We do not deny March and Shapira’s conclusion that the norms of society and the conceits of managers play a role in managerial decision making. Still, in both managerial settings and many other settings where real or illusory control prevails – that is, where one’s actions are thought to make a difference in the probability of success – that control itself, as well as the competence that the decision maker has attained within the domain, may make a difference. The current studies suggest that they both do, which may benefit future research in management and other applied decision areas.

Endnote

[1] State population was taken as the 1999 Census Bureau estimate, and population density was the ratio of population to land area. Questions involving city comparisons used the 50 largest metropolitan areas in the continental U.S., to eliminate the confusion involved in considering driving distance from the mainland U.S. to San Juan, Puerto Rico (the 20th largest metropolitan area). No cities in Alaska or Hawaii were excluded by the "continental" requirement. City population was taken as the population of the entire metropolitan area as identified by the Census Bureau (this was made clear in the instructions), and driving distance was the distance to the central city.

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Figure Captions

Figure 1. Confidence calibration in (a) Experiment 1, (b) Experiment 2, (c) Experiment 3, and (d) Experiment 4. Confidence, accuracy and overconfidence were essentially equal between the groups in all four experiments.

Figure 2. Proportions of bets that were accepted in (a) Experiment 1, (b) Experiment 2, (c) Experiment 3, and (d) Experiment 4. At all confidence levels in all experiments, bets were accepted more frequently on answers than on random events.

Figure 3. Overall bet acceptance, accuracy and confidence in the five groups in (a) Experiment 5 and (b) Experiment 6. Bet acceptance was strongly correlated with accuracy, but this could be partly attributable to correlations between accuracy and confidence.

Figure 4. Bet acceptance among the five groups in (a) Experiment 5 and (b) Experiment 6. Groups with higher accuracy are depicted in darker symbols.

Figure 5. Slope and intercept of best-fitting linear betting curves in the five groups in (a) Experiment 5 and (b) Experiment 6. No systematic effect of accuracy is seen on slope or intercept.

Figure 6. (a) Confidence calibration and (b) bet acceptance in the two groups in Experiment 7. As in Experiments 1-4, all calibration measures are equivalent, but the Answers group accepted significant more bets.

Figure 7. Survey results in Experiment 7. All responses were made on a scale from 1 to 7. * - statistically significant

Figure 8. A potential combinatorial relationship between the impact of control and competence.

Table 1. Average confidence, accuracy and overconfidence in Experiments 1-4, and comparisons between Answers and Random groups.

Confidence

Experiment	Answers	Random	t	df	p
1	.751	.753	.07	74	.95
2	.768	.764	.21	65	.83
3	.780	.726	2.31	46	.026 *
4	.778	.756	.80	33	.43

Accuracy

Experiment	Answers	Random	t	df	p
1	.745	.757	.73	74	.47
2	.713	.713	.01	65	.99
3	.760	.751	.50	46	.61
4	.665	.694	1.07	33	.29

Overconfidence

Experiment	Answers	Random	t	df	p
1	.007	-.004	.57	74	.57
2	.055	.051	.19	65	.85
3	.020	-.025	1.52	46	.14
4	.113	.062	1.33	33	.051

* p < .05

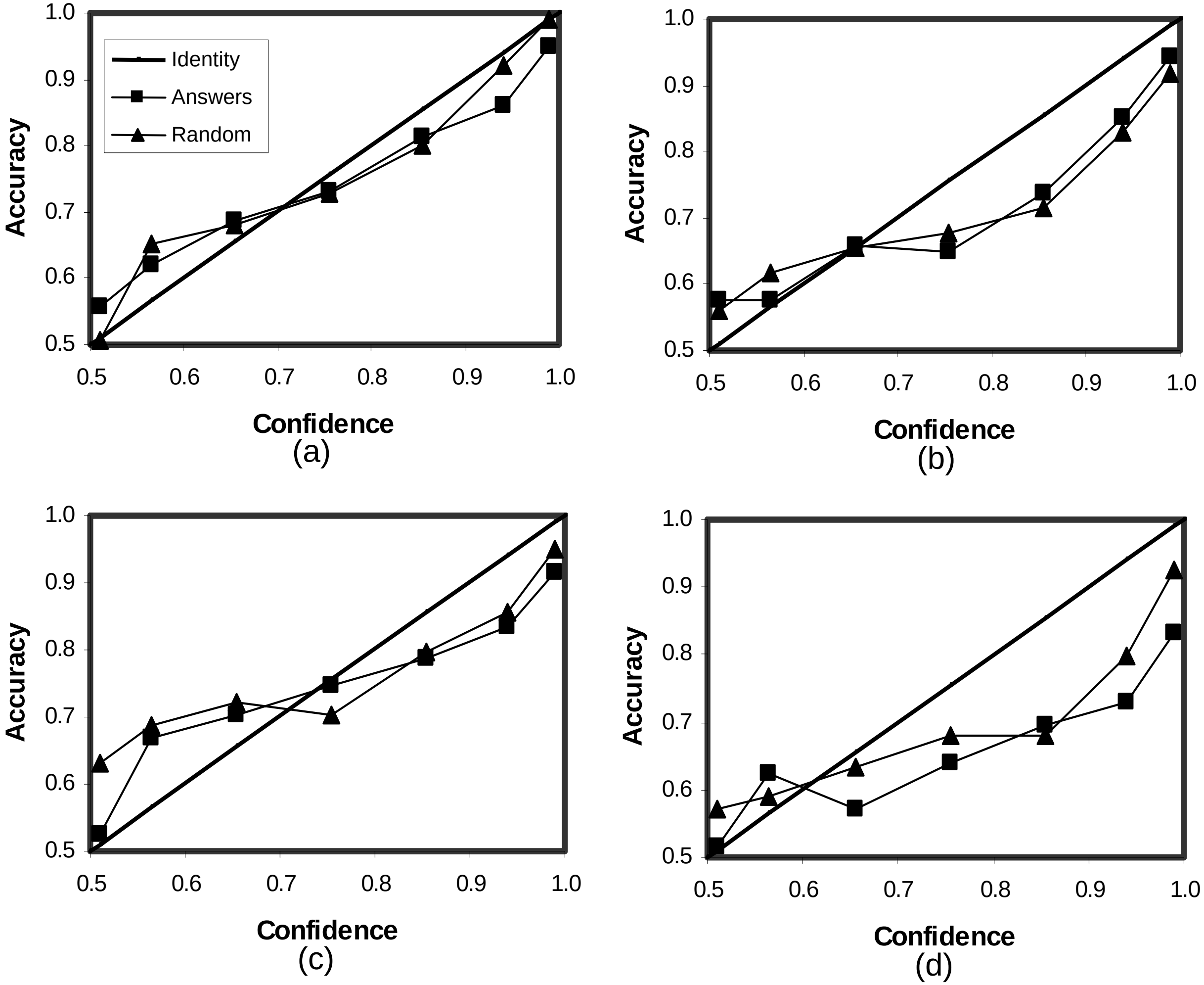
Table 2. Overall proportions of bets accepted on answers and random events in Experiments 1-4.

Experiment	Answers	Random	t	df	p
1	.739	.552	4.17	74	.000
2	.738	.621	2.41	65	.019
3	.802	.550	4.90	46	.000
4	.752	.498	2.67	33	.012
Average	.758	.555			

Table 3. Descriptive statistics of confidence, accuracy, overconfidence and betting slope within the groups in Experiments 5 and 6.

Experiment 5	Accuracy	Confidence	Overconfidence
City driving distance	.856	.887	.030
State area	.799	.843	.044
State population	.746	.711	-.035
State population density	.707	.742	.035
City population	.706	.758	.053
Experiment 6			
City driving distance	.840	.868	.028
State area	.778	.817	.039
State population density	.764	.730	-.033
State population	.730	.751	.021
City population	.691	.741	.049

Note: Groups are listed in declining order of accuracy in each experiment. The groups did not show the same ordering of accuracy in both experiments.



Identity
Answers
Random
Accuracy
Confidence
1.0
0.9
0.8
0.7
0.6
0.5
0.5
0.6
0.7
0.8
0.9
1.0
(a)
(b)
(c)
(d)

Figure 1

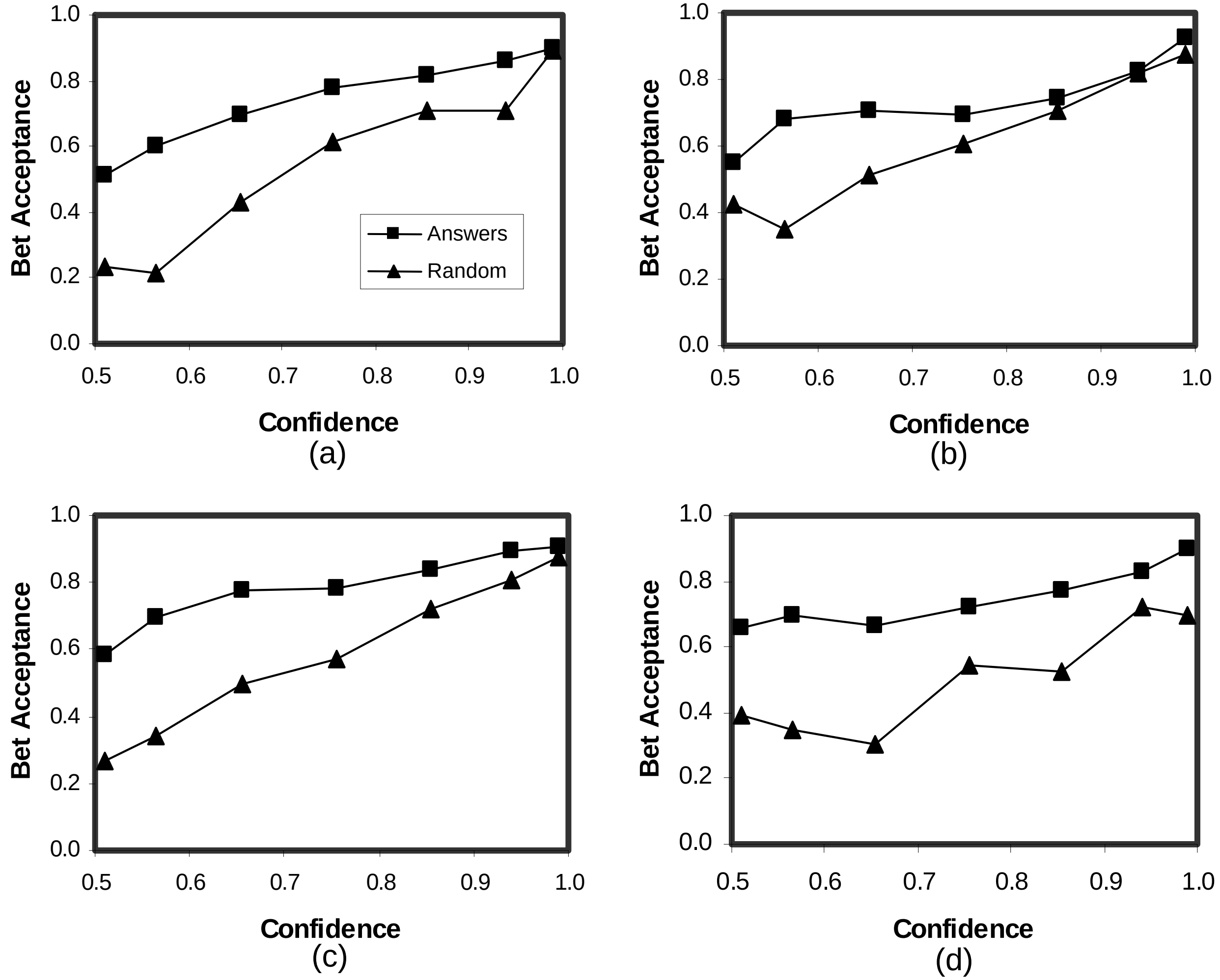
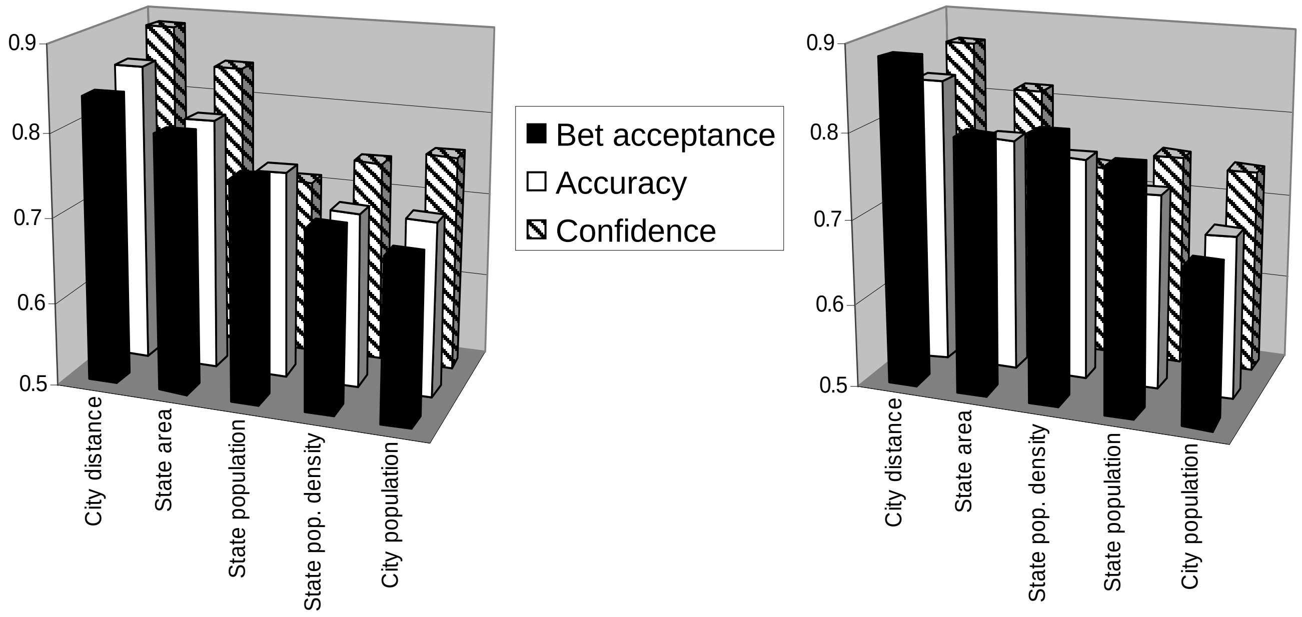
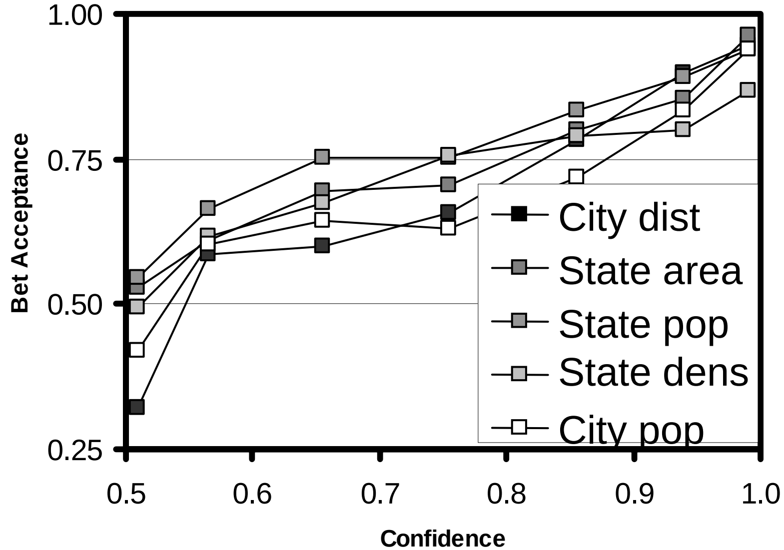

1.0
0.8
0.6
0.4
0.2
0.0
Bet Acceptance
0.5
0.6
0.7
0.8
0.9
1.0
Confidence
(a)
Answers
Random
(b)
(c)
(d)

Figure 2


0.9
0.8
0.7
0.6
0.5
City distance
State area
State population
State pop. density
City population
Bet acceptance
Accuracy
Confidence
City distance
State area
State pop. density
State population
City population

(a) (b)

Figure 3


1.00
0.75
0.50
0.25
Bet Acceptance
0.5
0.6
0.7
0.8
0.9
1.0
Confidence
City dist
State area
State pop
State dens
City pop
(a)

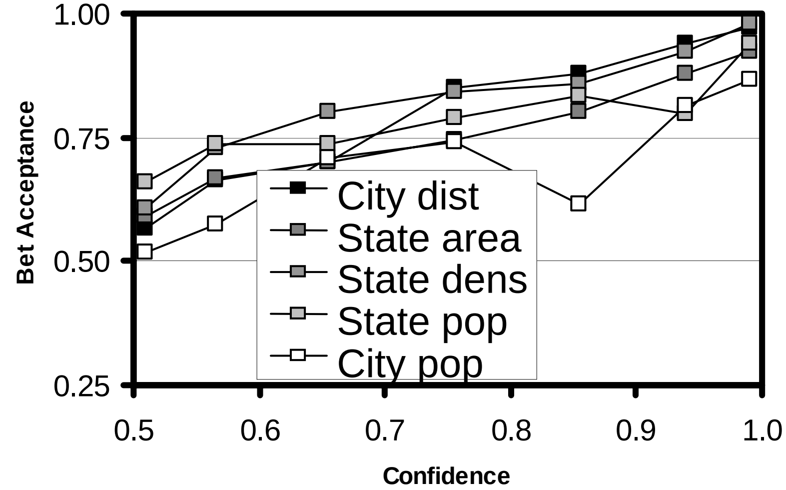
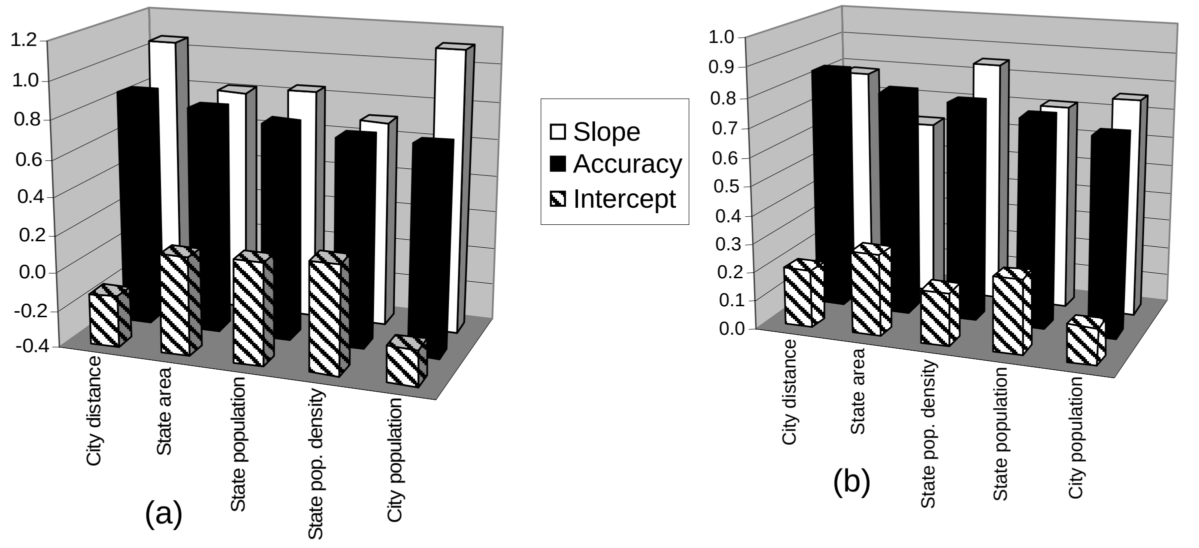
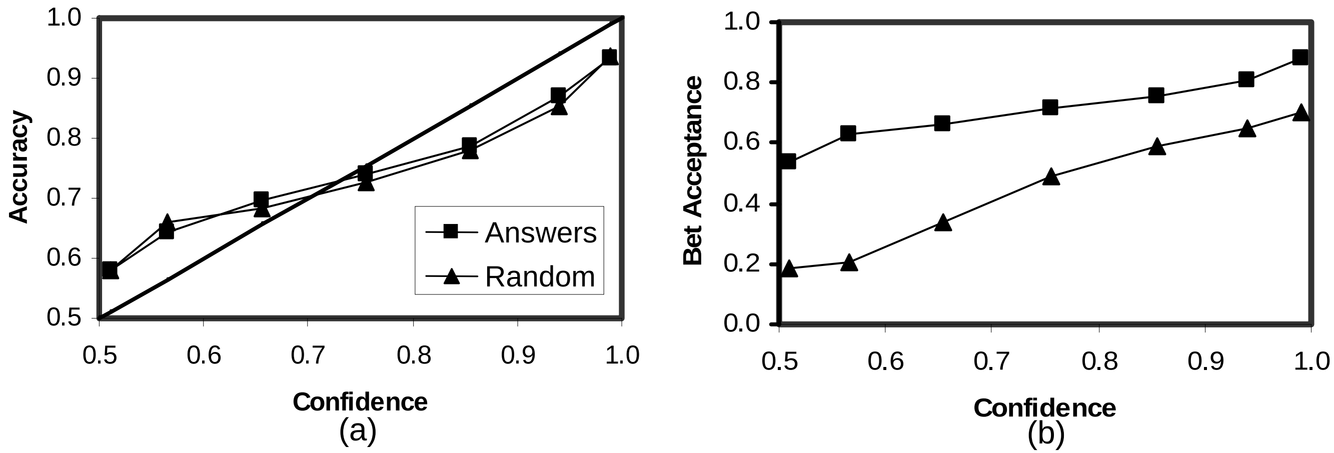

1.00
0.75
0.50
0.25
Bet Acceptance
0.5
0.6
0.7
0.8
0.9
1.0
Confidence
City dist
State area
State dens
State pop
City pop
(b)

Figure 4



1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
City distance
State area
State population
State pop. density
City population
(a)
Slope
Accuracy
Intercept
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
City distance
State area
State pop. density
State population
City population
(b)

Figure 5



Accuracy
1.0
0.9
0.8
0.7
0.6
0.5
0.5
0.6
0.7
0.8
0.9
1.0
Confidence
Answers
Random
(a)
Bet Acceptance
1.0
0.8
0.6
0.4
0.2
0.0
0.5
0.6
0.7
0.8
0.9
1.0
Confidence
(b)

Figure 6

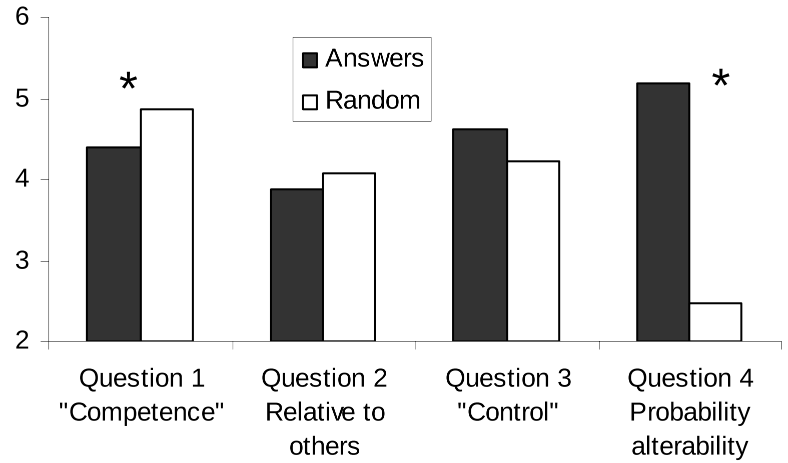

6
5
4
3
2
Answers
Random
*
*
Question 1 "Competence"
Question 2 Relative to others
Question 3 "Control"
Question 4 Probability alterability

Figure 7

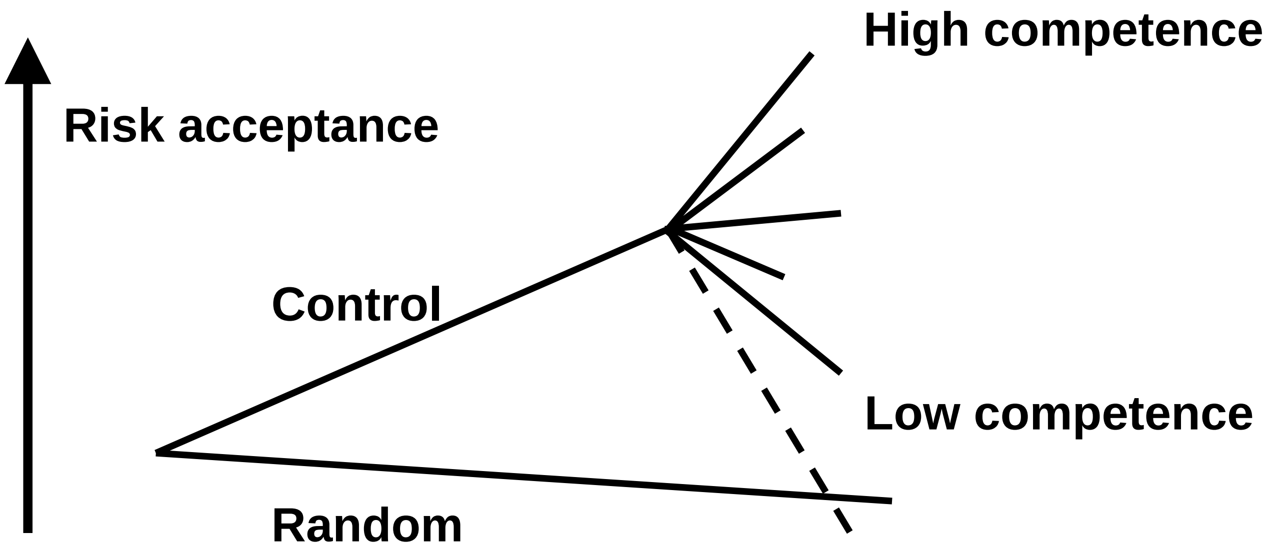

High competence
Risk acceptance
Control
Low competence
Random

Figure 8