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Adam J.L. Harris [a], Martin G. Rowley [b], Sarah R. Beck [c], Elizabeth J. Robinson [a] & Kerry L. McColgan [a]

[a] Department of Psychology, University of Warwick, Coventry, UK

[b] School of Psychology, Keele University, Keele, UK

[c] School of Psychology, University of Birmingham, Birmingham, UK

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Agency affects adults', but not children's, guessing preferences in a game of chance

Adam J.L. Harris[1], Martin G. Rowley[2], Sarah R. Beck[3], Elizabeth J. Robinson[1], and Kerry L. McColgan[1]

[1]Department of Psychology, University of Warwick, Coventry, UK
[2]School of Psychology, Keele University, Keele, UK
[3]School of Psychology, University of Birmingham, Birmingham, UK

Adults and children have recently been shown to prefer guessing the outcome of a die roll after the die has been rolled (but remained out of sight) rather than before it has been rolled. This result is contrary to the predictions of the competence hypothesis (Heath & Tversky, 1991), which proposes that people are sensitive to the degree of their *relative* ignorance and therefore prefer to guess about an outcome it is impossible to know, rather than one that they could know, but do not. We investigated the potential role of agency in guessing preferences about a novel game of chance. When the experimenter controlled the outcome, we replicated the finding that adults and 5- to 6-year-old children preferred to make their guess after the outcome had been determined. For adults only, this preference reversed when they exerted control over the outcome about which they were guessing. The adult data appear best explained by a modified version of the competence hypothesis that highlights the notion of control or responsibility. It is proposed that potential attributions of blame are related to the guesser's role in determining the outcome. The child data were consistent with an imagination-based account of guessing preferences.

Keywords: Agency; Competence hypothesis; Developmental; Games of chance; Uncertainty.

To a greater or lesser extent, every aspect of human life is characterized by uncertainty. Will it rain later today? Will the 1045 train get Jane to London in time for her 1300 meeting? Is James's current girlfriend the love of his life? In order to function successfully, people must be able to live with uncertainty in their lives. We must often, therefore, make judgements based on uncertainty (should I carry my umbrella to work tomorrow?). In some situations, however, people will also make *guesses*. For example, guesses of red or black in a game of roulette, guessing whether the next card drawn from the top of a deck of cards will be higher or lower than the previous one, or guessing the outcome of a fair coin flip. In this paper, we are concerned with guesses. An understanding of guessing

Correspondence should be addressed to Sarah R. Beck, School of Psychology, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK. E-mail: s.r.beck@bham.ac.uk

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Adam Harris is now at Department of Cognitive, Perceptual and Brain Sciences, University College London, UK

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preferences is of theoretical importance, as in the absence of all other knowledge, a person's expectations, which inform decisions and thus future behaviour, can only be guided by guesswork.

Not all guesses are made under the same conditions, however. Even if the probability of success is kept constant, there exist other differences. These can be illustrated with respect to the "games of chance" represented in the above examples. If played properly, no skill is involved in making a correct guess about the spin of a roulette wheel, the draw of a card from a deck, or the flip of a coin. These events do, however, differ in whether or not an outcome has already been determined. Before the ball bearing settles in a roulette wheel, there is no objective reality as to what number it will settle on. That is, the outcome is as yet undetermined, a state we refer to as one of physical uncertainty. Before a card is picked from the top of a deck, however, there is an objective reality as to what card will be drawn. In a fair game, the identity of that card is determined once the deck has been shuffled, and there is, therefore, an objective reality. The uncertainty exists only because the guesser does not know the state of that reality. We refer to this state as epistemic uncertainty.[1]. A coin flip can be performed in such a way that it more closely resembles a roulette game, by asking the guesser to guess before the coin is flipped, or a card pick, by asking the guesser to guess when the coin is hidden beneath the flipper's hand. Objectively, the guesser has the same chance of success in both these latter two conditions, but subjectively he or she might be more willing to guess in one than in the other. Under what conditions might such preferences occur, and what might explain any such preferences?

The competence hypothesis (Heath & Tversky, 1991, p. 7) asserts that people would rather guess in contexts "where they consider themselves knowledgeable or competent than in contexts where they feel ignorant or uninformed". Furthermore, Heath and Tversky assume that subjective feelings of competence are determined by what people know relative to what they could know. A preference for guessing in contexts where people feel relatively competent is assumed to arise because of imbalances between potential attributions of credit and blame. The competence hypothesis neatly predicts the patterns of data that Heath and Tversky present in their studies, showing that people preferred to bet on their judgements when they were well informed about those judgements, but they preferred to bet on a chance lottery (whose probability of success was matched to participants' subjective probability ratings for the chance of being successful in the judgement task) when they were relatively ignorant. The competence account proposes that when people make a judgement about which they feel knowledgeable, this knowledge enables them to accept credit if they are correct, but also provides protection against blame should they be incorrect (because they are able to provide a reasonable justification of their judgements). When, however, they have made a judgement from a position of relative ignorance, they may be susceptible to blame for an incorrect response, whereas a correct judgement might be attributable to luck. This creates an imbalance in the likelihood of receiving blame versus credit. Because of this imbalance, if people feel relatively ignorant they will prefer not to make a judgement, so as to save face by avoiding the blame associated with a wrong judgement. For a lottery, which specifies which numbers will be "winners" (with the others nonwinners) before the drawing of a numbered ball (as in Heath & Tversky, 1991), there is less potential for the attribution of credit or blame following a successful or nonsuccessful draw.

The competence hypothesis has primarily been proposed as an explanation for data demonstrating that people would rather bet on a risky lottery (one with stated probabilities of success) than an ambiguous one (where the probabilities are not stated) (Ellsberg, 1961; see also, Keppe & Weber, 1995). This is because people prefer to bet in contexts where they feel knowledgeable than where they feel ignorant (e.g., of the

[1]Our use of terminology, physical versus epistemic uncertainty, follows Robinson, Rowley, Beck, Carroll, and Apperly, 2006).

probabilities in a lottery; Heath & Tversky, 1991). Heath and Tversky, however, explicitly generalized the competence hypothesis to account for results relating to guessing preferences about purely chance events—specifically, the previously published result that adults prefer to make guesses and bet more money on chance outcomes under conditions of physical rather than epistemic uncertainty (Brun & Teigen, 1990; Chow & Sarin, 2002; Rothbart & Snyder, 1970). For example, Rothbart and Snyder found that people bet more money on the outcome of a die roll before the die was rolled, rather than when it was out of sight having been rolled. In the former instance there is nothing that could be known, whereas in the latter instance there is an outcome that could be known, but the participant does not know it and is therefore "relatively ignorant".

Robinson, Pendle, Rowley, Beck, and McColgan (2009) observed that the majority of extant data demonstrating a pattern of guessing preferences whereby people preferred to guess under physical rather than epistemic uncertainty were obtained from "simulation" experiments in which participants were required to imagine rolling a die and then to choose the time point at which they would prefer to guess. In a systematic empirical investigation, Robinson et al. demonstrated a disassociation between adults' guessing preferences for live and imagined scenarios. All the experiments concerned the outcome of a die roll, but whilst the expected preference for guessing under physical uncertainty was replicated in "imagined" conditions, the preference switched for the "live" events. After live practice trials in which participants first experienced guessing under both physical and epistemic uncertainty, a significant proportion of adult participants subsequently preferred to guess under epistemic uncertainty. The same result using the live events was observed with 17-year-olds, 15-year-olds and 5- to 8-year-olds. Robinson et al. thus concluded that in reality the competence hypothesis does not extend to purely chance events and that the findings from "imagined" scenarios result from inaccurate mental simulations. To explain the "live" results, Robinson et al. offered an account in terms of ambiguity aversion (e.g., Ellsberg, 1961). In the live tasks, Robinson et al.'s adult participants tended to explain their preferences with reference to feeling uneasy about guessing an outcome that does not exist (physical uncertainty), as opposed to an outcome that does at least have a reality (epistemic uncertainty). Although the same preferences were observed in adults and children, it is not clear that they were driven by the same underlying cognitive mechanism. Indeed, the concluding sentence in Robinson et al. (2009, p. 658) poses the question "To what extent do adults' and children's preferences for guessing . . . arise from the same underlying mechanism . . . ?". Were there situations in which adults' and children's preferences disassociate, these would support the supposition that their guessing preferences are driven by different underlying mechanisms, directly addressing Robinson et al.'s final question.

The aim of the present study was to provide a further test of the limits of the competence hypothesis in both adults and children. Specifically, we sought to investigate the effect of agency on guessing preferences. If people wish to avoid guessing in situations where they can be blamed for a wrong answer (in line with the competence hypothesis), then when they "control" a chance outcome they might prefer to guess under conditions of physical than epistemic uncertainty. Contrastingly, when a third person controls the chance outcome, there is no reason for guessing preferences to be different from the pattern observed in Robinson et al. (2009)—that is, a preference for guessing under epistemic uncertainty. The term "control" requires some clarification in this context. A standard definition of control might be that an agent can alter the subjective probability of an outcome's occurrence (e.g., Goodie, 2003). Of course, only perception of such control is necessary, as in Rothbart and Snyder's (1970) proposal that their participants had an illusion of control that they could alter the probability of throwing a particular number on a dice roll and therefore preferred to guess before throwing. Robinson et al. used "real" live dice throwing, in which participants received practice trials for guessing at the different time points, an

inclusion that Robinson et al. argue is necessary to move from "simulated" to "live" events. Under these conditions, participants preferred to guess under epistemic than physical uncertainty regardless of whether they threw the die or whether the experimenter threw it. Thus, an illusion of control cannot explain guessing preferences with dice throwing. In the present context, control of a chance outcome relates to a situation in which a conscious decision made by the participant obviously and predictably affects the outcome, although without the participant being able to alter the subjective probability of an outcome's occurrence, thus maintaining the chance element of the game. Specifically, in the present study, one of five pens was picked from a pot. Although the pens all looked identical, their ink was of five different colours. Participants were required to guess the colour of a circle drawn with a picked pen. What is novel in this task is that the pen that is picked from the pot is under the conscious and obvious control of the picker, although the ink colour is not. This is what we here refer to as control of a chance outcome.

Adults and the pens game

Although knowing that they themselves are equally ignorant as to the colour of the circle under both physical and epistemic uncertainty, participants might infer that other people would expect them to have some knowledge under epistemic uncertainty—after all, they chose the pen and drew the circle themselves. It is this fear of blame, or fear of negative evaluation (see also, Curley, Yates, & Abrams, 1986; Trautmann, Vieider, & Wakker, 2008) that we predict will lead participants who pick their own pen to exhibit a preference for guessing under physical rather than epistemic uncertainty, in line with the predictions of the competence hypothesis (Heath & Tversky, 1991).

Children and the pens game

By six years old, it is cognitively viable that children could be susceptible to feelings of relative (in)competence in their guessing preferences. Robinson et al. (2009) drew an analogy between studies investigating children's evaluations of regret and the likelihood that children might be affected by feelings of relative (in)competence. This analogy was based on the similar cognitive requirements for these evaluations: specifically, requirements of counterfactual thinking and the evaluative comparison of the counterfactual state with the experienced reality. Three studies have investigated children's propensity to experience regret themselves (Amsel, Robbins, Tumarkin, Foulkes, Janit, & Smalley, 1999, as cited in Amsel & Smalley, 2000; Burns, Riggs, & Beck, 2010; Weisberg & Beck, 2010). Amsel et al. failed to observe feelings of regret in children aged 3 to 5 years old. In a similar task, Weisberg and Beck (see also, Burns et al., 2010) demonstrated adult-like experienced regret in 5- to 6-year-old children. Thus, 5- to 6-year-olds could be sensitive to feelings of relative (in)competence in their guessing preferences. Recent evidence, however, suggests that children's guessing preferences are susceptible to different biases. In their live dice tasks, Robinson et al. (2009) demonstrated that, like adults, children preferred to guess under epistemic rather than physical uncertainty. Beck, McColgan, Robinson, and Rowley (2010) account for this, their own, and related findings (McColgan, Robinson, Beck, & Rowley, 2010; Robinson et al., 2006) as resulting from children imagining an outcome that has already occurred under epistemic uncertainty and inferring from this rich, imagined image that this is the correct outcome. Thus, children fail to appreciate the uncertainty that still exists. In one task, Robinson et al. (2006) provided children with the task of ensuring that they caught an object that was to be pushed through one of two possible doors (which door it was to be pushed through was determined by a 50:50 chance draw). They could do this by placing mats beneath both possible doors. Although 87% of children correctly put out two mats under physical uncertainty, under epistemic uncertainty (once the object was already hidden behind a door) only 43% of 5- to 6-year-olds correctly put out two mats. The remaining 57% put out only one mat, suggesting

that they already thought they knew which door the object would fall from. Beck et al. (2010) tested their imagination-based account by manipulating the ease with which children could imagine the outcome. Using a similar "doors" apparatus to Robinson et al. (2006), either children knew that a pom-pom, drawn from a transparent box, was to be hidden behind a door (the "specified" condition), or they were told that "something", drawn from an opaque box, would be hidden behind a door (in the "unspecified" condition). In Experiment 1, children only exhibited a preference for guessing under epistemic uncertainty in the specified condition. In the unspecified condition, children were equally likely to indicate a preference for guessing under physical as under epistemic uncertainty. Further evidence for the imagination account came from Experiment 2, in which children were required to put out either one or two "mats" in order to catch an object that was already hidden behind a door that it would subsequently be pushed through (as in Robinson et al., 2006). Children were less likely to correctly put two mats out (one under each door) in the specified condition, suggesting that their imagination led them to act as though they knew the outcome under these conditions.

Robinson and colleagues' previous results, together with the identification of a mechanism to explain them (Beck et al., 2010), therefore makes it likely that children will prefer to guess under epistemic uncertainty regardless of who controls the outcome. If the predicted difference in guessing preferences is observed across the two conditions for adults, this demonstrates a necessary condition for the competence hypothesis to affect adults' guessing preferences. Consequently, if there is no difference between conditions in children's guessing preferences, then a moderated competence hypothesis would appear to be a less valid hypothesis for explaining children's treatment of uncertainty than it is for adults. Such a result would demonstrate that adults' and children's guessing preferences obtain for different reasons, thus answering the final question posed in Robinson et al. (2009).

The present experiments

Experiment 1 tests the influence of an agency manipulation on adults' preferences for guessing under physical versus epistemic uncertainty. Experiment 2 uses the same task to test whether the same results hold for 5- to 6-year-old children. We deal with guessing preferences rather than bet placing in both experiments, so as to enable a direct comparison between preferences obtained from adults and those obtained from children, since a betting paradigm would be unacceptable in research involving children. A new game (the "pens game") was developed for these experiments. The game was suitable for both adults and children and introduced a greater degree of agency for the actor than do other games of chance, whilst nevertheless remaining a game of chance devoid of a skill component.

EXPERIMENT 1

We predicted that when the outcome was controlled by the experimenter, adults would prefer to guess under epistemic uncertainty (in line with Robinson et al., 2009), because no blame could be attributed to them for a false guess, whilst they would prefer to guess under physical uncertainty when they controlled the outcome themselves (due to the perceived potential attribution of blame).

Method

Participants

A total of 129 psychology undergraduates completed the experiment in return for course credit. A total of 90 other members of the University of Warwick community—81 undergraduates (3 psychology), 7 postgraduates (1 psychology), and 2 support staff—also completed the experiment in return for payment. Across the whole sample there were 52 males and 167 females, with an age range of 18 to 42 years (median = 19 years).

Design

A between-participants design was employed. Participants had to guess the colour of a circle drawn out of sight with a pen that could be one of five colours. The experimental manipulation concerned who controlled the outcome. The circle was drawn either by the participant themselves ("self" condition), or by the experimenter ("experimenter" condition). Crucial to this design is the fact that which pen is picked is controlled by the actor, although they have no knowledge as to the colour of that pen. The dependent variable was *when* participants chose to guess the colour of the circle. They could guess either before a pen had been picked (under physical uncertainty) or after the circle had been drawn (under epistemic uncertainty). The order in which these options were presented to participants was counterbalanced and corresponded with the order of the options in the answer booklet. Participants marked all their responses privately in their answer booklets.

Apparatus

Sets of five fineliner pens (brown, purple, black, orange, and red) were used. These were identical in appearance apart from the fact that their colour was identified at either end. In order to conceal what colour they were, their own lids were replaced with a standard colour lid for a set, and standard pencil stoppers were put on their ends. With their lids on, the pens were therefore identical and indiscriminable. Each set of pens was held in a plastic tumbler throughout the experiment. Paper was used for the participant to draw on. In the "self" condition, a grey A4 box file was used as a screen and was placed between the participant and the paper during the game. The screen was of sufficient size that the participant could not see their circle after they had drawn it, but narrow enough that they could fit their arms around it in order to draw the circle behind the screen. In the "experimenter" condition, two screens were placed at right angles to one another, to form a nonvisible corner, so that neither the experimenter nor participants could see the colour of the circle. The experimenter was only able to reach his right arm around the screens to draw the circle. Participants won a wrapped chocolate if they correctly guessed the colour of the circle.

Participants indicated their responses in their response booklet and were under no obligation to tell the experimenter what they had guessed.

In this "pens game", the colour of the circle is clearly controlled by the pen that the actor chooses to pick up. Since the colour of the pen is unknowable to participants, however, the game is also a game of chance.

Procedure

Participants participated in the experiment in groups of up to four people. Two groups of five also completed the experiment in the "experimenter" condition.

In the "self" condition, each participant was given a pot of pens. The experimenter (E) also had a pot of pens. E explained that although each of the five pens in a pot looked identical, they were actually five different colours. E proceeded to draw a line on a piece of paper with each of his or her pens, calling out the colour of each pen once a line was drawn. Participants were then provided with a piece of paper for themselves and were asked to check that the pens in their pots were the same five colours. In the "experimenter" condition, there were two pots of pens on the table next to the experimenter. E first tested one of the pots (as above), then asked as many of the participants as wished to to check the colours of the pens in the other pot. These pens were always checked and verified aloud by at least one participant. E subsequently used the pens he checked for the practice trials and the pens the participants checked for the "real" trial.

Once the pens were all "checked", the experimenter explained the nature of the task:

> In this game *you* are going to pick a pen from *your* pot. *You* will then move *your* arms behind the screen, remove the lid from the pen and draw a circle. *You* will then leave the pen behind the screen. Your task is to guess the colour *your* circle will be when we remove the screen. When we play this for real, you will win a sweet if you are correct.

(Words in italics are those that are different across conditions. The example speech is for the "self" condition. In addition to the predictable changes (i.e., replacing third person pronouns and possessives with first person pronouns and possessives), it is worth noting that in the "experimenter" condition, the circle was referred to as "the circle" rather than "your circle".) When mentioning the sweets, E gestured towards the boxes of sweets. E then demonstrated the procedure, vocalizing each stage. E then continued, acting out the procedure in the following, though without removing the lid from the pen to draw the circle:

> Your task will be to guess the colour *your* circle will be when we remove the screen. There are three time points at which you could feasibly guess. You could guess before *you* pick a pen, you could guess when *you've* picked a pen, but before *you* draw the circle, or you could guess after *you've* drawn *your* circle. Okay? Before we play the game for real to win sweets, we are going to practise playing the game in a couple of these different ways.

The procedure was followed as described above, twice. Participants first guessed the colour of the circle before a pen was picked (physical uncertainty), and then the circle was drawn. They then guessed the colour of a circle *after* a new circle had been drawn with a new pen (epistemic uncertainty). The order of these practice trials for guessing under physical and epistemic uncertainty was counterbalanced. In all conditions, E vocalized the procedure as it proceeded. In the "self" condition, this vocalization acted as step-by-step instructions.

Two different experimenters[2] ran the experiment in the "self" condition, using slightly different procedures. For Experimenter 1, in the "self" condition, there were two screens, against opposite walls of the experimental room. If more than two participants were in the group in these conditions, then they had to take turns practising the game, but nonplaying participants were always seated in a position where they too could not see the colour of the circle. In addition, in no variant of the task could an experimenter see the circle before the screen was lifted. These procedures avoided confounds associated with an aversion to guessing about an outcome another individual already knows, a situation in which one's relative ignorance would be particularly salient (Chow & Sarin, 2002; Fox & Tversky, 1995; Fox & Weber, 2002). Screens were not lifted until all practice trials were complete. This negated potential effects of participants using the success or failure of previous guessing points as cues for when to guess. For Experimenter 2, participants were seated in a row with their screen in front of them, and all participants could practise the game simultaneously. Also, these participants did receive feedback on the success or failure of their practice guesses. In the Results section, we show that neither of these differences affected the results and thus only serve to increase our confidence in the generality of these results, without affecting our major conclusions.

Once all practice trials were complete, participants were told that the practice was over and that they would now win a sweet if they were correct in their next guess. They were told that in this trial they could choose when they wanted to make their guess. Before the game commenced, participants were asked when they would like to make their guess. Did they want to guess before the pen was picked, or after the circle was drawn (counterbalanced)? Only once all participants had indicated when they wanted to make their guess did the game continue. The game was stopped at the two necessary timepoints (before picking the pen and after drawing a circle) in order to allow participants to make their guesses. Participants were subsequently rewarded for correct guesses, thanked, debriefed as to the purpose of the experiment, and paid, if appropriate.

Results and discussion

The data in the "self" condition were collected using two slightly different procedures by the two experimenters. A comparison of responses for the "self" condition using the two different procedures showed no difference, $\chi^2(1, N = 124)$

[2]A. J. L. Harris (Experimenter 1) and K. L. McColgan (Experimenter 2) ran the experiments. K. L. McColgan only ran participants in the "self" condition.

= 1.30, $p = .254$, with 27 of Experimenter 1's 66 participants and 18 of Experimenter 2's 58 participants preferring to guess under epistemic uncertainty. In subsequent analyses, we therefore collapsed across these two procedures (on legitimacy, see, e.g., Rosenthal, 1991). There were also no significant order or gender effects for any of the comparisons in this dataset, nor were preference patterns affected by whether participants participated individually or in a group, or by whether participants were psychology students or not. Thus, we do not consider these variables further in the analysis.

Analysing the data from both procedures, there was a significant effect of the agency manipulation, $\chi^2(1, N = 189) = 8.51$, $p = .004$, $r^2_\varphi = .21$. As shown in Table 1, participants preferred to guess under physical uncertainty when they drew the circle, $p = .003$ (Cohen's $g = .14$) by a binomial test. When the experimenter drew the circle, there was no significant preference for guessing under physical or epistemic uncertainty, $p = .22$ by a binomial test. It is worth noting that the trend in the "experimenter" condition is in the opposite direction to the preference observed in the "self" condition.

We thus observed a significant difference in adults' guessing preferences depending on who controlled the outcome. In a novel game of chance, in which the actor controls the outcome, adults preferred to guess under physical (as opposed to epistemic) uncertainty when they themselves controlled the outcome, but this preference was not observed when the experimenter controlled the outcome.

In this "pens game", the outcome (the colour of the circle) is determined once the pen has been picked. Thus, we propose that it is the picking of the pen that provides a feeling of agency in the participants. In order to check this, a further sample of participants (tested by Experimenter 1, concurrently with the other conditions) completed a version of the task in which the experimenter picked a pen from the participant's pot for them, and participants proceeded to draw the circle as in the "self" condition. In this "experimenter picks" condition,[3] 16 out of 29 participants preferred to guess under epistemic uncertainty, a preference pattern that was marginally different from that observed in the "self" condition, $\chi^2(1, N = 153) = 3.50$, $p = .062$, $r^2_\varphi = .15$. The preference patterns in the "experimenter picks" and "experimenter" conditions were, however, very similar, $\chi^2(1, N = 94) = 0.09$, $p = .766$, $r^2_\varphi = .03$. Thus, the "experimenter picks" condition seemed to give rise to guessing preferences more in line with the "experimenter" condition than the "self" condition. The similarity between the "experimenter" and "experimenter picks" conditions is well illustrated with reference to odds ratios (e.g., Howell, 2002, p. 166). Participants were 1.15 times more likely to guess under physical uncertainty in the "experimenter" condition than in the "experimenter picks" condition. However, participants were 2.16 times more likely to guess under physical uncertainty in the "experimenter picks" condition than in the "self" condition. This pattern of results suggests that it is the responsibility of picking the pen (which determines the outcome) that participants are sensitive to in their guessing preferences. We thus propose that a feeling of responsibility for determining the outcome leads participants to feel particularly susceptible to blame for an incorrect guess about a determined outcome that they themselves are partly responsible for.

Table 1. *Adults' preferences for guessing under physical versus epistemic uncertainty in the "self" and "experimenter" conditions*

	Uncertainty	
	Physical	*Epistemic*
"Self"	79	45
"Experimenter"	27	38

EXPERIMENT 2

Experiment 2 was a replication of Experiment 1 with children. Having observed evidence

[3]We thank Gail Thornton for suggesting this experimental manipulation.

consistent with the effect of relative (in)competence on adults' guessing preferences in a situation in which they themselves controlled the outcome, Experiment 2 is the first test of whether feelings of relative (in)competence might affect children's guessing preferences. Robinson et al. (2009) detailed that, in order to be sensitive to feelings of relative (in)competence, children must be able to engage in counterfactual thinking and compare an evaluation of the counterfactual state with the experienced reality. Robinson et al. thus conjectured that, as these same cognitive prerequisites are required for the experience of regret, if children are too young to experience regret, they will also be too young to be sensitive to feelings of relative (in)competence. We therefore tested children who were in the same year of schooling as the 5- to 6-year-olds (who experienced regret) in Weisberg and Beck (2010).

Method

Participants

A total of 29 male and 23 female children aged between 4;11 (4 years, 11 months) and 6;10 (median = 5;9), towards the beginning or end of their second year of formal schooling, participated in the experiment. All attended a primary school in Coventry, UK, which serves a mixed working- to middle-class population. Two additional children were excluded because of failure to follow the task instructions. At the end of the experiment, children were given a sticker to thank them for their participation.

Design and apparatus

The design and apparatus for Experiment 2 were the same as in Experiment 1, with one addition. Five pieces of coloured paper corresponding to the colours of the pens were used as a reminder of the colours when children were making their guess.

Procedure

Children always participated in the experiment individually. The procedure was based on that employed by Experimenter 2 in Experiment 1.[4] However, as an additional manipulation in the "self" condition, 12 of the 23 participants were asked to guess the colour of the pen. The remaining 11 guessed the colour of the circle, as in the adult procedure.

When testing the pens, children were asked to name each colour as it was drawn. The majority of children could identify the colour of the pens, but if they did not know, or gave the wrong answer, they were told what colour it was. Children practised drawing behind the screen in the "self" condition before providing their practice guesses, and they gave verbal responses in conjunction with pointing at the coloured pieces of card. All other aspects of the procedure were identical to those employed by Experimenter 2 in Experiment 1. In place of sweets, children were given stickers as incentives for guessing correctly.

Results and discussion

As with the adult data, there were no order or gender effects that approached significance for any comparisons in this dataset. All analyses are therefore collapsed across order of presentation. There was also no difference between the preferences of children in the "self" condition who were asked to guess the colour of the pen (8 out of 11 chose epistemic uncertainty) and those asked to guess the colour of the circle (8 out of 12 chose epistemic uncertainty), $\chi^2(1, N = 23) = 0.10$, $p = .752$. In subsequent analyses, we therefore collapsed across these two conditions.

Table 2 demonstrates children's guessing preferences both when they picked a pen and drew the circle, and when these were done by the experimenter. Unlike the adult data, there was no difference in guessing preferences according to who controlled the outcome, $\chi^2(1, N = 52) = 1.26$, $p = .262$. When the child controlled the outcome, a marginally significant proportion preferred to

[4]K. L. McColgan ran all the experiments with children.

Table 2. *Children's preferences for guessing under physical versus epistemic uncertainty in the "self" and "experimenter" conditions*

	Uncertainty	
	Physical	*Epistemic*
"Self"	7	16
"Experimenter"	5	24

guess under epistemic uncertainty than under physical uncertainty, $p = .093$ ($g = .20$) by a binomial test. The same pattern of guessing preferences was observed when the experimenter controlled the outcome, $p = .001$ ($g = .33$) by a binomial test.

In line with the findings reported in Beck et al. (2010) and Robinson et al. (2009; also, McColgan et al., 2010), children preferred to guess under conditions of epistemic rather than physical uncertainty, and this effect was no different whether the child themselves, or the experimenter, picked the pen and drew the circle.[5]

Comparison of child and adult data (Experiment 1 and Experiment 2)

Experiment 1 demonstrated a significant effect of the agency manipulation on adults' guessing preferences, an effect that was not observed in children. Children exhibited a preference for guessing under epistemic uncertainty, both when the experimenter drew the circle and when they drew the circle themselves. This preference was not observed in the adult "experimenter" condition, and the difference between the adult and child data in the "experimenter" condition was significant, $\chi^2(1, N = 94) = 5.27$, $p = .022$, $r^2_\varphi = .24$. What, however, is more striking is the *reversal* in guessing preferences when the participant picked the pen themselves, $\chi^2(1, N = 147) = 8.85$, $p = .003$, $r^2_\varphi = .25$. Whilst children still preferred to guess under epistemic uncertainty, adults exhibited a significant preference for guessing under physical uncertainty when they picked the pen and thus exerted control over the outcome.

GENERAL DISCUSSION

We have presented the results of two experiments designed to test the limits of Heath and Tversky's (1991) competence hypothesis. Following Robinson et al.'s (2009) conclusion that the competence account does not extend to purely chance events, we investigated whether introducing an element of control to a game of chance would result in guessing preferences consistent with the predictions of the competence hypothesis. For adults, we observed precisely that result. Children, however, always preferred to guess under conditions of epistemic uncertainty, consistent with previous results and theory (Beck et al., 2010; McColgan et al., 2010; Robinson et al., 2009; Robinson et al., 2006). By setting up a situation in which adults' and children's guessing preferences disassociate, we have provided the first evidence that their guessing preferences are driven by different underlying cognitive mechanisms. The only other study to have compared guessing preferences of live chance events in adults and children (Robinson et al., 2009) observed no difference between their preference patterns. The current data suggest that although the pattern of preferences was the same across adults and children in Robinson et al.'s studies, these preferences did not result from the same underlying cognitive mechanism.

Implications for children's handling of uncertainty

Having demonstrated the moderating effect of personal control on the competence hypothesis in adults, Experiment 2 was the first test of whether children's guessing preferences are affected by feelings of incompetence. The lack of a difference in

[5]Note that these data are not readily explained as a response bias for children to always guess late in a game of chance. Beck et al. (2010) showed that when children were unable to imagine an outcome, they did not exhibit a bias to guess late in the game (see details in the introduction).

guessing preferences when the outcome was under self versus experimenter control is consistent with the suggestion that once an unknown reality exists, children imagine what it is, and the excellence of children's imagination leads them to behave as though they *know* what the outcome is (Beck et al., 2010). This imagination account can be proposed as an explanation for extant data that demonstrate children's poor judgements of their own knowledge or certainty. Even 7-year-olds tend to overestimate their knowledge of uncertain outcomes more than older children or adults (e.g., Beck, Robinson, & Freeth, 2008; Pieraut-Le Bonniec, 1980; Robinson & Robinson, 1982), and they are relatively poor at discriminating between different degrees of uncertainty (Koriat & Ackerman, 2010). Thus, regardless of who controls the outcome, the easier an outcome is to imagine (e.g., under epistemic uncertainty), the more confident a child will feel about guessing that outcome, as they will erroneously underestimate its associated uncertainty.

The present results, together with the data of Beck et al. (2010), thus suggest that the imagination account is a better explanation of children's responses to uncertainty than the competence hypothesis. Aside from the imagination account, there may also be developmental and social reasons for children not being sensitive to feelings of relative (in)competence. These reasons suggest that children may continue to be unaffected by these feelings even once they are better able to recognize their own uncertainty. By the very virtue of being new to the world, young children will almost always be in a state of relative ignorance. Avoidance of such a state in order simply to "save face" would not, therefore, seem to be an efficient strategy. As Siegler (2000, p. 27) notes, "Childhood is a period of life in which learning plays a particularly large role relative to performance". Indeed, were children to be deterred from engaging in tasks at which they find themselves to be incompetent relative to salient others (e.g., parents and older siblings), children would engage in very few tasks indeed, thus impeding development. It seems, therefore, that an effect of feelings of relative (in)competence on children's behavioural preferences might even be harmful to children's development. Furthermore, the face-saving act of guessing under physical uncertainty might not even be applicable to children. Children may often receive credit when they are correct, but have had less experience of receiving blame when they are wrong, as their incompetence is readily attributable to the fact that they are children. Consequently, as long as incompetence can be explained away in this manner, children's handling of uncertainty seems unlikely to be affected by feelings of relative (in)competence.

Further research is needed to investigate the developmental course of both the cognitive limitations (their poor discrimination of uncertainty levels) and potential social factors that protect children against feelings of relative (in)competence (as revealed in their guessing preferences). This work could begin by determining the age at which children's guessing preferences are in line with those of adults in games such as the above "pens game".

Implications for adults' handling of uncertainty

The adult data provide two insights into adults' preferences for guessing under uncertainty. First, the finding that adults did not prefer to guess under conditions of physical rather than epistemic uncertainty when the outcome was under the experimenter's control strengthens Robinson et al.'s (2009) conclusion that the competence hypothesis does not extend straightforwardly to chance events. Secondly, the observed preference for guessing under physical uncertainty in the "self" condition suggests that a modification to the competence hypothesis could account for the present results.

Although data from the "experimenter" conditions were consistent with Robinson et al.'s (2009) conclusion that the competence hypothesis does not extend to purely chance events, we failed to replicate the preference for guessing under epistemic uncertainty that they reported. We tentatively suggest an explanation for this failure to replicate based on the precise characteristics of the present task and participant scepticism. As

argued above, which pen is chosen is most certainly under the control of the chooser (although the colour is not). A small proportion of participants might have suspected that the experimenter was not ignorant of the colour of the pen, but had a way (unbeknown to them) of distinguishing the five pens. If this was the case, then for these participants, once the outcome is determined they are in a position of ignorance relative to the knowledge of the experimenter, which is likely to lead them to prefer guessing when both themselves and the experimenter are ignorant as to the outcome, under physical uncertainty (Chow & Sarin, 2002; Fox & Tversky, 1995; Fox & Weber, 2002). Participant scepticism as to the trustworthiness of an experimenter is somewhat unavoidable (see Christensen, 1977; Corner, Harris, & Hahn, 2010; Kelman, 1967; McKenzie & Wixted, 2001; McKenzie, Wixted, & Noelle, 2004), but it is important that, as researchers, we are sensitive to its potential existence. Regardless of the failure to replicate the preference observed in Robinson et al. (2009), no support was observed for the competence hypothesis when the chance outcome was not controlled by the participant themselves.

Support for the competence hypothesis

Thus far, we have argued that a preference to guess the outcome of a chance event before it is determined (under physical uncertainty) is evidence for preferences being driven by feelings of incompetence, and thus support for the competence hypothesis. We note that this conclusion very much relies on the past work, and indeed speculation (in relation to its extension to chance events), of Heath and Tversky (1991), and the present study provides little direct evidence for that account. The competence hypothesis is, however, a plausible account of adults' preferences to guess under physical uncertainty when they control the outcome. Furthermore, at an intuitive level the lack of a similar finding in children lends further credence to a competence-based explanation, as we have argued that children do not seem to possess the necessary cognitive tools (specifically, they are poor at recognizing their own uncertainty because of their keen imaginations) and social experience to be susceptible to feelings of relative (in)competence. In addition, alternative candidate theories do not seem to be able to account for the pattern of results observed here. Below, we discuss the merits of some alternative candidate accounts and conclude that a modified version of the competence hypothesis, which specifies the requirement of perceived responsibility for a chance outcome, provides the best account of the data.

Robinson et al. (2009) drew upon ambiguity aversion (Ellsberg, 1961) to explain their finding that adults preferred to guess under epistemic rather than physical uncertainty. Ambiguity aversion cannot, however, explain the preference for guessing under physical uncertainty observed in the "self" condition.

Mishra, Shiv, and Nayakankuppam (2008) offer two accounts that might be extended to account for preferences to guess under physical versus epistemic uncertainty. One of these is based on focalism (e.g., Kruger & Burrus, 2004; Wilson, Wheatley, Meyers, Gilbert, & Axsom, 2000), and the other they term the "blissful ignorance effect" (BIE). These accounts can be applied to the present situation when a practice guess is made under conditions of physical uncertainty. When practising guessing under physical uncertainty, if participants were to feel more confident about their guess after making their guess, but before picking their pen rather than after picking their pen (or vice versa), then they might use this information to guide their choice of when to guess.

The focalism-based account posits that, having made a guess, this guess is now a focal outcome. Before picking a pen, all colours are perceived as equally likely to be picked. Once a pen has been picked, however, people focus on the possibility of the focal outcome occurring and are hence more confident that it will occur. This account would therefore predict a preference for guessing under epistemic uncertainty, as is observed in Robinson et al. (2009). It should be noted, however, that contrasting empirical results have been observed, such that negative outcomes (i.e.,

the possibility of losing) are more salient, and thus more focal, than positive outcomes (e.g., Risen & Gilovich, 2007). This would predict exactly the opposite result to the focalism hypothesis, as it is described by Mishra et al. (2008). It is therefore unclear the direction of the effect predicted by a focalism-based hypothesis. Whilst Mishra et al. argue that positive outcomes will be focal and therefore overestimated, the results of Risen and Gilovich predict exactly the opposite result, whilst present consensus appears to be that when making unambiguous responses on an unambiguous response scale, estimates of probability are *not* directly affected by outcome utility (e.g., Bar-Hillel, Budescu, & Amar, 2008; Harris, Corner, & Hahn, 2009; Krizan & Windschitl, 2007).

The BIE account relies on the distinction between goals of accuracy and goals of direction (of wanting to arrive at a desired conclusion; e.g., Kruglanski, 1980; Kunda, 1990, 1999). Mishra et al. (2008) argue that when the outcome is undetermined, people are motivated to be accurate, whilst when the outcome is determined, people engage in motivated reasoning to increase their optimism that their guess is correct. People are only able to reconstruct the available evidence in such a way as to reach their desired conclusion in this latter stage if the information provided has some inherent ambiguity. In the present context, participants know the objective probability of a pen being a certain colour, and this information is therefore unambiguous. According to Mishra et al., they should therefore be more optimistic before the outcome is determined rather than afterwards. This is the result observed in the present "self" condition. The BIE account is, however, unable to account for the different guessing preference observed in the "experimenter" condition.

The reader might also draw an analogy between our control manipulation and Goodie's (2003; see also, Goodie & Young, 2007) account postulating the role of control in decision making. According to Goodie's hypothesis, people will prefer an ambiguous bet when the outcome of the bet contains a skill component, rather than when it is the outcome of a random process. Goodie and Young distinguish Heath and Tversky's (1991) competence account from Goodie's control account according to the characteristics of the individual. Both competence and control are characteristics of the task, such that there are steps that could increase the probability of success, but only competence incorporates the characteristic of the individual, such that the individual possesses the skill to increase the probability of success. The control account asserts that it is only the skill component to the task that is important, as by accepting the bet an individual is able to improve their performance on the task, thus increasing the likelihood of future successes. The results of the present task under conditions of "self" control are consistent with the competence hypothesis, but inconsistent with Goodie's control account. Participants are not competent and therefore desire to save face by guessing before the outcome has been determined. A preference for guessing early or late cannot be accounted for within Goodie's control account as participants are equally as unable to improve their performance on the task whether they guess before or after the outcome has been determined, and this symmetry is still apparent if participants do erroneously perceive the outcome as controllable (in the sense that they may be able to learn which pen is which colour).

A modified competence hypothesis

In observing a preference for guessing under physical uncertainty only for adults when the outcome was controlled by the participant, we have provided a test of the specific conditions required for participants to be susceptible to feelings of incompetence. Despite the fact that participants were unable to determine the colour of a pen when choosing it, the data are consistent with a proposal that the mere fact that they *had* chosen the pen (although not explicitly the colour) led them to feel relatively incompetent and potentially susceptible to a loss of face were their guess wrong after they had chosen the pen themselves.

Fox and Tversky's (1995; see also, Fox & Weber, 2002) comparative ignorance hypothesis extends the competence hypothesis by highlighting the role of comparative processes. They demonstrate that people show greater aversion to ignorance when the relative status of their ignorance is made clear. For example, whilst Fox and Tversky observed ambiguity aversion in a typical within-subject replication of Ellsberg's (1961) famous paradigm, they did not observe it using a between-subject design. Chow and Sarin (2001) subsequently demonstrated that ambiguity aversion was present both in comparative and noncomparative conditions, but that it was greater in comparative conditions. The work presented here, and in Robinson et al. (2009), extends work on the competence hypothesis further by demonstrating the necessary condition of agency.

In the absence of a plausible alternative explanation of our data, they are consistent with a modified version of Heath and Tversky's (1991) competence hypothesis. Given the metacognitive prerequisites required for people to be sensitive to feelings of relative (in)competence, the failure to observe the same pattern of data in 5- to 6-year-olds adds further credence to an explanation for the adult data in terms of relative (in)competence. The proposed modified version of the competence hypothesis asserts that an element of control is a necessary condition for adults' guessing preferences to be in line with the predictions of the competence hypothesis. Only when adults feel they are responsible for the outcome will they feel susceptible to blame should they guess wrongly, and therefore prefer to guess before the outcome is determined in order to save face. No other extant account has the facility to be modified in a satisfactory way so as to predict the observed effects of the "control" manipulation on adult guessing preferences. Future research should directly investigate the role of perceived competence, relative to potential competence, in games of chance, by including a measure of perceived competence and perceived potential competence.

CONCLUSIONS

Where the same results obtain for different developmental or experimental groups, it is tempting to conclude that there is no difference between the groups. However, the same results might obtain for very different reasons. By demonstrating a dissociation in the guessing preferences of adults and children in the present experiments, we suggest that the preference for guessing under epistemic uncertainty for "live" dice rolls (Robinson et al., 2009) obtained for different reasons in adults and children. Furthermore, by introducing a novel experimental game, the adult data further develop our understanding of the precise nature of Heath and Tversky's (1991) competence hypothesis. Some degree of control over a chance outcome appears to be required for the predictions of the hypothesis to extend to guessing preferences for chance events.

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