Power analyses[1]

Initial estimate

We estimated our experiment's power by computing the probability of detecting an effect through simulation (see, e.g., Robert & Casella, 2013).

An experiment's power is not only influenced by the sample size, but also by the experimental design. In primate research, for instance, researchers can establish cognitive capacities by only testing only one or two data monkeys with the appropriate experiment (e.g., Cantlon, et al 2015). In our experiments, we take advantage of one-sided predictions and inclusion questions to improve our experiments' power.

To compute the experiment's power, we first assumed that roughly 75% of children would succeed in the task. This success rate was based on previous data on related tasks with a similar age range (Jara-Ettinger, Gweon, Tenenbaum, & Schulz, 2015; using all data except for the control condition in Experiment 1 where children were expected to perform at chance).

Next, we took into account the fact that our experiments had one-tailed predictions, and not any deviation from chance could be interpreted as support for our theory. For example, in Experiment 1, if all children had reported that the knowledgeable puppet said "yuck," it would have been unreasonable and wrong to conclude that children understand that agents maximize expected utilities.

Finally, we assumed that the remaining 25% of children would struggle in the task due to task miscomprehension or nervousness (henceforth called *inattentive* children), and not because they lacked the fundamental underlying concepts of expected utility maximization (as we have argued previously, we believe these capacities may be at work from much earlier in life; Jara-Ettinger, Gweon, Schulz, & Tenenbaum, 2016). In order to reduce the noise, all our experiments had an inclusion question designed to identify and exclude children who were not following the task (note the inclusion questions only tested if children remembered important facts that the experimenter had mentioned. Thus, attentive children should pass the inclusion question even if our theory is wrong). The inclusion questions always had two possible answers, so inattentive children had a 50% chance of responding to the inclusion question correctly and proceeding onto the test question. These assumptions are visualized in Supplemental Figure 1a.

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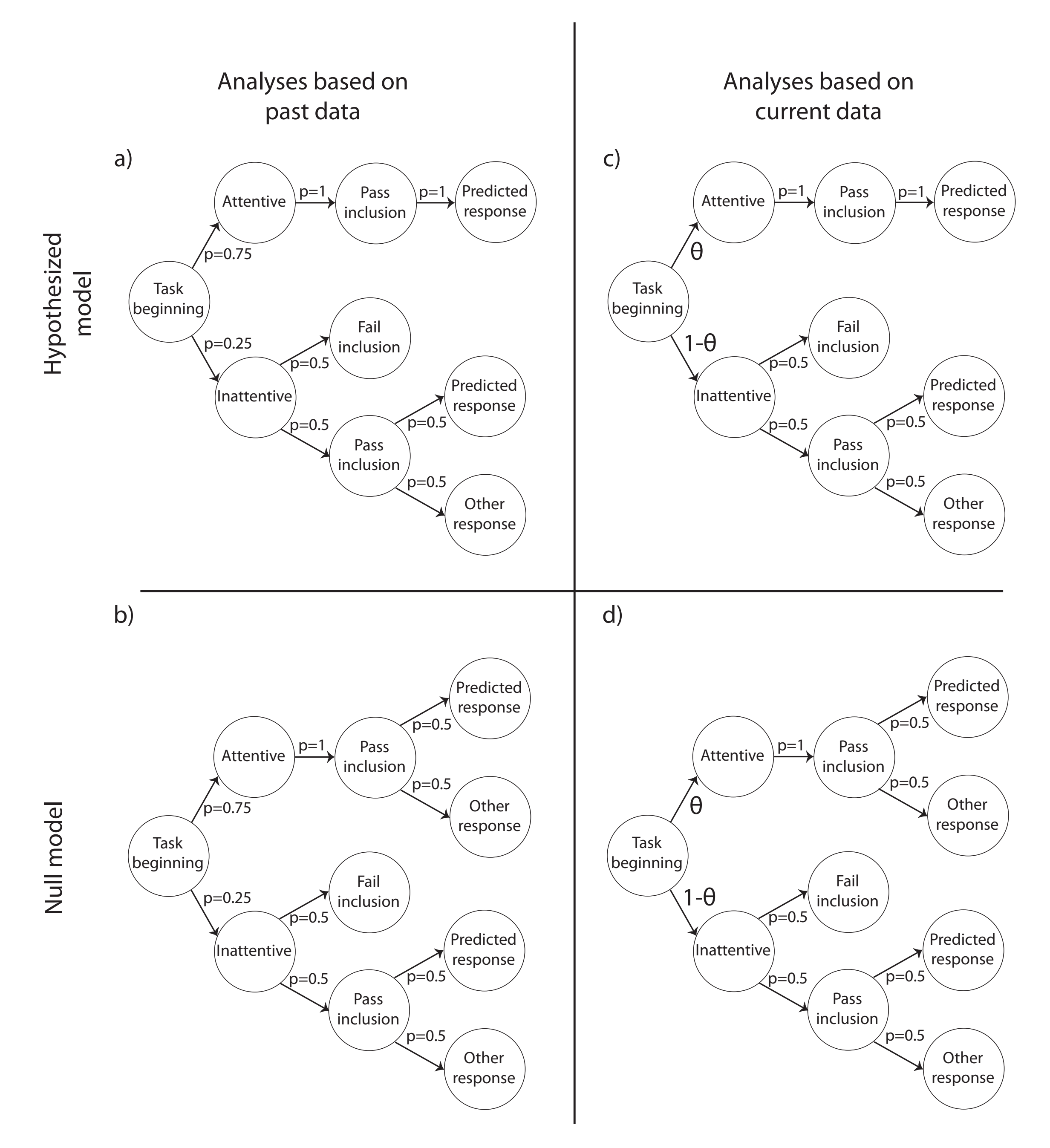
[1] These analyses were conducted prior to the review process. They do not include the data from Experiment 5b (with adults) or 6 control with children (with children) because these were later suggested by an anonymous reviewer.



Supplemental Figure 1. (a) Hypothesized causal model for children's performance. We predict that all children in our age-range understand that agents maximize utilities. If a child is attentive, she should pass inclusion and respond as predicted. The probability of a child being attentive (0.75) was estimated from data on similar tasks with similar age ranges (Jara-Ettinger et al, 2015). Inattentive children were assumed to have a .5 chance of failing inclusion (which was always a 2-alternative forced choice question), and a .5 chance of passing inclusion. Inattentive children who passed inclusion by chance were assumed to respond the test question at chance. (b) Causal model under the null hypothesis. Under this model, attentive children lack the understanding we are testing for and respond at chance. (c) Model used for the post-hoc power analysis. The causal relations are identical to panel (a) with the exception that the probabilities at the beginning are estimated from our data. (d) corresponding model of the null hypothesis after estimating the attention parameter.

Under this causal model, we expected 81.25% of participants to respond correctly (where 75% understood the task correctly, and 6.25% were inattentive, but passed inclusion and responded to the test question correctly by chance1), 12.5% of participants to fail the inclusion question and be therefore excluded from the study, and 6.25% to respond incorrectly (children who were inattentive, passed inclusion by chance, and responded the test question incorrectly).

Based on past sample sizes on similar experiments (Jara-Ettinger et al., 2015), we considered a sample size of n=16 (not counting children who fail inclusion). By running each experiment until obtaining sixteen responses from children who passed the inclusion question, our power analyses predict that we would have to recruit 18.29 children on average for each experiment, with 2.29 being excluded on average for failing the inclusion task. Under this model, the experiment's power is over .95.

To compute the probability of finding a false positive, we modified the causal model so that children who are attentive are nevertheless expected to respond at chance (Supplemental Figure 1b). As such, 43.75% of children are expected to respond correctly, 43.75% are expected to respond incorrectly, and 12.5% are expected to be excluded from the study due to distraction. Under this model, the probability of finding a significant effect under the null hypothesis is .04.

Overall, this analysis highlights the importance of inclusion questions and one-sided predictions in experimental design, which can have a much greater impact than increasing the sample sizes without reducing noise.

Post data collection

After collecting the data, we estimated the probability of children being attentive in our task, and used this estimate to repeat our power analysis (Supplemental Figure 1b).

In order to infer the percentage of attentive children we used Bayesian inference (Kruschke, 2014). According to Bayes' rule,

$$p(\theta|D) \propto p(D|\theta)p(\theta)$$

where $\theta \in [0,1]$ is the unobservable probability that a child is attentive and understands the task (see Supplemental Figure 1b), D is the set of data we collected, $p(\theta|D)$ is the posterior probability of the parameter given our collected data D, $p(D|\theta)$ is the likelihood of producing the observed data given the unobservable parameter, and $p(\theta)$ is the prior probability of the parameter.

The prior probability was set to the bias derived in the meta-analysis of Jara-Ettinger et al (2015; see supplemental text):

$$p(\theta) = Beta(68.64, 19.36)^2$$

and $p(D|\theta)$ was computed through the causal model shown in in Supplemental Figure 1, replacing the probabilities in the first branch for θ and $(1-\theta)$ for attentive and inattentive children, respectively. Our dataset D consists of the 10 experiments where our theory predicted performance different from chance: Experiments 1, 2, and its replication, 3, 4, 5a, 5b, 6, 6b, and 7a. Thus, $D = \{D_1, \ldots, D_{10}\}$ and

$$p(D|\theta) = \prod_{i=1}^{10} p(D_i|\theta).$$

Supplemental figure 2 shows the meta-analyses posterior distribution. The posterior distribution's expected value was 0.64. Re-running the power analyses from above while lowering the probability of attention from 0.75 to 0.64 continues to produce power over .95 (power = .976). Thus, although our initial estimate was higher than what we observed, our post-hoc analyses show that the experiment was nevertheless appropriately powered. The null-model with the corrected probability of attentiveness (Supplemental Figure 1d) continues to have a .04 probability of finding a false-positive. Finally, it is important to note that under this power, the probability of having at least one false negative in our experiments is 0.22.

Overall, both analyses converge on the conclusion that our experiment was appropriately powered. However, to interpret these results, it is critical to note a few things. First, although our sample size was set to sixteen data points entering our analyses, our true sample size is larger because we also recruit and test children who we are able to identify as being distracted. Second, although our sample size is higher than sixteen, the ability to identify noise in the dataset and remove it from the analyses gives an additional boost to the experiment's power. That is, we simultaneously increase the sample size while reducing the amount of noise that enters the analyses. Finally, our experiment's power was further boosted because we designed experiments with clear predictions. In all our conditions, it is impossible to argue that the opposite trend from what we predict can count as evidence for our theory. Altogether, our analyses show that the experiment was appropriately powered, and that power not only hinges on sample size, but also on experimental design.

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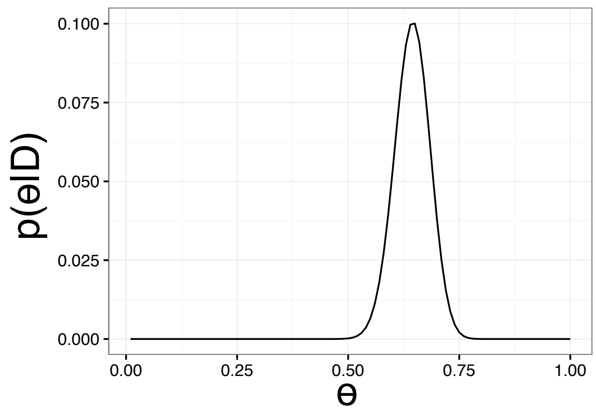
[2] In the meta-analysis of Jara-Ettinger et al (2015), the posterior distribution is parameterized in terms of μ (with expected value *0.78*) and κ (with expected value *88*). Here we use the more common parameterization $\alpha = \mu\kappa; \beta = (1-\mu)\kappa$.



Supplemental Figure 2. Posterior distribution of the probability that participants in our study were both attentive and understood that agents maximize expected utilities (as determined by our task). The prior distribution was set to the bias estimated in the meta-analysis of a similar set of tasks with a similar age range (Jara-Ettinger et al, 2015) and the likelihood was computed using the causal model from Figure 1.

Computational Modeling

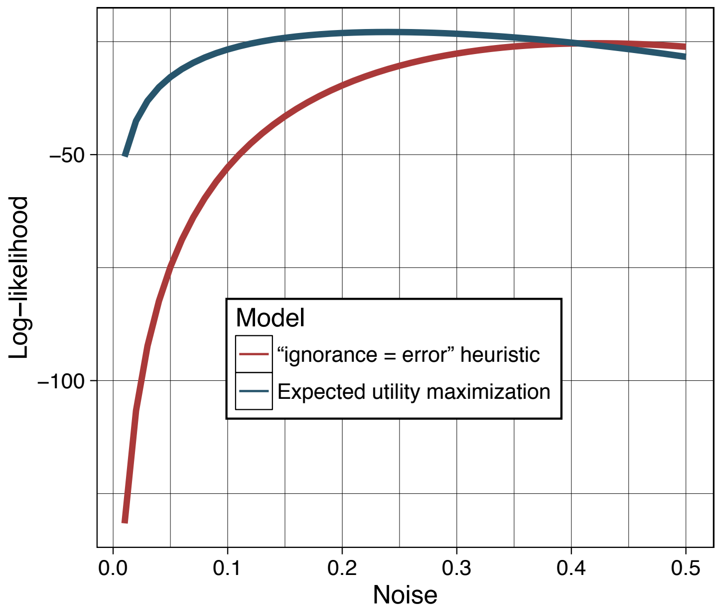
To explore the “ignorance = error” heuristic quantitatively, we implemented a simple model of expected utility maximization and we compared its predictions to those made by the “ignorance = error” heuristic. The expected utility maximization model assumes that each agent has different costs and rewards, but that knowledgeable agents know their true values whereas ignorant agents may not. The model predictions are obtained by computing the joint probability that the ignorant and knowledgeable agents would behave in the observed manner. The model code can be found it https://github.com/julianje/Beliefs-about-desires. The “ignorance = error” heuristic assumes that ignorant agents always have false beliefs in the domain of their ignorance. The heuristic’s predictions and rationale as shown in Table 1. To evaluate the models, we computed the likelihood that each of the two accounts could generate the 11 of our datasets (Experiment 1, experiment 2, the replication of experiment 2, experiment 3, experiment 4, experiments 5 and its control, experiment 6 and 6b, and experiments 7 and 7 control). Experiment’s 6 control is not included because both accounts predict chance performance.

Experiment	“Ignorance = error” heuristic	Prediction
1	The naïve agent has a false belief about her preferences, believing that she likes a fruit that she does not.	The naïve agent said “yuck.”
2	Same as in Experiment 1.	The agent who said “yuck” was naïve.
3	The naïve agent has a false belief about her preferences until the stops being ignorant.	The naïve agent changed her choice.
4	Same as in Experiment 4.	The agent who changed her choice was naïve.
5	The naïve agent has a false belief about the stairs and believes they are behind the yellow door. As such, the knowledgeable agent is choosing what she believes to be high cost whereas the naïve agent is choosing what she believes to be low cost.	The knowledgeable agent is more likely to like tomatoes.
5 control	The naïve agent has a false belief about the stairs and beliefs they are behind the red door (see Figure 8 in main text). As such, the knowledgeable agent is choosing what she believes to be low cost whereas the naïve agent is choosing what she believes to be high cost.	The ignorant agent is more likely to like tomatoes.
6	The agent who didn’t know about the stairs must believe that the stairs are behind the yellow door. Because the rewards are matched, an agent with a false belief should therefore choose the red door.	The agent who choose the red door is ignorant.
6 control	The agent who did not know about the stairs must believe that the stairs are behind the yellow door.	It is impossible to determine who is ignorant.

	Because the stairs' location does not matter. They play no role in the choice.	
6b	The naïve agent must believe that the tomato was behind the yellow door.	The agent who choose the yellow door is ignorant.
7	The naïve agent believed the stairs were behind the yellow door and corrected her belief after opening the red door.	The ignorant agent revised her choice.
7 control	The naïve agent believed that the stairs were behind the red door. She was therefore choosing a high cost plan and corrected her belief after opening the door, realizing the plan's cost is lower.	The ignorant agent revised her choice.

Supplemental Table 1. Description of experiment predictions according to the "ignorance = error" heuristic.

To compute the models' likelihoods, we introduced a noise parameter that determines the probability that a child gets distracted or confused during the task and makes a guess at random. The noise was first determined by finding the parameter that maximizes each model's fit. The heuristic account showed the best fit when the noise was set to 42% and the expected utility model showed the best fit when the noise was set to 24%. That is, the heuristic required almost twice as much noise than the expected utility model in order to best explain the data. At these levels of noise, the expected utility model was 11.98 times more likely to have generated the data. Thus, the expected utility model required less noise to explain the data and explained it better. When the heuristic model's noise was matched to the expected utility model's noise (both set to 24%), the expected utility model was over 3,600 times more likely to generate the data. In contrast, when the expected utility model's noise was matched to the heuristic's noise (both set to 42%), the heuristic account was only 1.5 times more likely to generate the empirical data. Thus, even when the noise was set to a high value in order to benefit the heuristic account, its advantage over the expected utility model was negligible. More broadly, for any hypothesized amount of noise between 0% and 40% the expected utility maximization model explains the observed data better than the heuristic model (see Supplemental Figure 1).



Supplemental Figure 2. Likelihood that the heuristic account (red) and that the expected utility maximization account (blue) could generate the data from all 11 experimental conditions. The x-axis marks a model parameter, the amount of noise in children's responses, and the y-axis shows the model's log-likelihood.

Finally, it is important to note that all our experiments used inclusion questions to ensure children were following the task. As such, if 42% of children who reached the test question were responding at chance, we would expect the inclusion question to have roughly excluded the same proportion of children (there is a 50% chance for children to pass the inclusion question by responding at random). Thus, a 42% level of noise predicts that roughly 74 children should have been excluded in the inclusion phase (42% of the 176 children who passed the inclusion question is 73.92). Empirically, however, only 18 children failed the inclusion question. This number suggests that only around 18 out of the 176 children in the data-set were responding at chance. At this level of noise (10.23%), the expected utility model is over 2x10e11 times more likely than the heuristic model to have generated the data.

Experiment Scripts

In each experiment the inclusion question is underlined and the test question is in italics.

Experiment 1.

Here we have some strange fruits. These fruits are called rambutans [place on table] and these fruits are called African cucumbers [place on table].

Here we have two friends: This is Anne and this is Sally.

Anne has never seen these fruits before and she doesn't know what they taste like [shake your head your head as you explain this]. Anne doesn't know what the Rambutan tastes like [move Annie towards the rambutan] and she doesn't know what African Cucumber tastes like [move Annie towards the African Cucumber].

Sally knows all about these fruits. She knows what they taste like [nod as you explain this]. She knows what the Rambutan tastes like [move Sally towards the rambutan] and she knows what the African Cucumber tastes like [move Sally towards the rambutan].

Can you remind me, which of our friends has tasted these fruits before? Sally or Anne? And which of our friends has not tasted these fruits before? Sally? Or Anne? [move each puppet as their name is called].

Earlier today, we told our friends they had to pick one fruit to eat and both of our friends picked a rambutan. [place on treat in front of each puppet].

When they took a bite one of them said "yum!". And one of them said 'yuck!".

<u>Can you remind me, which one of our friends had tasted these fruits before? Sally or Anne? And which of our friends had not tasted these fruits before? Sally? Or Anne?</u>

Now, which of our friends is the one who said "Yum?" And which of our friends is the one who said "Yuck?"

Experiment 2.

Here we have some strange fruits. These fruits are called rambutans [place on table] and these fruits are called African cucumbers [place on table].

Here we have our two friends: This is Anne, and this is Sally.

Earlier today, we told our friends they had to pick one fruit to eat, and both of our friends picked a rambutan. [place treat in front of each puppet].

Anne and Sally both took a bite from their rambutans. Anne [or whoever begins] said yum [if she's the knowledgeable one]. Sally said yuck.

But guess what! One of our friends *didn't know* what rambutans tasted like until today.

<u>Can you remind me, which one of our friends said yum? Anne or Sally? And which one of our friends said yuck? Anne, or Sally?</u>

Now can you tell me, which one of our friends didn't know what rambutans tasted like until today? Anne or Sally?

Experiment 3.

Here we have some strange fruits. These fruits are called rambutans [place on table] and these fruits are called African cucumbers [place on table].

Here we have two friends: This is Anne and this is Sally.

Anne has never seen these fruits before and she doesn't know what they taste like [shake your head your head as you explain this]. Anne doesn't know what the Rambutan tastes like [move Annie towards the rambutan] and she doesn't know what African Cucumber tastes like [move Annie towards the African Cucumber].

Sally knows all about these fruits. She knows what they taste like [nod as you explain this]. She knows what the Rambutan tastes like [move Sally towards the rambutan] and she knows what the African Cucumber tastes like [move Sally towards the rambutan]

Can you remind me, which of our friends has tasted these fruits before? Sally or Anne? And which of our friends has not tasted these fruits before? Sally? Or Anne? [move each puppet as their name is called].

Earlier today, we told our friends they had to pick one fruit to eat and both of our friends picked a rambutan. [place on treat in front of each puppet].

<u>Can you remind me, which one of our friends knows all about these fruits? Sally? Or Anne?</u>

<u>OR</u>

<u>Can you remind me, which one of our friends has never tried these fruits? Sally? Or Anne?</u>

Now, both of our friends took a bite from their fruit and one of them changed her mind and decided she wanted to eat a different fruit. *Can you tell me, which one of our friends changed her mind? Anne? Or Sally?*

Experiment 4.

Here we have some strange fruits. These fruits are called rambutans [place on table] and these fruits are called African cucumbers [place on table].

Here we have our two friends: This is Anne, and this is Sally.

Earlier today, we told our friends they each had to pick one fruit to eat, and both of our friends picked a rambutan. [place treat in front of each puppet].

Anne and Sally both took a bite from their rambutans.

Anne [or whoever is knowledgeable] kept eating the rambutan.

Sally changed her mind and said she wanted an African cucumber instead.

But guess what! One of our friends did *not* know what rambutans tasted like until today.

Can you remind me, which one of our friends kept eating the rambutan? Anne, or Sally? And which one of our friends changed her mind and wanted an African cucumber instead? Anne, or Sally? [move each puppet as their name is called].

Now can you tell me, which one of our friends did not know what rambutans tasted like until today? Anne, or Sally?

Experiment 5 – Test condition.

This is a yellow door, and this is a red door. There's a huge set of stairs behind the red door, but there are no stairs behind the yellow door! I'm going to put a piece of corn right behind the yellow door, and a tomato behind the red door—but the tomato is going all the way at the top of the stairs, so it's way harder to get. [open the doors so they see where the food is]

Do you see how the tomato is all the way at the top of the stairs?

And here are two friends! Hi! [Have them both wave at the same time]

Let's tell them which is the tomato door, and which is the corn door. Hey, puppets! [Angle the puppets so they're looking up at you] There's a piece of corn behind the yellow door, and a tomato behind the red door!

I'm actually going to tell one of the puppets a secret! [Whisper into ear of one of the puppets] Hey friend! Behind the red door, there's also a set of stairs that you have to climb in order to get the tomato! So this puppet [wave puppet] knows about having to climb the stairs to get the tomato, but [wave the other puppet] this one doesn't know.

Now we are going to ask the puppets to choose one of the foods. Hey, puppets! Do you want some corn, or tomato? Let's see what they do! [Both puppets move over to the tomato door] Whoa! Both puppets chose the tomato!

So, can you remind me who doesn't know about the stairs/And who knew about the stairs? (Counterbalance this question order)

And who really likes tomatoes?

Experiment 5 – Control condition.

This is a yellow door, and this is a red door. There's a huge set of stairs behind the yellow door, but there are no stairs behind the red door! I'm going to put a tomato right behind the red door, and a piece of corn behind the yellow door—but the piece of corn is going all the way at the top of the stairs, so it's way harder to get. [open the doors so they see where the food is]

Do you see how the corn is all the way at the top of the stairs?

And here are two friends! Hi! [Have them both wave at the same time]

Let's tell them which is the tomato door, and which is the corn door. Hey, puppets! [Angle the puppets so they're looking up at you] There's a piece of corn behind the yellow door, and a tomato behind the yellow door!

I'm actually going to tell one of the puppets a secret! [Whisper into ear of one of the puppets]Hey friend! Behind the yellow door, there's also a set of stairs that you have to climb in order to get the corn! So this puppet [wave the puppet] knows about having to climb the stairs to get the corn, but [wave the other puppet] this one doesn't know.

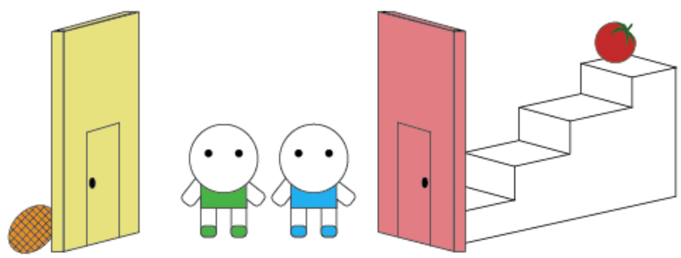
Now we are going to ask the puppets to choose one of the foods. Hey, puppets! Do you want some corn, or tomato? Let's see what they do! [Both puppets move over to the tomato door] Whoa! Both puppets chose the tomato!

<u>So, can you remind me who doesn't know about the stairs/And who knew about the stairs?</u> (Counterbalance this question order)

And who really likes tomatoes?

Experiment 5b Test (Adults tested online).

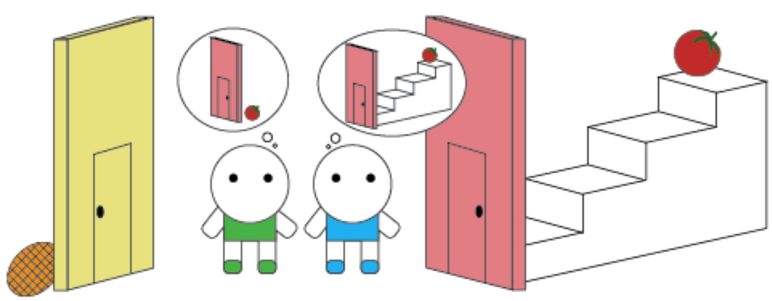
This place has a yellow room and a red room.



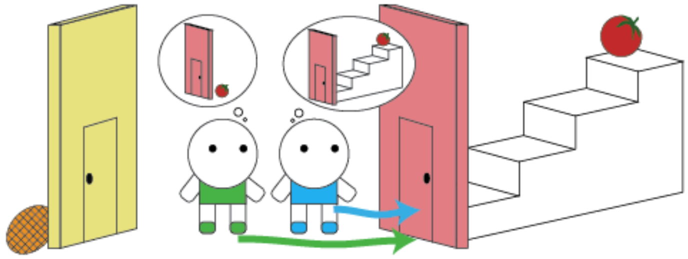
There is a huge set of stairs behind the red door, but there are no stairs behind the yellow door. There is a piece of corn right behind the yellow door, and a tomato behind the red door—but the tomato is all the way at the top of the stairs, so it is a lot harder to get.

There are two people who are going to choose what to eat. They both know that there is corn behind the yellow door, and a tomato behind the red door.

However, only one of them knows that there is a huge set of stairs behind the red door (the one wearing a blue shirt). The other person does not know (the one wearing a green shirt):



When both people were asked to choose what to eat, they both chose the tomato:



The two people made their choices separately, without knowing what the other one chose.

Please answer the following questions.

who really likes tomatoes? [the person who knew about the stairs / the person who did not know about the stairs]

How obvious is the answer? [not obvious at all / somewhat obvious / obvious / extremely obvious]

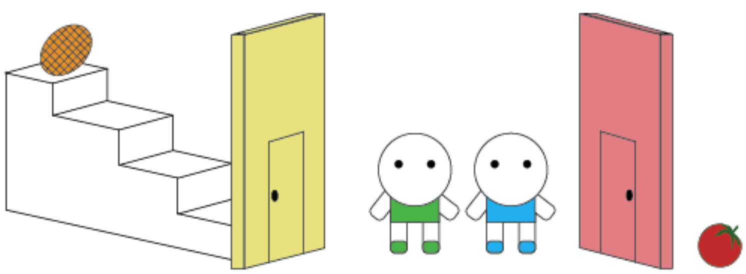
<u>Did both people know what food was behind each door? [yes / no]</u>

<u>Did both people know that there were stairs behind the yellow door? [yes / no]</u>

<u>Did both people choose what to eat together? [yes / no]</u>

Experiment 5b Control (Adults tested online).

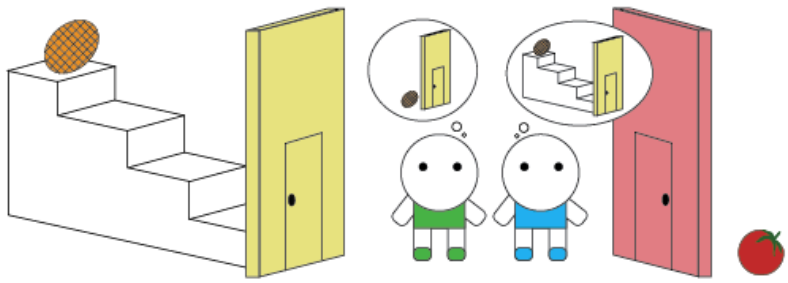
This place has a yellow room and a red room.



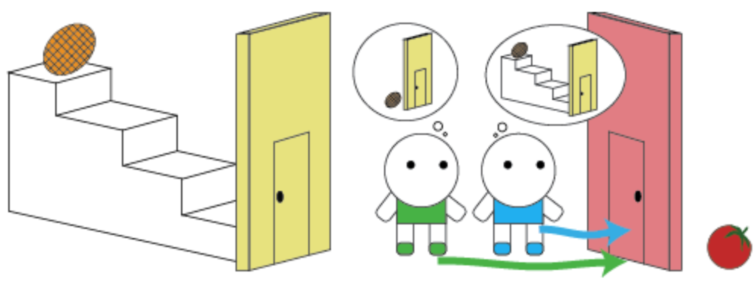
There is a huge set of stairs behind the yellow door, but there are no stairs behind the red door. There is a tomato right behind the red door, and a piece of corn behind the yellow door—but the piece of corn is all the way at the top of the stairs, so it is a lot harder to get.

There are two people who are going to choose what to eat. They both know that there is corn behind the yellow door, and a tomato behind the red door.

However, only one of them knows that there is a huge set of stairs behind the yellow door (the one wearing a blue shirt). The other person does not know (the one wearing a green shirt):



When both people were asked to choose what to eat, they both chose the tomato:



The two people made their choices separately, without knowing what the other one chose.

Please answer the following questions.

who really likes tomatoes? [the person who knew about the stairs / the person who did not know about the stairs]

How obvious is the answer? [not obvious at all / somewhat obvious / obvious / extremely obvious]

<u>Did both people know what food was behind each door? [yes / no]</u>

<u>Did both people know that there were stairs behind the yellow door? [yes / no]</u>

<u>Did both people choose what to eat together? [yes / no]</u>

Experiment 6 test.

I have these two doors. Behind the yellow door, there's nothing there. But behind the red door, there's a huge set of stairs, so if someone wanted to get to the top, they would have to climb and climb and climb. I'm going to put this tomato behind the yellow door so if someone wanted to get it they could just pick it up they wouldn't have to climb anything at all, but I'm going to put the other tomato at the top of the stairs so if someone wanted to get it, they would have to climb and climb and climb.

And I actually have two friends. HI!

And these friends are going to get to choose one of the doors. So I'm going to tell my friends: behind the yellow door is a tomato, and behind the red door is also a tomato.

So, let's see what they do! This puppet chose the red door/yellow door and this puppet chose the yellow door.

<u>Can you remind me who chose the red door/yellow door? And who chose the red door/yellow door?</u>

And it turns out that one of our friends didn't know about the stairs behind the red door. *Which one didn't know about the stairs behind the red door?*

Experiment 6b.[3]

I have these two doors and a tomato. Behind the yellow door, there's nothing there. But behind the red door, there's a huge set of stairs, so if someone wanted to get to the top, they would have to climb and climb and climb. I'm going to put the tomato behind the red door, but I'm not going to put anything behind the yellow door.

So if someone chooses the red door they are going to get a tomato. But if someone chooses the yellow door they're not going to get anything at all!

<u>So remind me what's behind the red door? And what's behind the yellow door?</u>

And I actually have two friends. So I'm going to tell my friends: there's a tomato behind one of these doors—it could be behind the red door, or it could be behind the yellow door.

So, let's see what they do! This puppet chose the red door and this puppet chose the yellow door. And it turns out that one of our friends didn't know that the tomato was behind the red door. *Which one didn't know that the tomato was behind the red door?*

Experiment 6 control.

I have these two doors. Behind the yellow door, there's nothing there. But behind the red door, there's a huge set of stairs, but they don't matter. I'm going to put this tomato behind the yellow door so if someone wanted to get it they could just pick it up they wouldn't have to climb anything at all. And I'm going to put the other tomato behind the red door, so if someone wanted to get it they could also just pick it up. They wouldn't have to climb anything at all. So the stairs don't matter.

And I have two friends. Hi!

And these friends are going to get to choose one of the doors. So I'm going to tell my friends: behind the yellow door is a tomato, and behind the red door is also a tomato.

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[3] This experiment was replaced with Experiment 6 control following a reviewer suggestion. The methods and results of Experiment 6b presented below.

So, let's see what they do! This puppet chose the red door/yellow door and this puppet chose the yellow door.

<u>Can you remind me who chose the red door/yellow door? And who chose the red door/yellow door?</u>

And it turns out that one of our friends didn't know about the stairs behind the red door. *Which one didn't know about the stairs behind the red door?*

Experiment 7 – Test condition.

This is a yellow door, and this is a red door. There's a huge set of stairs behind the red door, but there are no stairs behind the yellow door! I'm going to put a piece of corn right behind the yellow door, and a tomato behind the red door—but the tomato is going all the way at the top of the stairs, so it's way harder to get. [open the doors so they see where the food is]

Do you see how the tomato is all the way at the top of the stairs?

And here are two friends! Hi! [Have them both wave at the same time]

Let's tell them which is the tomato door, and which is the corn door. Hey, friends! [Angle the puppets so they're looking up at you] There's a piece of corn behind the yellow door, and a tomato behind the red door!

Now we are going to ask the friends to choose one of the foods. Hey, friends! Do you want some corn, or tomato? Let's see what they do. [Both puppets move over to the tomato door] Whoa! Both friends chose the tomato!

Then this friend peeked! She looked behind the red door, and saw that there was actually a huge set of stairs to climb to get the tomato.

<u>So, can you remind me which one of our friends already knew about the stairs? And who didn't know about the stairs?</u>

But guess what? One of our friends changed his/her mind and said s/he wanted to go to the other door to get corn instead.

Can you tell me, which one of our friends changed his/her mind?

Experiment 7 – Control condition.

This is a yellow door, and this is a red door. There's a huge set of stairs behind the yellow door, but there are no stairs behind the red door!

I'm going to put a tomato right behind the red door, and corn behind the yellow door—but the corn is going all the way at the top of the stairs, so it's way harder to get. [open the doors so they see where the food is]

Do you see how the corn is all the way at the top of the stairs?

And here are two friends! Hi! [Have them both wave at the same time]

Let’s tell them which is the tomato door, and which is the corn door.

Hey, friends! [Angle the puppets so they're looking up at you] There’s a piece of corn behind the yellow door, and a tomato behind the red door!

Now we are going to ask the friends to choose one of the foods. Hey, friends! Do you want some corn, or tomato? Let’s see what they do. [Both puppets move over to the tomato door] Whoa! Both friends chose the tomato!

Then *this* friend peeked! S/he looked behind the red door, and saw that the tomato was right there. S/he could just pick it up and didn’t have to climb any stairs.

So, can you remind me which one of our friends already knew that there were no stairs behind the red door? And who didn’t know that there were no stairs behind the red door?

But guess what? One of our friends changed his/her mind and said s/he wanted to go to the other door to get corn instead.

Can you tell me, which one of our friends changed his/her mind?

Other experiments

Experiment 5b test (adults)

Participants. 24 adult participants from the US (as determined by their IP address) were recruited from Amazon's Mechanical Turk Platform. 10 additional participants were recruited but excluded from the study because they failed to respond correctly to three questions that ensured they had read the story (see Experiment 5b script above).

Procedure. Participants read a simple story with accompanying pictures (see Experiment 5b script above for story and pictures). At the end they were asked to respond five questions: the test question, a question regarding how obvious the answer to the task was, and three questions designed to ensure they had read the task.

Results. Only participants who responded to the three questions that ensured they read the story were included in the study. Out of the 24 participants who passed the inclusion questions, 23 said that the knowledgeable agent had a strong preference (96%; 95% CI: 0.92-1). Results from the obviousness question were coded numerically with 0 indicating "not obvious at all" and 3 indicating "extremely obvious." On average, participants gave a rating of 1.38 (95% CI: 0.96-1.80)

Experiment 5b control (adults)

Participants. 24 adult participants from the US (as determined by their IP address) were recruited from Amazon's Mechanical Turk Platform. 8 additional participants were recruited but excluded from the study because they failed to respond correctly to three questions that ensured they had read the story (see Experiment 5d script above).

Procedure. The procedure was identical to Experiment 5b Test.

Results. Only participants who responded to the three questions that ensured they read the story were included in the study. Out of the 24 participants who passed the inclusion questions, 19 said that the ignorant agent had a strong preference (79%; 95% CI: 0.67-0.96). Results from the obviousness question were coded in the same way as Experiment 5b Test. On average, participants gave a rating of 0.92 (95% CI: 0.63-1.21). Although, on average, participants in Experiment 5b Test gave lower obviousness rankings compared to participants in Experiment 5b Test, these results were only marginally different ($t(39)=1.71$, $p=0.09$).

Experiment 6b (children)

Participants. 16 participants (mean age (SD): 4.96 years (170 days), range 4.14-5.74) were recruited at an urban children's museum. 2 additional participants were recruited for the experiment but excluded from analysis and replaced for failing the inclusion question (n=1) and due to an experimenter error (n=1).

Procedure. The experiment is conceptually similar to Experiment 6 with the difference that there was only one tomato which was placed directly behind the door that had the stairs (the red door) and nothing was placed behind the door that did not have stairs (the yellow door). The experimenter told participants, "I'm going to put the tomato right behind the red door, so if someone wanted to get it, they could pick it right up. But I'm not going to put anything behind the yellow door." Children were then asked two memory questions (order counterbalanced) to ensure they had paid attention to the story "If someone picked the red door what would they get? And if someone picked the yellow door what would they get?" As in the test condition, each puppet chose a different door (puppet counterbalanced). As such, in contrast to experiment 6, the puppet choosing the red door now made a high-utility choice whereas the puppet choosing the yellow door made a poor choice (no rewards). Children were asked, "Who didn't know there was a tomato behind the red door?" such that the correct answer was the puppet that chose the yellow door. If children simply choose the puppet that chose the red door when asked the test questions about the red door, they should choose at chance in Experiment 6b.

Results. Participants in experiment 6b were coded as responding correctly if they indicated that that the puppet who chose the red door was the one who knew the location of the tomato. Of the 16 participants who made a choice, 13 responded correctly (81.25%; 95% CI:62.5-100%). Together, with the test condition of Experiment 6 these results suggest that children believe that agents who fail to maximize utilities are more likely to have been ignorant about the costs.