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Constraints on Children's Judgments of Magical Causality

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In 3 studies we addressed the operation of constraints on children's causal judgments. Our primary focus was whether children's beliefs about magical causality, specifically wishing, are constrained by features that govern the attribution of ordinary causality. In Experiment 1, children witnessed situations in which a confederate's wish appeared to come true. Three features of causality—priority, consistency, and exclusivity—were systematically violated in the wishing scenarios. The dependent measure was children's attribution of a causal role to the confederate's wish in explaining the appearance of an object. Results revealed that children's attribution of a causal role to the process of wishing was constrained by 2 features of ordinary causality—priority and exclusivity. Results from Experiments 2 and 3 demonstrated that children honored these same constraints in attributing physical causality to a novel machine and to a marble toy. It is concluded that magical causality is constrained by some of the same features that constrain ordinary causality.

Ample evidence demonstrates that young children have a wealth of knowledge about many of the specific causal processes that operate in the world and have a good idea of what sorts of events and processes are possible and impossible in both the physical and psychological domains (e.g., Browne & Woolley, 2004; Rosengren & Hickling, 1994; Shtulman & Carey, 2004; Subbotsky, 1994). In the psychological domain in particular, by the age of 3 children understand that certain mental states, like desires, can cause actions, and, in return, certain events can cause or produce mental states (Bartsch & Wellman, 1995). Children also understand that certain mental states can cause other mental states; for example, seeing a dog can remind someone of their own recently deceased dog, which can then make

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that person sad (Lagattuta, Wellman, & Flavell, 1997). Importantly, children also know that ordinary mental states do not directly cause distal outcomes in the physical world. In other words, they know that they cannot alter a physical object "just by thinking about it" (Estes, Wellman, & Woolley, 1989).

Yet there is one exception to this rule: Children believe that by wishing for something they can affect physical reality. Research indicates that preschool-age children know a great deal about wishing and also believe in its efficacy. Vikan and Clausen (1993) showed 4- and 6-year-old participants drawings of children and told them that the child was making a wish in an attempt to influence another person depicted in another scene. Children were asked to indicate the effectiveness of the child's wish. Results showed that 94% of the 4- to 6-year-old children believed they could influence others by wishing. Woolley, Phelps, Davis, and Mandell (1999) used a mixture of interview questions and structured tasks to assess 3- to 6-year-old children's concepts of wishing and beliefs about its efficacy. They reported that a majority of preschool-age children have made wishes themselves, and believe in its efficacy, both regarding their own wishes and those of hypothetical story characters.

Although children believe that wishing works, and that it involves the mind exerting a direct effect on physical reality, they also understand that wishing is not the same as ordinary mental causality. As Woolley et al. (1999) argued (see also Johnson & Harris, 1994, Experiment 2), children believe that wishing is a magical, not an ordinary, process. When asked about the magical nature of wishing, children's responses indicate that they consider wishing to be more similar to magical events, like a frog turning into a princess, than to ordinary events, like water coming out of a faucet (Woolley et al., 1999). Woolley et al. also had children make wishes that appeared to come true. When asked whether magic was involved in the event, children overwhelmingly responded affirmatively. Thus, rather than representing a case of ordinary mental–physical causality, children appear to view wishing as a form of magical causality.

Although research shows that young children hold beliefs in wishing, as well as in other forms of magical causality (see, e.g., Johnson & Harris, 1994), there is little information in the literature concerning what these beliefs are like. It does seem clear that children believe that, in the realm of magic, specific causal laws or regularities are considerably relaxed (Rosengren & Hickling, 1994). A fundamental question that has not been addressed, however, is the extent of this "causal freedom." Is it possible that, in addition to allowing for violations of specific causal links, magic allows for violating or relaxing the basic features of causality in general?

According to Nemeroff and Rozin (2000), anthropologists have often assumed that general features of causation are suspended in both religious and magical activities. That is, there are believed to be no constraints on the kinds of entities and processes that can exist in these domains. But more recently, Boyer (1994; Boyer

& Walker, 2000) argued that there are important general constraints on reasoning that operate in all causal domains (see also Barrett, 1994; Barrett & Keil, 1996). Barrett's (1994; Barrett & Keil, 1996) work, for example, shows that in certain types of tasks, adults reason about God as if He were subject to constraints of ordinary causality. Kelly and Keil (1985) argued that although in fantasy one can imagine all kinds of transformations, certain ones that reflect properties of conceptual structure will be favored. For example, in both Ovid and in Grimm, when characters are transformed into other characters, they are more likely to maintain ontological status than to violate it. Boyer (1994) argued that these sorts of constraints on how people conceive of various entities and what people find believable reflect the basic cognitive architecture of the mind. If this is the case, then one would expect that they would affect children's reasoning as well.

To address this issue, we must specify and explain those general features of ordinary causality whose role in magical causality is in question. Classic studies of how people perceive events have shown that the perception of causality depends on three features of the relation between an event and its possible causes: (a) priority, (b) consistency, and (c) exclusivity (see, e.g., Michotte, 1963). Priority, or temporal order, is arguably the most basic feature of ordinary causality (see, e.g., Einhorn & Hogarth, 1986; Michotte, 1963). Peoples' notions of everyday causality are strictly constrained by the order in which events occur; specifically, causes always precede their effects. This is true for both the psychological and the physical domains. In the psychological domain, particular beliefs are often considered to be the cause of particular actions or behaviors, provided the beliefs were formed before the behaviors were observed. For example, suppose one knows that Joe became a vegetarian, and that he subsequently learned about certain objectionable practices of the meat industry. In explaining his decision to become a vegetarian one would not invoke his knowledge of the meat industry because this knowledge was obtained after the decision and therefore could not have caused it. Similarly, regarding the physical domain, if a vase cracks and subsequently falls off the shelf, its falling could not have caused the vase to crack. Even infants react to events in which this basic causal constraint is violated (Leslie & Keeble,1987; Oakes, 1994), and the causal judgments of children as young as 4 years have been shown to be constrained by this feature in the domain of physical causality (Bullock, 1985; Kuhn & Phelps, 1976; Kun, 1978; McCabe & Peterson, 1988).

Perception of causality is also dependent on the similarity, or *consistency*, between the attributes of the cause and those of the effect. In general, causes that are consistent with their effects are more likely to be perceived as causal (see, e.g., Einhorn & Hogarth, 1986). The influence of consistency on people's causal notions has been demonstrated in both the physical and psychological domains. For example, in research by Michotte (1963), participants' judgments of physical causality were guided by the expectation that when one ball collides with another and causes it to move, the speed and direction of the two balls should be roughly con-

sistent with each other. In the domain of everyday psychological reasoning, people generally see behavior as caused by intentions and other mental states whose content is consistent with the behavior to be explained. Thus, unless one has sufficient information to the contrary, one would assume that Mary pressed the Coke button at a soda machine because she wanted to get a Coke, not because she wanted to get a Sprite. Of course, everyday psychological reasoning does allow for exceptions to this constraint. When we interpret someone's behavior as an accident, for example, we are usually noting the inconsistency between the behavior and the content of the person's intentions.

One set of studies (Shultz & Ravinsky, 1977) showed that, by the age of 6, children are sensitive to consistency in their judgments of ordinary causality. In these studies, 6- to 12-year-olds chose causes that matched effects on dimensions such as color and intensity over potential causes that were inconsistent along these same dimensions. Although we do not know whether preschoolers' notions of physical causality adhere to this constraint, we know that in the psychological domain they do explain behavior with reference to content-consistent mental states (e.g., Wellman & Gelman, 1998). Evidence of 3-year-olds' use of a matching rule in judgments of intentionality also suggests that consistency guides young children's causal judgments (Shultz & Wells, 1985). In Shultz and Wells's study, children observed shooters who picked a certain color card and then either hit that color target with their shot or not. Children as young as 3 years used the match between the color of the card and the color of the target to infer the shooter's intentionality.

Finally, perception of causality is also dependent on the feature of exclusivity. According to Michotte (1963), to be certain of the cause of an event, rival causes for the event should not exist. For example, to identify the action of one ball as the cause of another ball's movement to a new position, one should not also witness someone simultaneously picking up the second ball and moving it to the new position. Of course, in many cases there may be multiple possible causes for an event. In these cases, the scheme for multiple sufficient cause (Kelley, 1967) dictates that when one possible cause for an effect is known to be operative, other causes should be discounted. Research by Shultz and Butkowsky (1977) indicated that children as young as 5 years are sensitive to this constraint in judgments about causes for people's behavior. However, other research indicates that children may not reliably discount multiple causes until around 7 years of age. In these studies, young children, when given multiple possible causes for an event, simply accepted both causes as playing a role in the event (Costanza, Grumet, & Brehm, 1974; Karniol & Ross, 1979; Smith, 1975).

In this research we sought to address these questions about the extent to which features involved in the perception of causality in the ordinary realm additionally constrain beliefs about magical causality, specifically, the process of wishing. We reasoned that if children's beliefs about wishing are so constrained, then they should hold the following three beliefs about how wishing works. For a wish to be

perceived as causing an object to appear, (a) the wish needs to be made *before* the wished-for object appears (priority), (b) the object that appears should be the *same one* that was wished for (consistency), and (c) wishing should be the *only apparent explanation* for the appearance of the event (exclusivity). When these conditions are violated, children should not consider wishing as an explanatory force, or they should be less likely to do so. In two additional studies, we assessed the operation of these same constraints regarding ordinary causality, in scenarios that are parallel to the wishing scenarios in Experiment 1. We chose 3- to 6-year-olds as our target age group, because this is the age at which previous research (Vikan & Claussen, 1993; Woolley et al., 1999) showed that children believe most strongly in wishing.

EXPERIMENT 1

Method

Participants. Seventy seven 3- to 6-year-old children participated (37 boys and 40 girls). Thirty eight were younger children (M = 4;1, range = 3;3–4;11) and 39 were older (M = 6;1, range = 5;3–7;1). Children's names were obtained from birth records kept on file at a university research laboratory and participants were recruited through letter and telephone contact with their parents. Most participants were middle-class and White, but several ethnic groups, including Asian American and Hispanic American were also represented.

Materials. Materials for the wishing tasks included a list of interview questions designed to assess children's general knowledge about and beliefs in wishing, 10 trick boxes ("wishing boxes"), and eight small, everyday items that were placed in the boxes. The items included a ring, a small silk flower, a sea shell, a small rock, a penny, a piece of gum, a piece of candy, and a button. The wishing boxes were colorfully decorated 3" × 1" × 1" plastic boxes containing a drawer with a hidden compartment activated by tilting the box one way to make an item inside "disappear" and the other way to make the item "appear." This mechanism allowed us to control the apparent outcome of a confederate's wishes for the various objects (see Procedure).

Procedure. Participants were tested individually in a testing room at the Children's Research Lab of the University of Texas. Children participated in one 15- to 20-min session. Before children were given the focal task, they were asked a few questions about their beliefs in wishing. These were taken from Woolley et al. (1999) and included questions like "Have you ever wished for anything?" and "Do peoples' wishes … come true?" (Appendix A). The interview was followed by the focal task, in which the experimenter introduced the confederate as someone who

"had a lot of things he/she wanted to wish for," and so was going to wish for them to appear in some boxes the experimenter had brought along. Children watched as the confederate wished for items to appear in a series of boxes and were then asked to make judgments as to whether the outcomes were caused by the wishes or were the result of some other cause. One might be concerned that answering the questions in the wishing interview would result in children endorsing wishing more in the box task. Although that is a possibility, it is not one with which we were concerned, as our focus was not absolute levels of belief but rather how belief was affected by violations of the constraints.

Each child received a total of 10 trials, 2 of each of 5 types. Three trial types *(Violation of priority, Violation of consistency, Violation of exclusivity*) were the experimental trials in which the causal features were violated. On *Honored* trials, all causal features were honored and an object appeared in the box; on *Failed* trials, the causal features were honored but nothing appeared in the box. The wished-for items were presented in a fixed order for all participants. The trial types were presented in a unique semirandom order for each participant, with the constraints that Trial 1 was always an *Honored* trial and Trials 3 and 7 were the *Failed* trials (see Table 1).

On the *Honored* trials, the experimenter first opened a box and showed the children that it was empty. The box was then closed and the confederate wished for an item to appear in the box. To wish, the confederate first gave a short reason for her wish (e.g., "I collect pennies"), then closed her eyes and wished by saying aloud, "I wish for a (e.g., penny) to be in the box right now!" While the confederate's eyes were closed, the experimenter asked the children if they thought the wish came true, and what they thought would be in the box: "Let's open the box. What will we see?" Next, the experimenter opened the box to reveal that the wished-for item was in the box. Children were then asked the test question: "How do you think that got there?" If children's answers did not indicate that the outcome was the result of either the wish or some other, nonmagical cause, this question was followed with, "Did her wish put that there?"

TABLE 1
Study Design

Trial	*Initial Status of Box*	*Event*	*Outcome*
Honored	Empty	E2 wishes for Object A	Object A appears
Violation of priority	Object A in box	E2 wishes for Object A	Object A appears
Violation of consistency	Empty	E2 wishes for Object A	Object B appears
Violation of exclusivity	Empty	E2 wishes for Object A E1 places Object A in box	Object A appears
Failed	Empty	E2 wishes for Object A	Empty

The *Violation of priority* trials followed the same general pattern, but began a bit differently. Before the experimenter opened the box, the confederate excused herself from the room to get a tissue or a drink of water, saying that she would make a wish upon returning. While the confederate was gone, the experimenter opened the box for the children as usual, but this time the box was not empty; one of the items was already inside. The experimenter said, "[Confederate] didn't see this like we did, so let's close the box and not tell her what's inside. We'll just see what happens." The confederate then returned and proceeded to wish for the item that the children knew to be in the box. The rest of the trial continued as previously described. The *Violation of consistency* trials followed the procedure for the *Honored* trials exactly except that a different item from the one that was wished for appeared in the box.

Finally, the *Violation of exclusivity* trials violated the causal feature of exclusivity by providing two apparent causes for the items' appearances in the boxes. These trials began in the general fashion, but as the confederate wished for an item to appear, the experimenter simultaneously, in full view of the children, placed the wished-for item in the box and then closed it. The rest of the trial proceeded in the usual way.

On all the test trials described thus far, there was always something in the box after the confederate's wish. Because of this we were concerned that children might fall into a pattern of unthinkingly expecting objects to appear. To break such potential response sets, we included two *Failed* trials, in which nothing appeared in the boxes after the confederate's wishes. Upon revealing the empty box, rather than asking, "How do you think that got there?" the experimenter instead asked, "What happened?" and whether the wish had come true.

After all 10 trials were completed, children were asked if they had ever seen boxes like the ones used in the experiment. Five of the 77 children reported that they had seen the boxes before. The scores of these 5 children did not differ significantly from the scores of the remaining children, $t(185) = -1.44$, *ns,* so their scores were not removed from the analyses that follow.

Results

Interview. Affirmative responses on the interview were scored as 1 and negative responses were scored as 0. Question 1 was intended as a conversation starter and not as a test question, thus percentages are not reported. Responses to the other questions are reported in Table 2. As can be seen in the table, a majority of the children reported that they had wished before (Question 2). There was a trend toward more younger than older children reporting that their past wishes had come true (Question 3), $\chi^2(1) = 3.32$, $p = .08$. Younger children were significantly more likely than older children to claim that wishes always came true if they had previ-

TABLE 2
Percentages and Numbers of Positive Responses to Wish Interview Questions

	Age Group					
	Younger[a]		Older[b]		Overall[c]	
Question	%	*n*	%	*n*	%	*n*
2. Has wished for something in the past	82	28	70	26	76	54
3. Past wish came true	55	17	31	8	44	25
4. If yes to #3, do wishes: always come true? (yes)	65	11	13	1	48	12
If no to #3, do wishes ever come true? (yes)	25	3	6	1	13	4
5a. If child wanted something, he or she would wish for it	80	28	87	27	83	55
5b. (If yes) Thinks this wish would come true	82	23	56	15	69	38

Note. *n*s are slightly different for each question due to missing data.
[a]$N = 38$. [b]$N = 39$. [c]$N = 77$.

ously said that their wish had come true (Question 4), $\chi^2(1) = 5.1$, $p < .03$. Most of the children (83%) reported that they would wish for something they really wanted (Question 5a); however, fewer (69%) claimed that they thought these wishes would actually come true (Question 5b). This difference was entirely due to the performance of the older children, with significantly more younger than older children claiming that their wish would come true, $\chi^2(1) = 4.55$, $p < .04$. These findings as a whole are consistent with those reported by Woolley et al. (1999) and thus serve as a partial replication of those findings.

Wishing box task. We first assessed children's expectations about whether the wishes made by the experimenter would come true. Affirmative responses were given a 1 and negative responses a 0. Across all trial types there was a moderately high level of expectation in the efficacy of the wishes ($M = .86$, $SD = .20$). However, consistent with the results of the interview, there was a significant decrease with age in claims that the wishes would come true, $F(1, 57) = 16.84$, $p < .001$, with younger children ($M = .95$, $SD = .11$) having stronger expectations than older children ($M = .76$, $SD = .23$). We also addressed the possibility that seeing the wishes "come true" early on in the experimental session might influence children's predictions on later trials, thus possibly inflating overall estimates of children's beliefs in wishing. To assess this we compared children's predictions on the first instance of each trial type (summed) with the second instance of each trial type

(summed). This comparison was nonsignificant, $t(75) = 1.05$, $p = .30$. Thus, children did not seem to be "learning" across trials to adjust their expectations. Indeed, it makes sense that they would not systematically have adjusted their expectations in either direction, as participants were receiving mixed feedback throughout the session.

Children's claims about whether or not the confederate's wishes had caused the wished-for items to appear in the boxes constituted the primary dependent variable in the analyses. These responses consisted of answers to the question "How do you think that got there?" and if responses were unclear, the follow-up, "Did her wish put that there?" Children's answers were entered onto response forms by the primary experimenter. Responses indicating that the wish caused the outcome were scored 1 and responses that either indicated that the wish was not the cause or that implicated some other, nonmagical cause (e.g., "you put it there") were scored 0. Thirty percent of the responses were also scored by a second coder; agreement was 96%. Scores were averaged across the two instances of each trial type to generate total "wish scores" for each trial type.

We conducted a 2 × 2 × 4 (Age × Sex × Trial: *Honored, Violation of priority, Violation of consistency, Violation of exclusivity*) analysis of variance (ANOVA) with repeated measures on the last factor on children's wish scores. The *Failed* trials were inserted solely for the purpose of breaking response sets. In addition, because the object did not appear in these trials, we could not ask children the test question, "How did (X) get there?" Thus, the *Failed* trials are not included in our analyses.

The analysis revealed a significant main effect of age, $F(1, 267) = 30.97$, $p < .001$; younger children ($M = .72$, $SD = .42$) endorsed wishing as the cause of the appearance of the objects significantly more often than did the older children ($M = .56$, $SD = .44$). There was also a significant effect of sex, $F(1, 267) = 15.25$, $p < .001$, with girls ($M = .71$, $SD = .42$) more often than boys ($M = .58$, $SD = .43$) attributing outcomes to wishing.

Most important, the ANOVA also revealed a significant main effect of causal feature, $F(3, 267) = 30.97$, $p < .001$, and no interactions involving it. Children's wish scores were highest on the *Honored* trials ($M = .85$, $SD = .30$), in which none of the causal constraints were violated. In other words, on these trials, children were most likely to attribute causal power to the confederate's wish. Post hoc tests revealed that wish scores on both the *Violation of priority* trials ($M = .68$, $SD = .42$), in which the object appeared before the wish, and the *Violation of exclusivity* trials ($M = .29$, $SD = .39$), in which the experimenter placed the object in the box, were significantly different from scores on the *Honored* trials at $p < .01$. Violation of these two causal constraints significantly decreased the number of claims that wishing was the causal force behind the objects' appearance. The *Violation of consistency* trials did not yield scores that were statistically significantly different from those on the *Honored* trials ($M = .75$, $SD = .39$). In other words, when a differ-

ent object appeared in the box from what was wished for, children still attributed causal power to the wish as much as they did in the *Honored* trials. In addition, the analyses indicated that scores on the *Violation of exclusivity* trials were significantly lower than scores on both the *Violation of consistency* and *Violation of priority* trials (both *p*s < .001).[1] Violation of exclusivity appeared to affect children's claims more than these other two types of constraint violations.

Discussion

The goal of this experiment was to assess the operation of causal constraints on children's beliefs about wishing. The primary finding was that children's use of wishing as an explanatory force was constrained by two features of ordinary causality—priority and exclusivity. We reserve discussion of this finding, however, for the General Discussion (so that we can discuss Experiments 1, 2, and 3 together) and will address here findings that are specific to this experiment. First, results of the interview questions are consistent with Woolley et al.'s (1999) findings from a very similar interview, thus replicating those findings. It is interesting to note that, although most of the questions addressing the efficacy of wishing exhibited an age-related decrease, responses indicating that children would wish for an object that they wanted did not decrease with age. One might think that if children believed less in wishing as they got older then they would also be less likely to plan to engage in it, but this does not appear to be the case. This might reflect something akin to the verbal–behavioral dissociations discussed by Subbotsky (1993), in which children's beliefs in magic appear to disappear first in their verbal responses and only later in their behavior. Alternatively, it may represent something similar to a phenomenon that often governs superstitious behavior (see, e.g., Vyse, 1997; Woolley & Phelps, 1994) in which, despite lack of a strong belief in a particular process, people engage in that process if the cost of doing so is low.

On the wishing box task, girls were more likely than boys to claim that wishing was the cause of the object appearing in the box. An effect of sex on children's beliefs in wishing has not previously been found, thus it is hard to offer a clear interpretation of this finding. To attempt to explain this, one step would be to include

[1]An additional consideration was the potential effect of false belief understanding on children's processing of the *Violation of priority* trials. If children did not understand that someone could have a false belief, they might assume that the confederate knew that the item was already in the box, thus making it less likely that they would claim that the wish was the causal force involved. As part of another research question (and so not discussed in this article), all children in the experiment were given a standard deceptive contents false belief task (half of the children were given this task before the wishing tasks and half after). Thus, we were able to assess the potential effects of false belief understanding on responses on the *Violation of priority* trials. A *t* test comparing children who passed versus children who failed the false belief task revealed no effect of false belief understanding on performance on the *Violation of priority* trials, $t(48) = -1.11$, *ns.*

older age groups in similar studies, to assess whether the sex difference persists as children get older, or whether girls' level of belief decreases to that of the boys by age 6 or 7. It might also be fruitful to probe relations between sex differences in beliefs about wishing and other fantasy-related beliefs (e.g., imaginary companions; see Taylor, 1999), as well as potential interactions with general fantasy orientation and/or play styles.

EXPERIMENT 2

As the primary focus of our research is the relation between magical causality and ordinary causality (specifically, whether they are similarly influenced by causal principles), our conclusions about constraints on beliefs about wishing would be strengthened by including both kinds of causality in our investigation. Thus, in Experiment 2 we explore whether the principles that constrain children's judgments about magical causality also constrain their judgments about physical causality. This will provide a "benchmark" with which to compare the results of Experiment 1 and thus permit assessment of how magical causality relates to ordinary causality. Without such a benchmark, we cannot know for certain how much of the influence of priority and exclusivity on causal judgments to attribute to the fact that the causal process was magical, and how much to attribute to the particulars of the paradigm employed. By assessing the influence of the causal features on ordinary causality using a paradigm that is parallel in every way except for the causal mechanism involved, we can essentially isolate "type of causality" (magical vs. ordinary) as a variable and thus compare the effect of the causal constraints on the two types of explanation.

Method

Participants. Seventy seven 3- to 6-year-olds (34 girls and 43 boys) participated. Forty were younger children (M = 4;1; range = 3;3–4;11) and 37 were older (M = 6;1; range = 5;2–6;10). Names were obtained from the same birth records file as in Experiment 1, and children were recruited through letter and telephone contact with the parents. Most participants were White and middle-class, but several ethnic groups, including Asian American and Hispanic American, were represented. None of the children participated in Experiment 1.

Materials and design. To parallel the wishing paradigm as closely as possible using a nonmagical causal process, we constructed a "machine," functionally similar to a vending machine, that ostensibly places objects into boxes. Whereas in Experiment 1 the verbalization of wishes marked the activation of the causal process in each trial, here the causal process was activated by pressing buttons on the ma-

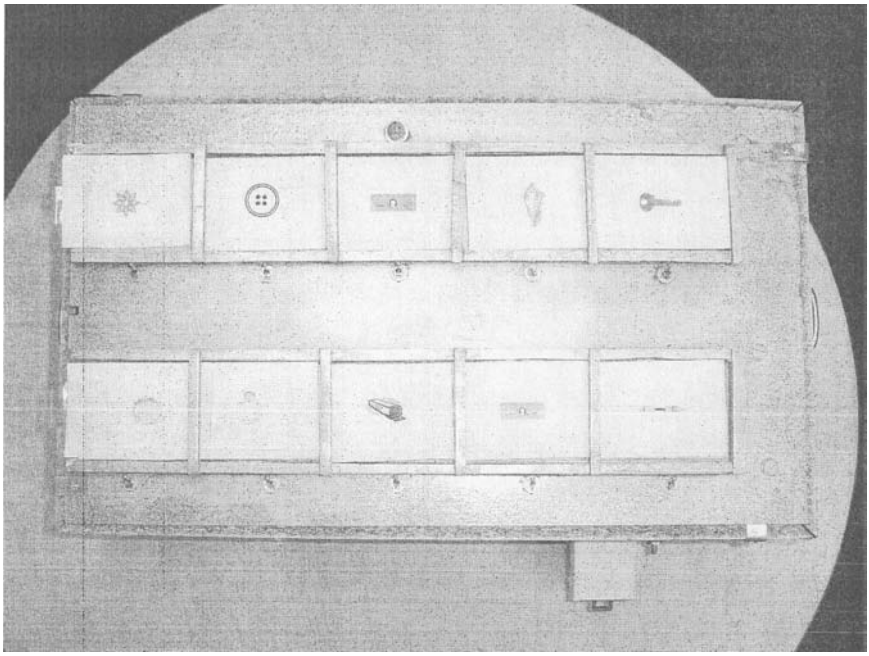

FIGURE 1 The machine used in Experiment 2.

chine. The apparatus, shown in Figure 1, consisted of a metallic grey box with a slot in the front into which small boxes (trick boxes from Experiment 1) could be inserted individually. There were 10 buttons on the top of the machine, each with a picture of an object adjacent to it. Six of the items from Experiment 1 were reused (ring, flower, shell, penny, gum, and button) and four new items were added: a crayon, a key, a $1 bill, and a $5 bill. When pressed, the buttons activated a yellow light on the machine, as well as a noise-making motor, located inside the machine. The purpose of the light and the noise was to make the causal process seem real (not magical), as most machines (e.g., computers, fax machines) have an indicator light and/or make some kind of noise that people use to gauge whether the machine is operating.

As in Experiment 1, each participant received 10 trials. The five trial types were the same as in Experiment 1 (*Honored*, *Violation of consistency*, *Violation of priority*, *Violation of exclusivity*, and *Failed*), but they were adapted to the machine paradigm (see Table 1). The order of presentation of the trials was randomized across children, except that, as in Experiment 1, the first *Honored* trial always came first and the two *Failed* trials were always third and seventh. In each trial, (a) the child looked into one of the trick boxes; (b) the experimenter announced the object she would try to obtain (ostensibly chosen at random from a bag of cards, but actually planned); (c) the experimenter inserted the box into the machine and pressed the

button corresponding to that object for 4 seconds; and finally (d) the experimenter removed the box from the slot, and the child looked inside. For the *Honored* trials, the machine worked "as advertised": The trick box was empty before being inserted in the machine and the correct object was in the box when it was removed. For the *Violation of consistency* trials, the object that appeared in the box did not correspond to the button that was pressed. For the *Violation of priority* trials, the children saw the desired object in the box *before* the box was inserted and the button pressed. To achieve the *Violation of exclusivity* manipulation, the experimenter removed the box from the machine while the button was being pressed, placed the desired object in the box, and re-inserted the box. On *Failed* trials, no object was in the box when it was removed from the machine.

Procedure. Participants were tested individually in a testing room at the Children's Research Lab of the University of Texas. Children participated in one 15- to 20-min session. First, the experimenter briefly introduced children to the machine by saying, "I want to show you my machine. It puts things in little boxes like this (showed a trick box); all we have to do is put one of these little boxes in the machine, press the button for whatever we want to get in the box, and when we take it out, the thing we pressed the button for should be in the box." At the beginning of each trial, the experimenter opened the box, showed it to the child, and said, "It's empty" (or, for the *Violation of priority* trials, "Look, there's an X in there; let's just leave it in there and close it up"). After pressing the button, but before opening the box, the experimenter asked, "Do you think it worked?" and, to make sure children remembered which button was pressed, "What do you think will be in the box?" If children did not indicate the item designated by the button, they were reminded of the item for which the button was pressed. Incorrect responses, which included "don't know" responses, or claims that a different object or nothing was in the box, represented only 1% of children's responses. At the end of each trial, after removing the box from the machine and opening it, the experimenter stated what was in the box (e.g., "Oh look, a penny," or, for the *Failed* trials, "There's nothing in there"), and asked the test question, "How do you think that got there?" (or, on *Failed* trials, "What do you think happened?"). In response to ambiguous answers to this question, a follow-up question was asked: "Do you think the machine put it there?"

Results

Responses to the prediction question that was asked after the button was pressed but before the box was opened ("Do you think it worked?") were scored as they were in Experiment 1: Affirmative responses were given a 1, negative responses a 0. Across trial types, children indicated high levels of expectation that the machine had worked (M = .93, SD = .11). As in Experiment 1, there was an effect of age,

with younger children's expectations ($M = .97$, $SD = .09$) being higher than those of older children ($M = .89$, $SD = .11$), $F(1, 74) = 9.94$, $p < .01$. To assess whether children's expectations changed throughout the session, we compared children's predictions on the first instance of each trial type (summed) with the second instance of each trial type (summed). This comparison was nonsignificant, $t(75) = 1.63$, indicating that children were not adjusting their expectations across trials.

The primary dependent variable was children's responses to the question, "How do you think that got there?" (or, when there was no response or responses were ambiguous, "Do you think the machine put that there?") after the contents of the box were revealed to the child at the end of each trial (except the *Failed* trials). Scoring was parallel to that in Experiment 1: Responses indicating that the machine was responsible for the item's appearance in the box were given a 1, responses indicating that the machine was not responsible or supplying an alternate explanation were given a 0. A second coder independently scored one third of the responses, with 97% agreement between the two coders.

Preliminary analyses did not indicate any effects of sex, thus it was not included in subsequent analyses. A 2 × 4 (Age × Trial: *Honored, Violation of priority, Violation of Consistency, Violation of exclusivity*) repeated measures ANOVA was performed on children's average endorsement of the machine across the four types of trials. The analysis revealed a significant main effect of age, $F(1, 298) = 70.13$, $p < .001$, with younger children ($M = .82$, $SD = .33$) endorsing the machine as the cause of the item's appearance significantly more often than older children ($M = .56$, $SD = .46$).

In addition, there was a significant main effect of trial type, $F(3, 298) = 110.43$, $p < .001$. Post hoc comparisons by Fisher's *LSD* tests revealed that children were significantly more likely to attribute the cause of the object's appearance to the machine on the *Honored* trials than on the *Violation of priority* and *Violation of exclusivity* trials (both ps $< .001$). In addition, both the *Violation of priority* and *Violation of consistency* trial scores were significantly different from the *Violation of exclusivity* trial scores (ps $< .001$). As is illustrated in Figure 2, there was also an Age × Trial interaction, $F(3, 298) = 22.05$, $p < .001$. To investigate this interaction, simple effects analyses were conducted. As is also evident in Figure 2, both age groups responded similarly across the four trials, with the older children's pattern simply being more differentiated. Post hoc tests by Fisher's *LSD* indicated that the younger children endorsed the machine more on the *Honored* trials than on the *Violation of priority* ($p < .005$) and *Violation of exclusivity* ($p < .001$) trials, as did the older children (*Violation of priority*, $p < .001$, and *Violation of exclusivity*, $p < .001$).

Simple effects analyses on trial types revealed significant development in the operation of both the priority and exclusivity constraints. Priority constrained older children's explanations ($M = .19$, $SD = .13$) much more strongly than it did

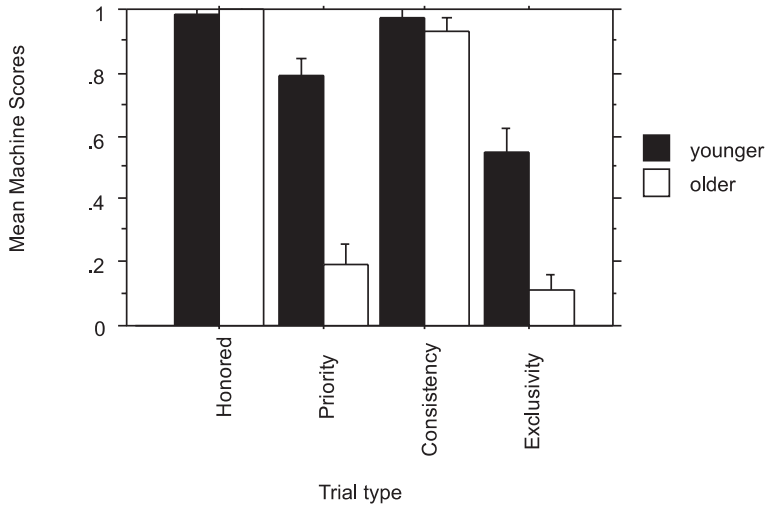

FIGURE 2 Mean number of claims (out of 4) that the machine caused the object to appear in the box by age and trial type. Error bars indicate standard error.

those of younger children (M = .80, SD = .10), $t(74) = 7.77$, $p < .001$. Exclusivity similarly constrained the judgments of older children (M = .11, SD = .09) more strongly than those of younger children (M = .54, SD = .21), $t(75) = 4.86$, $p < .001$.

Discussion

The results of Experiment 2 provide new information about young children's understanding of ordinary causality and provide a benchmark from which to interpret the findings of Experiment 1. Previous research indicated that the physical causal judgments of children as young as age 3 are governed by the priority constraint. In our experiment, the explanations of children in both age groups were affected by violations of the priority constraint, but the effect was stronger in the older children. Thus, our research reveals significant development in the operation of this constraint between 3 and 6 years of age.

Our findings regarding the exclusivity constraint indicate that exclusivity does constrain young children's ordinary causal explanations, but, as with priority, does so increasingly with age. When another explanation was available for the appearance of the object in the box, children of both age groups significantly discounted the causal efficacy of the machine. The older children discounted the causal efficacy of the machine almost entirely. Why younger children did not discount the operation of the machine as extensively as the older children is a question that

could be addressed in future research. One possibility, as suggested by previous work on children's social causal attributions (e.g., Costanza et al., 1974; Karniol & Ross, 1979; Smith, 1975), is that younger children may generally be more accepting of multiple explanations for an event. It is also possible that the alternative explanation was somehow less salient for the younger children (Shultz, Fisher, Pratt, & Rulf, 1986). Finally, violating consistency did not affect children's attributions of a causal role to the machine. This suggests that the lack of an effect of this constraint on children's beliefs about magical causality may be more likely to be a general phenomenon rather than something specific to magical causality. We discuss possible explanations for this in the General Discussion.

Because an important component of our claims is that children apply similar constraints to ordinary and magical causal processes, we must consider the possibility that children did not consider the machine to represent ordinary causality. Because the machine was unfamiliar, children may have conceived of it as a magical device of some sort. Although this is possible, we doubt it was the case for several reasons. First, research by Phelps and Woolley (1994) indicated that children do not appeal to magic simply when an outcome is unfamiliar or even mysterious; rather, outcomes must violate ordinary causal principles for children to consider them magical. Second, the statements children spontaneously volunteered indicated that they did not conceive of the machine as a magical device. Several children gave mechanical explanations for how the machine worked. One 5-year-old said, "The box right here (pointed to the ring picture next to the button) is filled with rings. The ring falls down and opens the box," and another that, "It's like machines that make metal toys; it makes rings." Another clever 6-year-old proposed that "air sucks the thing out and drops the ring in the box. The air blows back in, it closes it up and it's done." Although younger children did not often generate attempts to explain the workings of the machine, their questions suggest that to them it was similar to other ordinary machines. One 4-year-old asked, "How does the machine open the box? Is there a puller in there?" No children offered mechanical explanations or asked mechanically oriented questions in Experiment 1. Finally, children who viewed the workings of an "incredible shrinking machine" created by DeLoache, Miller, and Rosengren (1997) rarely described that machine as magic. If children do not consider a machine that shrinks rooms to be magic, it seems unlikely they would consider ours to be so (see also Esterly, 1997, for evidence of children's acceptance of the legitimacy of a similar sort of machine).

Despite these arguments, it may be possible that some children perceived the workings of the machine as magical rather than ordinary. There are potential concerns with treating a machine as representing ordinary causality. One concern is that many of the machines with which children interact may seem quite magical to them. Computers, DVD players, and even keyless entry devices on cars may seem to children to defy ordinary causal principles without arousing much concern. Be-

cause it is possible that children viewed the machine in this fashion, we conducted an additional study to assess the operation of causal constraints on physical causal reasoning.

EXPERIMENT 3

Method

Participants. Participants were 22 children (12 boys and 10 girls), 4 to 5 years of age (M = 5;1, range = 4;6–5;10), representing the average age of the children who participated in Experiments 1 and 2. Names of children were obtained from the same birth records file as in Experiments 1 and 2 and children were recruited through letter and telephone contact with the parents. Most participants were White and middle-class, but several ethnic groups were represented, including African American, Asian American, and Hispanic American. None of the children had participated in Experiment 1 or 2.

Materials. Materials consisted of a marble toy in which a marble is dropped in one end of a chute and appears at the other end. The toy is made up of many small parts, some curved and some straight, and some open and some enclosed. We constructed a large set-up in which there were two separate marble chutes that both ended in the same cup. The entrance to the chutes was covered by a large plastic cup (to conceal the fact that there were two separate chutes) and construction paper coverings were attached so that the passage of the marble through the chutes was not visible to the children. One chute (used in *Honored* trials) led directly to the cup. The other chute (used in *Failed*, *Violation of priority*, *Violation of consistency*, and *Violation of exclusivity* trials) led to the cup by a different route. This route contained a blocker (an eraser) that blocked the marbles from entering the cup at the end. This blocker was used in the exclusivity and priority violation trials to ensure that only one marble was in the cup at the end, and in the *Failed* trials to ensure that no marbles entered the cup. In the *Violation of consistency* trial, this blocker was removed to allow multiple marbles to enter the cup (see Procedure). Additional materials included six plastic marbles and paper cups with cotton in them (to dampen the sound of the marbles landing in the cup).

Procedure. Participants were tested individually in a testing room at the Children's Research Lab of the University of Texas. Children participated in one 10- to 15-min session. When children entered the room, they were first asked if they were familiar with the marble toy. Fifty percent of the children responded that they were. Children were instructed that the experimenter would put marbles in the toy and that they could watch and tell her what happened. The experimenter ex-

plained that when she puts a marble in at the top it comes out the bottom and lands in the cup. At the beginning of each trial, the experimenter picked up a cup, showed it to the child, and asked what was inside. For all trials except *Violation of priority,* the cup was empty (except for the cotton). For *Violation of priority* trials a marble was already in the cup. Then the experimenter announced that she would put a marble in the chute. After placing the marble in the appropriate chute, the experimenter placed the cup under the end of the chute. After the marble (or marbles) landed in the cup (or did not land), the experimenter first asked the children if they thought the toy had worked, and then asked how many marbles they thought would be in the cup. Then she showed children the cup, asked what was in it, and then asked the test question, "How do you think that marble got there?" (or, in the *Failed* trials, "What do you think happened?" or, in *Violation of consistency* trials, "How did these marbles get there?"). If children's answers were ambiguous, the experimenter asked the follow-up question, "Did it/they get there because I put a marble in the chute or some other way?"

The various trial types were constructed to parallel those in Experiments 1 and 2. In the *Honored* trials, a marble was placed in the chute and it dropped into the cup at the end. In the *Violation of priority* trials, the cup already contained a marble before the experimenter put a marble in the chute. In the *Violation of exclusivity* trials, immediately after the experimenter dropped the marble in the chute, she removed the cup from the apparatus, and, in full view of the child, deposited a marble directly into the cup, and then replaced the cup in the apparatus. For the *Violation of consistency* trials, the experimenter dropped a marble down the chute, but multiple marbles landed in the cup instead of just one. This was accomplished by blocking marbles on previous trials (with the eraser) and then releasing the blocker on the *Violation of consistency* trials. Finally, on the *Failed* trials, a marble was placed in the chute, but through use of the blocker, the cup remained empty. The trials were presented in 20 semirandom orders, with the following three constraints: (a) one *Honored* trial was always first; (b) the *Failed* trials were in Positions 3 and 7; and (c) two *Violation of consistency* trials could not be adjacent, as this would preclude build-up of multiple marbles in the blocked pathway.

Before the experiment began, children were given three practice trials: one *Honored* trial, one *Failed* trial, and one *Cup only* trial. The *Honored* and *Failed* trials were the same as in the focal task. In the *Cup only* trials, the experimenter placed an object directly into the cup in full view of the child, placed the cup at the end of the apparatus, and waited 4 sec. Then she removed the cup from the apparatus and showed it to the children. On all three trials, children were first asked whether they thought the toy worked and what would be in the cup. Then they were shown the outcome and provided with an explanation by the experimenter. For the *Honored* trial the experimenter said, "That's right. It got there because I put it in the chute," and for the *Cup only* trial, "That's right. It got there because I put it in the cup." For the *Failed* trials, the experimenter simply said, "That's right. I guess it

didn't work." These three trials were included for two purposes: (a) to expose children to the two types of ways that the marble could get into the cup and (b) to demonstrate that the apparatus sometimes worked as expected and sometimes did not. Because half of the children reported having experience with the marble toy and half did not, we hoped that this would provide all children with a shared body of knowledge about how our particular toy worked.

Results and Discussion

Responses to the prediction question ("Do you think it worked?") were scored as in Experiments 1 and 2: Affirmative responses were given a 1, negative responses a 0. Across trial types, children indicated high levels of expectation that the marble toy had worked (M = .90, SD = .16). To assess whether children's expectations changed throughout the session, we compared children's predictions on the first instance of each trial type (summed) with the second instance of each trial type (summed). This comparison was nonsignificant, $t(21) = 1.10$, indicating that children were not adjusting their expectations across trials.

The primary dependent variable was children's responses to the question, "How do you think that got there?" (or, when there was no response or responses were ambiguous, "Did it/they get there because I put a marble in the chute or some other way?"). Scoring was parallel to that in Experiments 1 and 2: Responses indicating that putting the marble in the chute was responsible for the appearance of one or more marbles in the cup were given a 1; responses indicating that putting the marble in the chute was not the cause or supplying an alternate explanation (e.g., "you put it in the cup") were given a 0. A second coder independently scored half of the responses, with 98% agreement between the two coders.

Preliminary analyses did not indicate any effects of sex, thus it was not included in subsequent analyses. A one-way repeated measures ANOVA was conducted on the mean number of attributions of causality to the causal force (the experimenter dropping a marble in the chute) across the four types of trials. The analysis revealed a main effect of trial type, $F(3, 82) = 8.20$, $p < .001$. Post hoc comparisons by Fisher's *LSD* tests revealed that children were significantly more likely to attribute the cause of the marble's (or marbles') appearance to the marble being dropped into the chute on the *Honored* trials (M = .93, SD =.18) than on the *Violation of priority* (M = .50, SD = .44), *Violation of exclusivity* (M = .55, SD = .43), and *Violation of consistency* (M = .35, SD = .49) trials, all ps < .01. Overall results are parallel to those found in Experiments 1 and 2: When all constraints were honored, children attributed causality to the experimenter putting the marble in the chute. When the causal constraints were violated, children were significantly less likely to attribute causality to the experimenter's action. These findings thus provide further evidence that the same causal constraints operate in both magical and physical causality.

GENERAL DISCUSSION

These studies provide new information about children's causal reasoning. The results of this research show that there are commonalities in children's attributions of causality to a magical process—wishing—and to two ordinary events—the workings of a machine and a toy. Children in the age groups we tested constrained their attributions of both magical and ordinary causality to cases in which certain ordinary causal constraints were honored. Violations of priority resulted in decreased attributions of causality to wishes, to a machine, and to putting a marble down a chute. The same was true for exclusivity. In addition, violation of consistency resulted in decreased attributions of causality to putting the marble down the chute. Overall, our research indicates that children's magical causal reasoning is constrained in important ways.

Although there are no other studies of how children's magical causal reasoning specifically is constrained, these findings parallel findings regarding children's metaphysical beliefs. The kinds of questions children ask often indicate that they are bringing real-world knowledge to bear on their understanding of counterintuitive aspects of the metaphysical. Harris (2000), for example, discussed data from Isaacs (1930, cited in Harris, 2000) in which children ask questions like "Why do angels never fall down to Earth when there is no floor to Heaven?" Here children appear to be trying to apply biological and physical constraints to their knowledge about religious entities and events. Boyer and Walker (2000; Boyer, 1994) argued that religious concepts are constrained by an "intuitive ontology"; that is, people's knowledge and assumptions about the types of things and causal relations in the world. For instance, whereas angels might violate biological principles of immortality and certain physical principles, they are otherwise conceptualized as being quite human-like in form and are imbued with characteristics contained in people's theories of mind. Research by Barrett (1994; Barrett & Keil, 1996) showed that adults' concepts of God are constrained by their concepts of intentional agents. In recounting the events from a passage about God, participants misremembered events to make them congruent with a conception of a God with human limitations.

Constraints also seem to operate when children are required to generate mental models, regarding both imaginary and real content. Research by Harris and Kavanaugh (1993; Harris, Kavanaugh, & Dowson, 1997) indicated that children expect pretend scenarios to abide by real-world causal principles. For example, like real liquid, they expect pretend liquid to "spill" when a container holding it is tipped over, and they expect it to cause what it spills on to get "wet." Vosniadou and Brewer (1992; Samarapungavan, Vosniadu, & Brewer, 1996) questioned elementary school age children about their mental models of the earth. Their results revealed that although most children answered that the earth is round, they still did not conceptualize the earth as adults do. According to Samarapungavan et al., the models that chil-

dren develop are constrained by assumptions children make about their world based on their everyday experiences. For instance, children know that the earth is round because they are told that it is. However, their experience with the physical world leads them to assume that the earth is flat because the ground is flat and the earth cannot be experienced as a sphere. Thus they conceptualize the earth as a flat disk, incorporating their assumptions into a conception of "roundness."

Despite the priority and exclusivity constraints operating similarly in all three experiments, violation of consistency did not affect children's judgments regarding wishing and the machine, but did affect their judgments regarding the marble toy. Why might this have been the case? One possible explanation concerns the potential complexity of the mechanisms involved. For both wishing and the machine, the mechanism by which objects appeared in the boxes was admittedly unfamiliar to children. No one knows exactly how wishing 'works' and machine mechanisms tend to be beyond children's everyday understanding. Thus, although the object that appeared was not the object that was supposed to be in the box, they may have been unable to think of any other way it could have gotten there, and preferred explaining it in terms of the wish or the machine to having no explanation. In contrast, with the marble toy, children did often come up with alternative explanations for how multiple marbles could emerge when only one marble was put into the chute, suggesting, for example, that some marbles might have gotten stuck and then gotten pushed out. Perhaps their greater familiarity with the workings of the marble toy made it easier for them to intuit alternate explanations. It would be valuable to explore in future research the effects of familiarity with the causal mechanism on the operation of these and other constraints.

The drive to come up with some explanation for unexpected events may also have operated to some extent in the younger children's reactions to violations of priority. Although these children did attribute causality significantly less when priority was violated than when it was honored, they still often attributed a causal role to wishes, the machine, and putting the marble in the chute in the face of this violation. Another possible explanation for causal claims in the face of violation of priority, however, relates to people's tendencies to claim that their own acts were intentional even when they were not. Theories of cognitive dissonance and self-perception center on the tendency in adults to change their attitudes to be consistent with what they perceive as intentional actions (Festinger, 1957). Similarly, children sometimes make presumptions about people's prior intentions after observing their actions (Schult & Wellman, 1997). It may be that the children in Experiment 1, for example, assumed that, in addition to wishing after the object was placed in the box, the person had also made the wish before the object appeared in the box, perhaps before the experiment had begun. In Experiment 2, children may have assumed that the person had pushed the button on the machine earlier. Because we did not systematically ask for explanations, we cannot address this possibility with these data, but it could be assessed in future studies.

Finally, another explanation is that motivational forces were operating; children may have wanted the various causal forces to work. Given the high level of belief in the efficacy of wishing, the machine, and the marble toy, as shown in children's predictions, many children may have felt some desire to interpret the events in these tasks as being consistent with their efficacy beliefs. It is certainly quite common for people to interpret or even distort data to be consistent with their theories, perhaps particularly so in the domain of fantastical beliefs (see, e.g., Jones & Russell, 1980; Russell & Jones, 1980). In our studies, children's explanations for their answers often indicated that they found clever ways to "maintain" causal efficacy in the face of causal violations. On one *Violation of consistency* trial, one child, in explaining why she had said that the wish caused the object to appear, responded that, "the box forgot what she wished for" and another stated that "the wishing star made a mistake."

Regarding the exclusivity constraint, the alternative causal explanation—seeing the experimenter put the object in the box or in the cup—arguably presented children with an effective explanation with which they have much experience. It will be important in future studies to address what the effect would be of an alternative that was less familiar or one about which children had less knowledge or certainty. For example, would children be more likely to ascribe a causal role if the alternative explanation involved the experimenter doing something apparently magical like tapping the top of the box three times?[2] Pitting these different sorts of alternative explanations against one another would allow researchers to determine whether there are also constraints on what children consider an acceptable alternative explanation.

In conclusion, the findings of this experiment begin to illuminate the nature of children's magical causal reasoning. The results point to important links between children's reasoning about the physical world and their magical thinking. Specifically, children's beliefs in wishing appear to be constrained by features of ordinary causality. Although wishing may appear fanciful in its violation of aspects of mental causality, its operation is not entirely lawless; rather, it honors two basic physical causal constraints—priority and exclusivity. As Harris (2000) put it, there is "coherence in the nonactual world" (p. 173) as well as in the actual one.

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[2]We thank Marjorie Taylor for this suggestion.

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APPENDIX
Wishing Interview Questions

1. Do you know what wishing is?
   1a. What is it?
2. Have you ever wished for anything?
   2a. (If yes) What did you wish for?
3. Did your wish come true?
   3a. (if no) Why do you think your wish didn't come true?
4. (If wish DID come true) Do people's wishes *always* come true?
   (If wish did NOT come true) Do people's wishes *ever* come true?
5. What is something that you want?
   5a. If you *really* want it when you get home today, will you wish for it?
   5b. Do you think your wish will come true?