Published in final edited form as:
Cogn Psychol. 2010 November ; 61(3): 248–272. doi:10.1016/j.cogpsych.2010.06.002.

Believing What You're Told: Young Children's Trust in Unexpected Testimony about the Physical World

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Abstract

How do children resolve conflicts between a self-generated belief and what they are told? Four studies investigated the circumstances under which toddlers would trust testimony that conflicted with their expectations about the physical world. Thirty-month-olds believed testimony that conflicted with a naive bias (Study 1), and they also repeatedly trusted testimony that conflicted with an event they had just seen (Study 2)—even when they had an incentive to ignore the testimony (Study 3). Children responded more skeptically if they could see that the testimony was wrong as it was being delivered (Study 3), or if they had the opportunity to accumulate evidence confirming their initial belief before hearing someone contradict it (Study 4). Together, these studies demonstrate that toddlers have a robust bias to trust even surprising testimony, but this trust can be influenced by how much confidence they have in their initial belief.

Keywords

testimony; credulity; skepticism; toddlers; naïve physics

Children routinely face conflicts between what they are told and what they already believe. For example, in their everyday lives, the earth looks flat, and yet they will hear it described as round. Eels look like snakes, but they may hear them referred to as "fish." They might remember having left their shoes outside, but hear a parent explain that they are in the closet. How do they reconcile a belief they have acquired or generated themselves with a conflicting piece of information offered by another person?

One possibility is that they will cling to their own beliefs until they have obtained first-hand evidence to support whatever surprising claim they have heard. The primary advantage of this strategy is that it would prevent them from being misled by a poorly informed or intentionally deceptive speaker. But it would also severely limit the amount of knowledge they could acquire. It is highly unlikely, for example, that they would ever be in a position to detect the curvature of the earth for themselves. A second possibility is that children will simply give up beliefs that conflict with what someone tells them. Blind deference would allow them to quickly and efficiently acquire knowledge that would be difficult to obtain on their own (e.g., Coady, 1992; Harris, 2002a, 2002b, 2007). But it would also leave them epistemically vulnerable. For

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a variety of reasons, including error, ignorance, and deception, people sometimes say things that are wrong (e.g., Fricker, 2006; Perner, 1988).

A third possibility is that children are, by default, inclined to trust what they are told (e.g., Dawkins, 1995; Reid, 1764/1997), but that they can over-ride this default bias under certain circumstances. Some research suggests that adults operate with such a “truth bias:” In the very act of comprehending a statement, they seem to accept it as true (Gilbert, 1991; Gilbert, Krull, & Malone, 1990; Gilbert, Tafarodi, & Malone, 1993; Grice, 1975). Of course, adults can go back to “unaccept” a proposition, but this requires cognitive effort. For example, Gilbert et al. (1990) showed that when adults’ cognitive resources were taxed, they were more likely to misremember as true something they had earlier learned was false, than to misremember as false something they had earlier learned was true. In other words, when they had only limited cognitive resources available, they had difficulty “unaccepting” what they were told.

When children are faced with testimony that conflicts with their expectations, at least three factors seem to influence how readily they can over-ride the normally reasonable expectation that what they have been told is true (for an analogous list for adults, see Jaccard, 1981). One is how confident they are in the source of the testimony. For example, preschoolers are more likely to trust unexpected testimony from an informant who speaks authoritatively than one who speaks hesitantly (Jaswal & Malone, 2007; see also Sabbagh & Baldwin, 2001), and from an informant who seems to have some privileged knowledge about the matter being testified to than one who does not (Jaswal, 2006; Robinson, Champion, & Mitchell, 1999). A second factor is just how unexpected the testimony is. For example, although children are willing to accept that a dog-like animal is a “cat” (Jaswal, 2004), even toddlers may object if a speaker refers to a typical exemplar of a car as a “ball” (Pea, 1982; see also Koenig & Echols, 2003). In both cases, the objects and labels are highly familiar, so the most likely explanation for the difference is that dogs and cats are similar enough that it is possible that an animal that looks like a dog could actually be a cat (see Quinn, Eimas, & Rosencrantz, 1993). Cars and balls are much less similar in appearance (and are dissimilar in function), making it highly unlikely that a something that looked like a car could actually be a ball.

A third factor that may influence children’s response to unexpected testimony—and the focus of the studies here—is how much confidence they have in their initial belief. This factor has received relatively little attention experimentally, but there is some evidence to suggest that the more confidence children have in a belief, the less persuasive they find testimony that conflicts with that belief. For example, in Tamis-LeMonda et al. (2008), the mothers of 18-month-olds offered unsolicited advice to their children about whether they should attempt to walk down ramps of varying slopes. On ramps that their child had earlier walked down without falling, they would discourage him or her from attempting it (“No!” “Stay there!”); on ramps their child had earlier always fallen on, they would encourage him or her (“Come here!”); and on ramps they had sometimes walked down and sometimes fallen on, they would either discourage or encourage the child. Infants tended to ignore their mothers’ advice on slopes they had earlier walked down without falling, as well as those they had always fallen on, presumably because they were confident in what the outcome would be in those cases. But they heeded her advice on the borderline slopes—the ones about which they were uncertain.

Children’s initial confidence in a belief may depend, in part, on the extent to which knowledge in that domain can be acquired autonomously, without input from other people. Knowledge in some domains seems more dependent on testimony than knowledge in others. For example, knowledge that is a matter of convention, such as a vocabulary, can only be acquired from other people. Even very young children seem to be aware of this epistemological constraint on conventional knowledge. They abandon words they coin themselves (e.g., “plant-man” for "gardener") once they hear the conventional terms (Clark, 1991), suggesting that at least implicitly, they have very little confidence in the accuracy of self-generated vocabulary terms.

Children also rely on other people to acquire knowledge that has a non-obvious basis. For example, a child's initial hypothesis about the category to which an animal belongs will usually be based on its appearance, but this hypothesis can be over-ridden in the face of conflicting testimony. Preschoolers will accept, often without question, an adult's assertion that something that looks like a bat is actually a bird (Gelman & Markman, 1986; see also Jaswal, 2004; Jaswal, Lima, & Small, 2009). This deference to adults in the case of category membership is adaptive because what something looks like is only an imperfect cue as to what it actually is, particularly in the case of natural kinds (e.g., Bloom, 2000; Gelman, 2003): baby flamingos look like ducklings (Mervis, Pani, & Pani, 2003), glass lizards look like snakes, and kaibab squirrels look like rabbits. Although non-obvious knowledge can be acquired autonomously (after all, someone discovered it initially), it is much more efficiently learned from other people.

Compared to knowledge that is a matter of convention or that has a non-obvious basis, knowledge about the visible physical world seems less dependent on input from other people. Well before they can understand or make use of testimony, children know a great deal about the properties of inanimate objects, including that two objects cannot occupy the same space and that they continue to exist when they disappear from view (e.g., Spelke, 1994). In Baillargeon's (1987) classic study, for example, 3.5–4.5-month-olds looked longer at an event in which one object seemed to pass through a second object than an event in which the first object stopped when it came into contact with the second. Clearly, no one has to explain basic physical principles, such as solidity and object permanence, to infants.

Further evidence that some knowledge about the physical world is available without social input comes from studies showing that non-human primates share in common with humans a number of expectations about objects. For example, Santos and Hauser (2004) found that adult rhesus monkeys, like 4-month-old human infants (Spelke, Breinlinger, Macomber, & Jacobson, 1992), possess an expectation about solidity: They looked longer at an event in which an object appeared to have fallen through a shelf than an event in which it landed on the shelf. Regardless of whether such knowledge is specified innately or acquired through early experience, the important point for our purposes is that it is not learned from others.

Of course, some of children's early expectations about objects are wrong or immature, but personal experience rather than testimony has traditionally been emphasized as the epistemological engine that corrects these errors (e.g., Baillargeon, 2004; Piaget, 1970). For example, until about seven or eight years of age, children who have just agreed that two identical balls of clay weigh the same amount will claim that if one of the balls is flattened, it will weigh more than the other. Simply explaining to children that this intuition is wrong—that, in fact, the two masses of material still weigh the same amount—is insufficient to correct this error: Although short-term gains on conservation tasks can be achieved through instruction (Brainerd, 1974, 1977; Gelman, 1969; Murray, 1972; Silverman & Geiringer, 1973; Rosenthal & Zimmerman, 1972), most gains fail to persist over a delay or to generalize to tasks different from those used in training (Field, 1987; Kuhn, 1974; but see Brainerd, 1973, 1978).

In fact, children's confidence in self-generated beliefs about the physical world can sometimes lead them to ignore evidence that conflicts with those beliefs. One striking demonstration of this comes from a study by Karmiloff-Smith and Inhelder (1975). Children between 4.5 and 9.5 years of age were presented with a task in which the goal was to balance each of several rods on a narrow bar. Some of the rods were designed so they would balance at their geometric center and others were weighted in such a way so that they could not balance there. Children below 5.5 years of age succeeded by using trial and error, and those older than 7.5 years of age succeeded by checking the weight distribution of each rod before attempting to balance it. But many children between 5.5 and 7.5 years of age simply gave up, claiming that the task was "impossible." Karmiloff-Smith and Inhelder suggested that this middle age group's poor performance was caused by a robust theory that an object's center of gravity and its geometric center are the same, even though of course, children could plainly see that this was not always the case.

In short, the physical world—and in particular, the behavior of inanimate objects— represents a unique domain in which to investigate children's receptiveness to unexpected testimony. Unlike other domains where this topic has been studied, such as vocabulary or categorization, a good deal of object knowledge comes about autonomously, without input from other people. Additionally, children seem to have a good deal of confidence in their self-generated beliefs about objects, and many of these beliefs are repeatedly confirmed in their everyday observations and interactions.

In the studies reported here, we investigated how young children would resolve a conflict between a robust belief about the trajectory of a falling object and what they were told. In Study 1, toddlers heard a presumably credible speaker make a claim that conflicted with a naive expectation they have about gravity. In Studies 2 and 3, they heard someone make a claim that conflicted with an event they had just witnessed. Finally, in Study 4, children again heard someone make a claim that conflicted with an event they had just witnessed, but some children first had an experience designed to increase their confidence in their initial, self-generated beliefs. In each case, our interest was in which source of information—the self-generated or the socially obtained—children would weight more heavily.

Study 1

Children have a robust, naive expectation that unsupported objects fall straight down (Hood, 1995, 1998; Kaiser, Proffitt, & McCloskey, 1985; Kim & Spelke, 1999). This expectation is so robust, in fact, that it can lead them to make a surprising error: Until about 3.5 years of age, they will search for an object directly beneath where they saw it dropped—even when its actual trajectory is constrained by the path of a visible and crooked tube (Hood, 1995). For example, when they see a ball dropped through the left chimney of the apparatus shown in Figure 1, they will incorrectly search for the ball in the left cup, even though they can see the opaque tube that connects the left chimney to the right cup. In a series of seminal studies, Hood and his colleagues have shown that this error represents a "gravity bias:" The error persists even after multiple trials (Hood, 1995), it can re-emerge in older children under conditions of divided attention (Hood, Wilson & Dyson, 2006), and it is not caused by mere adjacency considerations because the analogous error is not obtained if the ball travels in the upward direction (Hood, 1998).

In Study 1, we asked simply whether 30-month-olds would believe testimony that conflicted with this highly robust gravity bias. After dropping the ball through one of the chimneys, the experimenter invited children to indicate where it had landed. Next, the experimenter reported the location where it actually did land, and then invited children to search for it. Of interest was whether toddlers would search for the ball in the location consistent with the gravity bias, or whether they would search for it in the location consistent with the testimony the experimenter had just provided.

We chose to focus on 30-month-olds for three reasons. First, whether 30-month-olds can benefit from unexpected testimony about the physical world is an open question. As noted above, conservation training studies have shown that older children are receptive to testimony that conflicts with their expectations about the material world, though they tend to revert to their naive expectations later (e.g., Field, 1987; Kuhn, 1974). Interestingly, children below four years of age have rarely been included in these studies, and when they have been included, they have failed to show even temporary gains in performance (Field, 1981, 1987). The inability of younger children to benefit from testimony in these conservation studies could reflect a linguistic or cognitive limitation, or an unwillingness to accept "on faith" an experimenter's assertion about the physical world that conflicts with their own beliefs.

A second reason we chose to focus on 30-month-olds is that the gravity bias is extremely robust at this age: On trial after trial, they will search for objects in locations directly beneath where they saw them dropped. Beginning about a year later (3.5 years of age), children can inhibit the gravity bias and will instead follow the trajectory of the tube to locate objects (e.g., Hood, 1995). Finally, we wanted to be sure that our participants would understand the experimenter's simple testimony about where the ball had landed so that if they did not defer to it, it would not be because of linguistic limitations.

Method

Participants—Eighteen 2.5-year-olds (mean = 2 years, 6 months; range: 2;4 to 2;8; 7 boys) participated in a single visit. Most children in this and the following studies were Caucasian and from middle-class backgrounds, and all were exposed primarily to English in the home. An additional toddler was excluded because she completed fewer than half of the test trials (see below).

Apparatus—The apparatus was based on the one used by Hood (1995), and is shown in Figure 1. It was constructed out of wood and was 61 cm tall, 55 cm long, and 12 cm wide. Three chimneys (each measuring 6 cm in diameter) were mounted at equal intervals into the top brace of the apparatus. Three opaque cups (each measuring 5 cm in diameter and 9 cm in height) could be placed into the lower brace of the apparatus, 47 cm beneath the chimneys. Flexible, opaque tubes, 6 cm in diameter and approximately 60 cm in length were used to connect each chimney to a non-adjacent cup. Each cup had one of three kinds of color stickers affixed to it: dogs, birds, or fish. Stickers were of typical exemplars. Finally, a small pompom made out of a plush material and approximately 2 cm in diameter was used. Differently colored pompoms (red, green, blue) were used on different trials if a participant's attention seemed to be waning.

Procedure—Children participated individually in a single session lasting approximately 15 minutes. They sat at a small table with the experimenter across from them.

Warm-up: Sessions began with a brief warm-up period, which served to familiarize children with each piece of the apparatus and to introduce the task. The experimenter first introduced each of the three cups (separated from the apparatus), one at a time and in a random order. For example, she held the cup with the dog stickers in her hand, rotated it slowly while directing children's attention to the stickers, and said, "Oooooh! Look at this! See the dogs on this cup?! We're going to call this our dog cup!" Children were allowed to hold the cup and to touch the stickers, and then the experimenter moved it out of their reach and repeated the procedure with the next cup. After introducing each cup, the experimenter placed all three in a row in the center of the table and asked children to point to each one, one at a time and in a random order. For example, "Where's the bird cup? Can you point to the bird cup?" After each request, she shuffled the positions of the three cups so that their left-middle-right configuration was different on each request. Children were given corrective feedback if necessary, and these warm-up trials continued until children successfully identified the dog cup, the fish cup, and the bird cup in succession. Three children required one additional trial to reach this criterion, and two required two additional trials. The three cups were then removed from the table.

Next, the experimenter familiarized children with one of the opaque tubes and with the pompom. First, she demonstrated that by looking in one end of the tube, she could see out the other end. Then, while holding the tube at an angle in front of a child, she explained that she was going to drop the "ball" through one end of the tube and that it would come out the other end. She dropped it and retrieved it once or twice and then invited the child to drop it through the tube him or herself once or twice. She then removed the tube from the table.

Finally, the apparatus was introduced. It was placed on the table without any tubes or cups attached. As the experimenter fixed each cup in place, she explained, "I'm going to put the fish cup right here, the dog cup right here, and the bird cup right here!" Whether each cup was placed in the left, middle, or center position of the apparatus was randomly determined. Next, she held a pompom directly over one of the cups, dropped it, and invited the child to search for it: "Watch this! (drop) Where's the ball? Can you find it?" Correct responses were praised and errors were corrected. This was repeated until the child located the ball in each of the three cups in succession. Three children required one additional trial to reach this criterion.

The experimenter then used the opaque tubes to connect each chimney in the top brace of the apparatus to a non-adjacent cup below. As shown in Figure 1, the left chimney was connected to the right cup, the middle chimney was connected to the left cup, and the right chimney was connected to the middle cup. The tubes remained in this configuration throughout the rest of the experiment, but, as will be described below, the apparatus itself was rotated on each trial so that the mirror-image of the configuration shown in Figure 1 was presented on alternating trials.

Test trials: Following the warm-up procedure, children were presented with six test trials. On each trial, children made a pre-testimony response and at least one post-testimony response. Their pre-testimony response was made when the experimenter dropped the ball through one of the three chimneys and asked them where it had gone: "Where's the ball? Which cup is it in?" Children responded by pointing to or saying the name of a cup at a particular location. Next, regardless of whether that response was correct, the experimenter told children where the ball had actually landed: "The ball's in the X cup!" (where X is the name of the animal stickers on that cup). Finally, children made a post-testimony response when the experimenter pushed the apparatus forward and invited them to search: "Can you find it?" If children did not find the ball on their initial post-testimony search, they were allowed to continue searching until they did. When children found the ball (regardless of whether it was on the initial or a later post-testimony search in a given trial), positive feedback was provided: "You found it!" Figure 2 provides a summary of the sequence of events associated with each test trial.

Across the six trials, the experimenter dropped the ball into the chimneys in a fixed order: left, right, middle, left, right, middle. As noted above, the experimenter rotated the apparatus 180 degrees after each trial. As a result, from the perspective of the child, across the six trials, the ball was ultimately found in the cups in the following order: right, left, left, middle, middle, right. Note that although the ball was occasionally found in the same spatial location on successive trials, the identity of the cup at a given location (as indicated by the stickers affixed to it) was not necessarily the same because the apparatus had been rotated. For example, the dog cup might be on the child's left on trial n, but because the apparatus was rotated, the fish cup might be on the child's left on trial n+1. Furthermore, the cups were not fixed to the apparatus, and so in the process of rotating, they sometimes slipped out. When the experimenter replaced them, she did not necessarily put them in the same positions they had been in earlier. In short, children could not reliably predict the location of the ball by choosing the cup in the same spatial location as in the previous trial or the cup of the same identity as in the previous trial. They could succeed only by following the trajectory of the opaque tube through which the ball had been dropped or by relying on the experimenter's helpful testimony.

Because our interest was in whether children's post-testimony responses would involve searching in the location consistent with their pre-testimony response or in the location consistent with the experimenter's testimony, we were interested only in those trials where the experimenter was able to provide testimony about where the ball had landed before the children began searching. Unfortunately, despite the experimenter's best efforts to keep the apparatus out of their reach, a number of children began searching for the ball before the experimenter's testimony on at least one of their six trials (i.e., they climbed on the table and looked into a cup as they made their pre-testimony response). The average number of test trials on which the experimenter was able to deliver the testimony before children searched was 5 (SD = 1.21; *range* = 3–6). (As noted earlier, one child was excluded because she had only two such trials.) Because the number of complete trials differed across subjects, data will be reported in terms of the percentage (rather than number) of trials on which children indicated each cup in their pre- and post-testimony responses.

Sessions in this and all studies were videotaped and coded off-line. A second coder scored at least 25% of the sessions from each study. Reliability was excellent, with at least 95% agreement in each study as to which cups were indicated by the child in their pre- and post-testimony responses. The few disagreements were resolved through discussion.

Results and Discussion

Preliminary analyses in this and the following studies showed no effects or interactions involving gender, so results are collapsed across this factor. There were three locations to which children could make their pre- and post-testimony responses: the "correct" location, corresponding to the cup where the ball actually landed; the "gravity" location, corresponding to the cup directly beneath the chimney where the ball had been dropped; and the "other" location, corresponding to the third cup on the apparatus. Thus, by chance, children would be expected to search in the correct location 33% of the time.

As Figure 3A shows, when the experimenter initially asked them to indicate where the ball had landed, children usually responded by pointing to or saying the name of the cup at the gravity location: 71% of their pre-testimony responses were to the gravity location, more than would be expected by chance, $t(17) = 5.61$, $p < .0001$, $d = 1.31$. This demonstrates that the gravity bias is extremely robust at 2.5 years of age, replicating Hood's (1995) original finding.

Our primary interest was in how children would respond to an assertion about the ball's location that conflicted with this gravity bias: Would they defer to the testimony, or would they maintain their original, naive belief? As Figure 3A shows, children were highly deferential: 72% of their initial post-testimony searches were to the correct location, more than would be expected by chance, $t(17) = 5.38$, $p < .0001$, $d = 1.26$. (Considering just the 71% of trials on which their pre-testimony response had been to the gravity location yields the same result: 67% (SD = 36%) of the initial post-testimony searches on these trials were to the correct location.) Children were significantly more likely to search the correct cup in their post-testimony response than they had been to indicate that cup in their pre-testimony response (72% vs. 11%), $t(17) = 8.00$, $p < .0001$, $d = 2.83$. In short, even though the testimony conflicted with the gravity bias (and usually with the pre-testimony response children had just made), they tended to trust the adult's word about where the ball had landed.

Importantly, this trust was evident from the very first trial; it did not develop over the course of the session. This can be seen in two ways. First, on the first trial, none of the children indicated the correct location before hearing the testimony, but 77% searched there in their initial post-testimony response. Second, the likelihood that children searched in the correct location post-testimony did not increase over the course of the session: Their initial post-testimony search was to the correct location, on average, 74% (*SD* = 35%) of the time on the first three trials and 70% (*SD* = 39%) of the time on the last three.

Finally, one might have expected that over the course of six trials, toddlers would learn to follow the trajectory of the tube on their own so that they would be more likely to make correct pre-testimony responses in later trials. However, this did not occur: On the first three trials, children indicated the correct location in their pre-testimony response, on average, just 12% (*SD* = 18%) of the time, and on the last three trials, they did so 11% (*SD* = 26%) of the time. Thus, toddlers did not learn to locate the ball on their own over the course of the session; they simply relied on the experimenter's testimony on each trial to point them to where it could be found.

Children's failure to overcome the gravity bias after repeated trials is striking, but consistent with previous research on the gravity bias. Hood (1995, Experiment 4) found that children repeatedly searched in the gravity location, even in a condition where the ball was dropped through the same chimney on each trial and so could have been located simply by searching in the location where it was found previously. Additionally, Hood found that children easily located the ball when clear rather than opaque tubes were used (Experiment 2), but success with clear tubes did not transfer when the same children were later tested with opaque ones (Experiment 3). In short, the gravity bias is extremely robust: Simply providing children with counter-evidence (through testimony and/or direct experience) in a brief experimental session does not seem to weaken it.

The studies here were not designed to investigate how children could learn to overcome the gravity bias (but see Joh, Jaswal, & Keen, under review). Instead, our interest was in whether toddlers would even believe testimony that conflicted with a naive belief about the physical world. Study 1 suggests that they are indeed receptive to such testimony.

At first glance, these results appear to conflict with those of Tamis-LeMonda et al. (2008), who found that children did not heed their mothers' advice when it conflicted with their own beliefs. Specifically, they tended to ignore her when she cautioned against walking down shallow slopes or when she encouraged them to walk down steep ones. It is important to point out, however, that the beliefs of children in Tamis-LeMonda et al.'s study were based on firsthand experience with slopes of various angles. In contrast, the beliefs of children in Study 1 were based on a naïve bias. Children may have more confidence in beliefs based on first-hand experience than on those based on a naïve bias.

In the remaining studies, we asked whether 30-month-olds would believe testimony that conflicts with an event they had actually just witnessed. As just suggested, it seems reasonable to expect that children would have more confidence in something they had experienced themselves than something that they were merely biased to believe. As Gelman (2009) suggested, "one might expect children to be deep-down empiricists, believing most powerfully in what they can see" (p. 130). Thus, in the remaining studies, the experimenter incorrectly asserted that the object landed in a location different from where children just saw it land. Unlike Study 1, in which the testimony directed children to the correct cup, the testimony in the remaining studies highlighted an incorrect cup.

Study 2

Study 2 again used the chimney apparatus, and the procedure was similar to that used in Study 1. This time, however, we used clear (rather than opaque) tubes, which allowed children to watch as a ball rolled down a tube and disappeared into a particular opaque cup. As noted earlier, Hood (1995, Experiment 2) showed that children can easily locate the ball when the tubes are clear rather than opaque. In the current study, after a ball was dropped through a chimney, an experimenter claimed that it had landed in a cup different from the one into which children just saw it disappear. In particular, he claimed that it landed in the cup consistent with the gravity bias. Of interest was whether children would believe the experimenter even though they had just seen the ball disappear into a different cup.

Additionally, even if children initially weight unexpected testimony more heavily than personal experience, one might expect the balance to shift when the unexpected testimony turns out to be repeatedly incorrect. A number of recent studies have shown that preschool-aged children are more likely to trust novel information from an individual who has been correct in the past rather than one who has been incorrect (e.g., Birch, Vaultier, & Bloom, 2008; Jaswal & Neely, 2006; Jaswal, VanderBorght, & McKercher, 2008; Koenig, Clement, & Harris, 2004). Thus, also of interest will be whether over the course of several trials, toddlers will stop trusting unexpected testimony from a speaker who has always been incorrect.

In addition to using clear rather than opaque tubes, we introduced two further modifications to the procedure. In Study 1, the same experimenter dropped the ball, provided the helpful testimony, and invited children to search. It is possible that children in that study felt pressure to search in the location the adult had just named because they did not want to contradict her. One way to eliminate this pressure would be to have the adult provide the testimony and then leave the room before children make their response (e.g., Jaswal et al., 2009; Lyons, Young, & Keil, 2007). However, practical considerations (e.g., the number of times the experimenter would have to enter and leave the room, the limited attention span of 30-month-olds, the size and weight of the chimney apparatus) precluded this option.

Instead, we turned the procedure into a game involving two experimenters and the child. As in Study 1, one experimenter (E1) manipulated the apparatus and asked children to indicate where the ball had landed. Then, E1 turned to a second experimenter (E2, who was seated next to the child) and asked him to indicate where the ball had landed. After E2's assertion that it had landed in the gravity location, E1 looked at the child and, with a puzzled expression and intonation indicating confusion, asked him or her to resolve the conflict: "Where should we look?" This kind of conflict resolution procedure has been used by Robinson and her colleagues to investigate older children's sensitivity to how well-informed an informant is (Robinson et al., 1999; Robinson, Mitchell, & Nye, 1995; Robinson & Whitcombe, 2003; Whitcombe & Robinson, 2000). For example, in Robinson et al. (1999), a puppet asked 3.5- to 6.5-year-olds to guess the contents of a container, they heard a better-informed or equally uninformed experimenter contradict their guess, and they were then asked by the puppet (which was operated by the experimenter) to resolve the contradiction. Our study did not involve a puppet; instead, the game was played with two adult experimenters.

Our second modification was an attempt to deal with a procedural difficulty encountered in Study 1. Recall that in Study 1, despite the experimenter's best efforts, children sometimes began searching before she had a chance to offer the testimony. In Study 2, we attached a clear Plexiglas barrier to the front of one side of the apparatus so that children could identify the cups by the stickers affixed to each one, but could not access them. After hearing E2's testimony indicating that the ball had landed in the gravity location, children did not actually search for the ball themselves. Instead, they instructed E1 (by pointing or saying the name of the cup) to search in a particular location on their behalf.

Method

Participants—Eighteen 2.5-year-olds (*mean* = 2 years, 5 months; *range:* 2;4 to 2;8; 10 boys) participated in a single visit. None had participated in Study 1. Four additional children participated, but their data are not included because they did not complete the session.

Apparatus—The apparatus was the same as that used in Study 1, but clear (rather than opaque) tubes were used to connect each chimney to a cup. The clear tubes were 4 cm in diameter and approximately 60 cm in length. Additionally, a Plexiglas screen (53 cm by 16 cm) was mounted in front of the three cups to prevent children from being able to remove them from the apparatus. Finally, the pompoms used as balls in Study 1 would sometimes get stuck when sliding down the clear tubes, and so a small wooden ball (1.5 cm diameter) was used instead.

Procedure—Children participated individually in a single session, lasting about 15 minutes. One experimenter (E1) sat across from children, and a second experimenter (E2) sat next to them.

Warm-up: The same warm-up procedure described in Study 1 was used to familiarize children with each part of the apparatus, but two additions were made to accommodate the presence of the second experimenter. First, when introducing the three cups, E1 first asked children to point to each cup (e.g., "Where's the dog cup?") and then asked E2 to do so. The reason for asking E2 to identify each cup was to make it clear to children that E2 knew the names of the cups that he would be referring to in the later test trials. Second, as in Study 1, after placing the cups in the apparatus but before attaching the tubes, E1 dropped a ball directly into a cup and asked children where it had gone. In Study 2, E1 also asked E2, who always reported its location correctly. E1 then asked children, "Where should we look?" and she proceeded to look in the cup children indicated in response to this last question. This sequence of questions occurred once for each of the three cups. This addition to the warm-up served to introduce children to the sequence of events that would occur during the test trials and also to introduce them to the fact that E1 would ultimately search where children told her to.

Test trials: Following the warm-up, E1 used clear tubes to attach the chimneys to the cups in the same configuration as used in Study 1 and as shown in Figure 1. Children were presented with six test trials. On each trial, E1 dropped the ball through one of the three chimneys, and invited children to point to or say the name of the opaque cup where the ball had landed: "Where's the ball? Which cup is it in?" After children had made this pre-testimony response, E1 turned to E2 and asked the same question. E2 always responded by asserting that the ball had landed in the gravity location: "The ball's in the X cup!" When delivering this misleading testimony and until the child made a post-testimony response, E2 looked directly at E1. Finally, E1 returned her attention to the children and, with a puzzled expression on her face, asked them to make a post-testimony response: "Where should we look?" When children pointed to or said the name of the cup at a particular location, E1 pulled out that cup and turned it upside down, either revealing it to be empty or revealing it to have the ball. If their initial selection was an empty cup, E1 invited children to make another selection: "Hmmm. Not there. Where should we look next?" If the second cup they indicated was also empty, E1 guided them to select the only remaining cup in the apparatus. When the ball was discovered (regardless of whether it was on the first or a later post-testimony response in a given trial), E1 and E2 provided positive feedback: "You found it!", "There it is!" Figure 2 provides a summary of the sequence of events associated with each test trial.

Across the six test trials, E1 dropped the ball into the chimneys in the same fixed order used in Study 1: left, right, middle, left, right, middle. Instead of rotating the apparatus 180 degrees after each trial, however, E1 rotated it 360 degrees. This minor change was made because the Plexiglas screen attached in front of the cups on one side of the apparatus made it impossible to insert and remove cups from that side. The rotation was intended to make it plausible (to a 30-month-old) that the configuration of the tubes was changing after each trial.

Results and Discussion

Despite the fact that E2 provided testimony that conflicted with an event children had just witnessed, they were surprisingly deferential to that testimony. As Figure 3B shows, before hearing the misleading testimony, children correctly identified the cup into which the ball had fallen 82% of the time, more often than would be expected by chance, $t(17) = 8.48$, $p < .0001$, $d = 2.00$. This replicates Hood's (1995, Experiment 2) finding that children have no difficulty locating the ball when clear tubes are used, because it allows them to watch as it rolls into a particular cup. But after E2 incorrectly asserted that the ball had fallen into the gravity cup, children usually instructed E1 to search for the ball there. As Figure 3B shows, they did so, on average, 62% of the time, more often than expected by chance, $t(17) = 3.67$, $p = .002$, $d = .86$. (Considering just the 82% of trials on which children's pre-testimony response had been correct, this figure remains the same: They directed E1 to search in the gravity location on 60% (*SD* = 36%) of those trials.) Children were significantly more likely to direct E1 to search the gravity location in their post-testimony response than they had been to indicate that location in their pre-testimony one (62% vs. 6%), $t(17) = 7.51$, $p < .0001$, $d = 3.23$.

Thus, children often instructed E1 to search in the gravity cup mentioned by E2—even though doing so conflicted with what they had just seen, with where they had just heard the ball land (the wooden ball, unlike the pompom used in Study 1, made noise as it traveled down the tube and landed in a particular cup), and with the cup in which they had usually said the ball landed just moments before. Although children were slightly less likely, on average, to defer to the misleading testimony in this study than they had been to defer to helpful testimony in Study 1 (62% vs. 72%), this difference was not significant, $t(34) < 1$. The extent of the deference in the present study is readily apparent in the data from the first trial: Only 6% of children indicated the gravity location in their pre-testimony response, but 67% instructed E1 to search there on their initial post-testimony response.

One question concerns whether E2's misleading testimony "over-wrote" children's initial, personally acquired belief about where the ball had landed (e.g., Harris, 2002a). Recall that if children directed E1 to search in an incorrect cup in their initial post-testimony response on a given trial, they were invited to direct her to search a second cup. If children's initial (correct) belief had been over-written by the misleading testimony, then on their second post-testimony response of a given trial, they should have been as likely to instruct E1 to search the "other" cup as the "correct" one. In fact, however, this was not the case. When children had indicated the correct cup in their pre-testimony response and the gravity cup in their initial post-testimony response, their second post-testimony response was to the correct cup 72% (*SD* = 34%) of the time, more often than expected by chance of 50%, $t(15) = 2.59$, $p = .02$, $d = .646$[1]. This suggests that children remembered their initial belief—not that the experimenter's misleading testimony had completely over-written it.

As suggested earlier, a number of studies have shown that 3- to 5-year-olds can quickly learn to discount information from a consistently inaccurate speaker (e.g., Birch et al., 2008; Jaswal & Neely, 2006; Jaswal et al., 2008; Koenig et al., 2004). In the current study, however, toddlers did not become more skeptical of E2's testimony despite his repeated errors: In their post-testimony responses, they instructed E1 to search in the gravity location indicated by E2, on average, 63% (*SD* = 36%) of the time on the first three trials, and 61% (*SD* = 37%) of the time on the last three trials.

Why did children start out and remain so deferential to E2's testimony, even when he was wrong on every trial? One possibility is that their deference was the result of the gravity bias.

[1]The degrees of freedom for this test are 15 rather than 17 because 2 participants never made an error in which they indicated the correct cup in their pre-testimony response and then directed the experimenter to search in the gravity cup in their initial post-testimony response.

Children's pre-testimony responses in Study 1 and in Hood's (1995) work showed that they expect unsupported objects to fall straight down. Perhaps toddlers in Study 2 were persuaded by E2's testimony even though it conflicted with what they had just seen because it coincided with this naive bias. According to this line of reasoning, if E2 had instead claimed that the ball landed in the third available cup (i.e., the "other" location), they might not have been as deferential. Study 2A investigates this possibility.

Study 2A

Twelve 2.5-year-olds (*mean* = 2 years, 6 months; *range* = 2;4 to 2;8; 5 boys) participated in a single visit. None had participated in either of the earlier studies. One additional child's data were excluded because he did not complete the session. The procedure was the same as that used in Study 2, with one exception. Rather than claiming that the ball had landed in the gravity location on all six test trials, E2 asserted that it landed in the gravity location on trials 1, 3, and 5, and in the other location on trials 2, 4, and 6 (or reversed). Of interest was whether children would be as deferential to a suggestion that the ball had landed in the other location as in the gravity location.

Results showed that, as in Study 2, children had no difficulty following the trajectory of the ball as it traveled down a clear tube: 78% (*SD* = 21%) of their pre-testimony responses were to the correct cup. But also as in Study 2, the most frequent post-testimony response was to direct E1 to search in the incorrect cup indicated by E2's misleading testimony. Most importantly, children were as deferential to E2's misleading testimony on the three trials where he asserted that the ball landed in the other location (56%; *SD* = 48%) as on the three trials where he asserted that it landed in the gravity location (also 56%; *SD* = 50%). Clearly, children's deference to E2's misleading testimony in Study 2 was not because it highlighted a location that coincided with their gravity bias. When E2 provided misleading testimony that the ball had fallen in the other location, children also tended to instruct E1 to search in that location.

Study 3

Children's willingness to defer to the adult's assertion about where the ball landed in Studies 1, 2, and 2A was striking: They met the informant just a few minutes earlier, and yet they were apparently willing to trust what he or she told them even when it conflicted with a naive expectation or with what they had just seen. Also striking was the fact that they continued to trust the experimenter's testimony in Study 2 even though it was wrong on every trial. It is possible that children in all the studies described so far were merely complying with an unfamiliar adult rather than actually believing that the ball would be found where she or he said it was. Our framing of the task as a game involving two experimenters in Studies 2 and 2A was meant to reduce the demand characteristics of the task, but toddlers may still have felt uncomfortable directly contradicting an unfamiliar adult; they did not know what consequences, if any, there might be for doing so. They may have viewed the social aspects of the game (e.g., positive interactions with the experimenter) as more important than finding the ball. Study 3 was designed to address directly two pragmatic reasons children may have deferred to the experimenter's testimony in the earlier studies.

In one condition (the "goldfish" condition), we investigated the possibility that children lacked the motivation to contradict E2. To do this, we offered them an incentive to ignore or discount what he said. The procedure was exactly the same as that used in Study 2, but rather than dropping a ball, the experimenter operating the apparatus dropped a goldfish cracker. Children watched as it traveled down a clear tube and fell into a particular cup, and they provided a pre-testimony response about where it landed. E2 then claimed that it landed in the gravity location, and finally, E1 asked children to resolve this conflict. When children directed E1 to search in the correct location—thereby disregarding E2's misleading assertion—she gave them the cracker to eat. But when they directed her to search in an incorrect location, she did not. Whereas in the previous studies, there was no real cost to searching the cup indicated by E2 first, in this condition, children who did so lost the opportunity to receive a tasty treat.

In the second condition of Study 3 (the "clear cups" condition), we investigated the possibility that children were deferential to E2's misleading testimony strictly out of compliance (e.g., not wanting to contradict an unfamiliar adult experimenter). In this condition, we altered the chimney apparatus so that both the tubes and the cups were clear. This allowed children to watch as a ball traveled down a tube and landed in a particular cup, and additionally to see it sitting in that cup throughout the rest of the trial. As in Study 2 (and like the goldfish condition just described), children made a pre-testimony response, heard E2 claim that the ball had fallen in the gravity location, and then instructed E1 about where to search. Note that this clear cup condition maintains exactly the same social demands of Study 2: An unfamiliar adult makes a claim that conflicts with what children have just seen, another adult asks them where to look, and children have to decide whether to trust what they have been told or their own eyes. However, in this condition, children should be much more confident in their belief about where the object is because they have continuous visual access to it; they do not have to infer that the object is in the opaque cup into which they saw it disappear. But if children's deference in the previous studies reflects pure compliance rather than deference to testimony in the face of uncertainty, then they should continue to be deferential in this condition.

Method

Participants—Twenty-four 2.5-year-olds participated in a single visit. Half participated in the goldfish condition (*mean* = 2 years, 6 months; *range* = 2;4 to 2;8; 6 boys) and half participated in the clear cup condition (*mean* = 2 years, 7 months; *range* = 2;4 to 2;8; 7 boys). None had participated in the earlier studies. Three additional children participated, but their data were not included because they failed to complete the session (2), or a sibling interfered (1).

Procedure

Goldfish condition: The procedure in the goldfish condition was very similar to that used in Study 2, with an object being dropped into a clear tube and disappearing into an opaque cup. This time, however, goldfish crackers were used instead of a ball. At the beginning of the warm-up phase, E1 offered children a goldfish cracker and assured them it was theirs to eat (none required much encouragement to do so), and also used goldfish crackers during each component of the warm-up phase. Children received around six crackers during the warm-up. During each of the six test trials, if children directed E1 to search in the cup where the cracker actually was on their initial post-testimony response, E1 gave them the cracker. If they directed her to an incorrect cup (either the gravity cup mentioned by E2 or the other cup), she showed them that the cup was empty and encouraged them to make a second post-testimony response. When they finally directed her to the correct cup, she showed them that it contained the cracker, but did not give it to them. We replaced the cup that had fish stickers attached to it with one that had bear stickers attached to it, so that there would be no ambiguity in the current study about whether an experimenter's use of the word "fish" referred to the goldfish crackers or to a cup with fish stickers.

Clear cup condition: The procedure in the clear cup condition was the same as that used in Study 2, except that we replaced the three opaque cups into which a ball fell with clear ones, each with several color stickers of either bears, dogs, or birds attached.

Results and Discussion

As in Studies 2 and 2A, toddlers' pre-testimony responses in both conditions of Study 3 were overwhelmingly to the correct cup. As Figures 3C and 3D show, before E2 made any claims about where the object had landed, children in the goldfish and clear cup conditions indicated the correct cup 81% and 97% of the time, respectively. The reason that the pre-testimony accuracy was so high in the clear cup condition was presumably because children could actually see the object sitting in the cup when they made their response.

Children's post-testimony responses, however, differed by condition. Toddlers in the goldfish condition were generally deferential to E2's misleading testimony, replicating the results of Study 2. As Figure 3C shows, they directed E1 to search in the gravity cup 55% of the time. (On the 81% of trials on which children in this condition indicated the correct cup in their pre-testimony response, they subsequently directed E1 to search in the gravity location 56% (*SD* = 37%) of the time.) Although this was only marginally more often than expected by chance, $t(11) = 1.98$, $p = .07$, $d = .57$, it was a significant increase over how often they had indicated the gravity location in their pre-testimony response (56% vs. 15%), $t(11) = 3.30$, $p = .007$, $d = 1.42$. As in Study 2, children in the goldfish condition did not become skeptical of E2's testimony over the course of the session even though his testimony was never accurate. They directed E1 to search in the gravity location, on average, on 50% (*SD* = 41%) of the first three trials, and on 60% (*SD* = 37%) of the last three trials. Finally, using goldfish crackers rather than a ball resulted in a slight decrease in the likelihood that children would defer to E2's misleading testimony (55% in the goldfish condition vs. 62% in Study 2), but this difference was not significant, $t(28) < 1$.

Children in the clear cup condition responded quite differently from those in the goldfish condition; they nearly always ignored E2's misleading testimony. As Figure 3D shows, on their initial post-testimony response, they directed E1 to search in the gravity location just 7% of the time, and in the correct location the remaining 93% of the time—clearly a different pattern of results from those obtained in the goldfish condition or in Study 2. Thus, mere compliance cannot explain children's deference to testimony. If children's deference in the previous studies had been entirely the result of the social demands (e.g., unwillingness to contradict an unfamiliar adult), they should also have been deferential in this clear cup condition because the social demands were the same. Instead, they readily dismissed the experimenter's testimony. Presumably, having continuous visual access to the ball made them highly confident in their own belief about where the object had fallen.

Study 4

We suggested in the Introduction that children might be especially confident in a self-generated belief about the trajectory of a falling object because this kind of knowledge can easily be acquired autonomously, without input from other people. We raised the possibility that this confidence might lead children to be skeptical of unexpected testimony in that domain. In fact, however, many children seemed to trust what they were told, even when it conflicted with a naive expectation about gravity (Study 1) or with an event they had just witnessed (Studies 2, 2A, and 3). The one situation where children were uniformly skeptical was in the clear cup condition of Study 3, when the speaker's testimony conflicted with their concurrent first-hand observations. Contrary to our initial hypothesis, then, the mere fact that a belief is about the physical world does not necessarily entail a high degree of confidence in that belief or skepticism about testimony that is at odds with it.

Our final study used a procedure similar to the one in the goldfish condition of Study 3. This time, however, we asked whether providing children with experience with the apparatus before the misleading testimony began could increase their confidence in their initial, self-generated belief. On the surface, this seems like an unlikely proposition. Children receive evidence that confirms naive beliefs about the physical world—for example, that an object cannot move from point A to point B without traversing the intervening space—just by opening their eyes. And yet, children (and adults) also routinely encounter devices that appear to defy the laws of physics (Keil & Wilson, 2000): A remote control can activate a television across the room; a microwave oven can heat food; videoconferencing allows us to see family members on the other side of the world; and so on. Indeed, children are even willing to believe that a machine can shrink a room (DeLoache, Miller, & Rosengren, 1997) or clone an object (Hood & Bloom, 2008).

It is possible that children in the studies so far viewed the chimney apparatus as one of these machines that could violate a physical principle—in this case, a device that could violate the principle of continuity (Spelke, 1994) by transporting an object that appeared to have landed in one location to another. After all, it was somewhat complicated-looking, and children never had the opportunity to inspect or interact with it once it was fully assembled and before the experimenter began contradicting their expectations. This does not explain why they weighted testimony more heavily than their self-generated belief in the first place, or why (in the case of Studies 2 and 3) they continued to do so even though the testimony had been wrong on each of the previous trials. However, it does suggest that if children first had experience that confirmed that this particular apparatus obeyed their expectations that an object that disappeared into one location would remain there, then they might be less receptive to later testimony that suggested otherwise. The final study was designed to address this possibility. (It is worth noting that in Tamis-LeMonda et al.'s (2008) ramp study, in which children ignored their mothers' advice about slopes they had consistently traversed or fallen on in the past, they had extensive experience with the apparatus—on average, 31 trials' worth—before their mothers began offering advice.)

Children in one condition of Study 4 (the "relevant experience" condition) watched a cracker travel down a clear tube and disappear into an opaque cup, as in the goldfish condition of Study 3. Unlike this earlier study, however, on an initial block of trials, E2 offered neutral rather than misleading testimony. We expected that under these circumstances, children would select the correct cup in both their pre- and post-testimony responses. Further, we expected that having their expectations repeatedly confirmed would increase their level of familiarity with the chimney apparatus and with the fact that a cracker that disappeared into one cup would remain there. On a later block of trials, E2 offered misleading testimony, as in Studies 2 and 3. Of interest was whether these children would better be able to resist the misleading testimony than children in a comparison condition who had not had relevant experience.

In designing the comparison condition, we wanted to equate the number of crackers children had the opportunity to eat and the amount of time they spent interacting with the apparatus. This would ensure that children in the two conditions would be similarly motivated when E2 began offering misleading testimony. Importantly, however, we did not want children in the comparison condition to become too familiar with how the apparatus worked or with the fact that an object that disappeared into one cup would remain there. To achieve these goals, children in this "irrelevant experience" condition were presented with an initial block of trials in which a cracker fell into a cup, as in the relevant experience condition. However, an opaque screen covered the tubes in the apparatus, so children did not have access to the mechanism by which a cracker traveled from a particular chimney to a non-adjacent cup. Additionally, during this initial block of trials, the cups into which the crackers fell were clear rather than opaque, meaning that children did not have experience seeing an object disappear into a particular cup and finding it there. Instead, once it had fallen into a cup, the cracker was always visible. After this initial block of trials, the screen covering the tubes was removed, the clear cups were replaced with opaque ones, and E2 began offering misleading testimony, as in the relevant experience condition.

The design of Study 4 also allows us to investigate an additional pragmatic explanation for why children in the earlier studies were so likely to defer to E2's unexpected testimony. Perhaps children interpreted the fact that E1 asked them to locate the dropped object twice on each trial (once pre-testimony and once post-testimony) as a signal that their pre-testimony response was incorrect (e.g., Siegal, Waters & Dinwiddy, 1988). On this account, children might change answers on pre- and post-testimony responses even if the testimony were neutral (rather than misleading) in content, simply because of the repeated questioning. Because Study 4 included several trials in which E2's testimony was neutral, we were able to address this possibility.

Method

Participants—Thirty-six 2.5-year-olds participated in a single visit. Half participated in the relevant experience condition (*mean* = 2 years, 6 months; *range* = 2;4 to 2;9; 10 boys) and half participated in the irrelevant experience condition (*mean* = 2 years, 6 months; *range* = 2;4 to 2;9; 10 boys). None had participated in the earlier studies. Four additional children participated, but their data were not included because they failed to complete the session (2), they had a side bias involving selecting the right-most cup on all pre- and post-testimony responses (1), or because of experimenter error (1).

Procedure

Relevant experience condition: Following a warm-up procedure that was the same as in the goldfish condition of Study 3, children participated in six no-conflict trials. On these no-conflict trials, children watched as a goldfish cracker was dropped through a chimney, traveled down a clear tube, and disappeared in an opaque cup. E1 invited children to indicate where the ball had landed, E2 made a neutral comment ("It's in one of these cups!"), and E1 asked children where to look. If they directed her to the correct cup, E1 gave them the cracker found there; if not, she showed them that the cup they selected was empty and invited them to make another response. When they eventually located the cracker, E1 put it aside.

After these six initial trials, children were given six conflict trials, which were identical to those in the goldfish condition of Study 3. Children watched as a cracker was dropped through a chimney, traveled down a clear tube, and disappeared into an opaque cup. E1 asked children to make a pre-testimony response, E2 claimed that the fish had landed in the gravity cup (i.e., provided inaccurate testimony), and E1 asked children where she should look. As in the no-conflict trials, when their initial post-testimony response indicated the correct cup, E1 gave them the cracker found there. Otherwise, she invited them to make additional responses until they located the cracker and then put it aside.

Irrelevant experience condition: The irrelevant experience condition was similar to the relevant experience condition with two exceptions. First, during the six initial no-conflict trials, the intertwined tubes connecting each chimney to a particular cup were covered by a cardboard screen. The screen prevented children from seeing the means by which an object dropped through a chimney ended up in a particular cup. The second difference from the relevant experience condition was that for the initial no-conflict trials, the crackers landed in clear (rather than opaque) cups. Thus, children in the irrelevant condition had as much experience locating (and eating) goldfish crackers as those in the relevant condition. But they never received experience that would confirm their intuition that a cracker that disappeared into an opaque cup would remain there. Six conflict trials followed, and these were exactly the same as those in the relevant experience condition, involving clear tubes and opaque cups, and an experimenter who claimed on each trial that the cracker had landed in the gravity location.

Results and Discussion

No-conflict trials—On the no-conflict trials, children in both conditions usually indicated the correct cup in their pre- and post-testimony responses. Those in the relevant and irrelevant experience conditions made correct pre-testimony responses on 80% (*SD* = 27%) and 93% (*SD* = 19%) of trials, respectively. When children made a correct pre-testimony response, they always made a correct post-testimony response, meaning that those in the irrelevant experience condition were slightly more likely to find (and eat) the goldfish crackers during these no-conflict trials, but this difference was not significant, $t(34) = 1.66$, $p = .10$. Thus, any differences between the two conditions in the conflict trials that followed cannot be attributed to fatigue or satiation caused by these no-conflict trials.

The results from the no-conflict trials of the relevant experience condition are also important in the context of Studies 2 and 3, as they show that children made the same pre- and post-testimony response when the testimony delivered by E2 was neutral. Thus, the changes that occurred between the pre- and post-testimony responses in the earlier studies were due to E2's misleading testimony, not to forgetting caused by the brief delay between the two responses or the pragmatic demands of being asked the same question twice (e.g., Siegal et al., 1988).

Conflict trials—Consistent with results from the no-conflict trials and results from the previous studies, children in both conditions tended to make correct pre-testimony responses on the conflict trials. As Figures 3E and 3F show, those in the relevant experience condition indicated the correct cup 88% of the time in their pre-testimony responses, and those in the irrelevant experience condition did so 77% of the time. In both cases, they indicated the correct cup more often than expected by chance, t's > 5.89, p's < .0001, d's > 1.38, and the two conditions did not differ from each other, $t(34) = 1.23$, $p = .22$.

The primary question in Study 4 was whether toddlers who had relevant experience during the initial no-conflict trials would be more skeptical of E2's misleading testimony on the conflict trials than toddlers who had irrelevant experience. This would be reflected in their post-testimony responses. Analyses of overall performance suggested that children in the two conditions were similarly influenced by E2's misleading testimony, but analyses of performance across trials revealed important differences.

Beginning with the similarities: As Figures 3E and 3F show, after hearing E2 claim that the cracker had landed in the gravity location, children in the relevant experience condition were slightly less likely to direct E1 to search there than those in the irrelevant experience condition (46% vs. 54%), but the two conditions did not differ from each other, $t(34) < 1$. (Considering just the trials on which their pre-testimony response had been correct yields the same pattern of results: Children directed E1 to search in the gravity location on those trials 43% (*SD* = 44%) and 53% (*SD* = 40%) in the relevant and irrelevant experience conditions, respectively.) There was a hint of a difference in the two conditions in that children who had relevant experience directed E1 to search in the gravity location at chance levels, $t(17) = 1.29$, $p = .21$, whereas those who had irrelevant experience did so at above-chance levels, $t(17) = 2.58$, $p = .02$, $d = .61$. But in both conditions, children were more likely to indicate the gravity location in their post- than their pre-testimony response (relevant experience condition: 8% vs. 46%, $t(17) = 4.03$, $p = .0009$, $d = 1.60$; irrelevant experience condition: 12% vs. 54%, $t(17) = 6.04$, $p < .0001$, $d = 2.35$).

A striking difference between the two conditions emerged when we analyzed children's deference to E2's misleading testimony on the first three trials compared to the last three. The likelihood that children in the irrelevant experience condition directed E1 to search in the gravity location *increased* from 46% (*SD* = 36%) to 61% (*SD* = 35%) from Trials 1–3 to 4–6. In marked contrast, the likelihood that children in the relevant experience condition directed

E1 to search in the gravity location *decreased* from 54% (*SD* = 41%) to 39% (*SD* = 48%) from Trials 1–3 to 4–6.

A two-way mixed ANOVA (Condition x Trial Block) on these data revealed only a significant interaction, $F(1,34) = 12.80$, $p = .001$, $\eta_p^2 = .27$. Simple effects tests showed that children in the irrelevant experience condition became more likely to direct E1 to search in the gravity location, $F(1,34) = 6.36$, $p = .02$, $\eta_p^2 = .16$, whereas children in the relevant experience condition became less likely to do so, also $F(1,34) = 6.36$, $p = .02$, $\eta_p^2 = .16$. Furthermore, on Trials 1–3, children in the two conditions were equally likely to direct E1 to search in the gravity location, $F(1,34) = 1.59$, $p = .22$, $\eta_p^2 = .05$. But on Trials 4–6, children in the relevant experience condition were significantly less likely than those in the irrelevant experience condition to direct E1 to search there, $F(1,34) = 14.31$, $p = .0006$, $\eta_p^2 = .30$.

Importantly, children in the relevant experience condition were not simply learning to avoid the location indicated by E2's misleading testimony; they were actually coming to weight their own initial belief more heavily. If they had been simply learning to avoid the location indicated by E2, then the number of selections of the other, non-gravity incorrect cup and the number of selections of the correct cup would both be expected to increase across trials. In fact, however, only selections of the correct cup increased. The likelihood that children in the relevant experience condition indicated the correct cup in their initial post-testimony response increased from 46% (*SD* = 41%) to 61% (*SD* = 48%) on Trials 1–3 to 4–6, $t(17) = 2.41$, $p = .03$, $d = .82$. The likelihood that they indicated the other incorrect cup was 0 on Trials 1 −3 and remained 0 on Trials 4–6. Thus, although children in the relevant experience condition were willing to "try out" E2's misleading testimony on the early conflict trials, they came to weight their own self-generated belief more heavily as the session went on.

Another way to look at these data is to consider the number of children who made the same, fewer, or more correct responses on Trials 4–6 than on Trials 1–3. Of the 18 children in the relevant experience condition, 10 made the same number; 1 made fewer; and 7 made more, a distribution that is marginally different from what would be expected by chance by a sign test, $p = .07$. In contrast, the distribution of responses in the irrelevant experience condition was almost the mirror-image: Of the 18 children in the irrelevant experience condition, 11 made the same number of correct post-testimony responses on Trials 1–3 as on 4–6; 6 made fewer; and just 1 made more, a pattern that trends in the opposite direction from the relevant experience condition, but is not significant by sign test, $p = .13$.

In short, children in the relevant experience condition came to ignore E2's misleading testimony as the session went on, and they placed more faith in their own, self-generated belief. In contrast, children in the irrelevant experience condition trusted E2's misleading testimony throughout; they continued to weight it more heavily than their own belief. We are reluctant to make much of the significant increase in deference in this condition, as it was not predicted and in the previous studies in this series that are analogous to this condition (Study 2 and the goldfish condition of Study 3), deference remained near the same level on the first and last three trials. The important point is that, as in the earlier studies, children in the irrelevant condition did not become more skeptical of E2's testimony even though he was wrong on each trial.

Individual Response Patterns Across Studies 2–4

Table 1 shows the percentage of children in Studies 2–4 who directed E1 to search in the gravity location (the location indicated by E2's misleading testimony) in their initial post-testimony response on none, 1–2, 3–4, or 5–6 of the 6 test (conflict) trials. The most notable aspect of the table is how much variability there is within each study or condition: Some children were never or only rarely deferential, and others were always or nearly always deferential. We will offer some speculation about these individual differences in the General Discussion.

General Discussion

Toddlers were surprisingly receptive to unexpected testimony about the behavior of inanimate objects. Study 1 showed that they responded in a manner consistent with what they were told about the trajectory of a falling object, even though that testimony conflicted with the gravity bias. Study 2 showed that they also deferred to testimony that conflicted with an event they had just witnessed. The goldfish condition of Study 3 showed that children were deferential even when they had an incentive to ignore the testimony. Only when they could plainly see that a piece of testimony was wrong (in the clear cup condition of Study 3), or when they had a particular kind of experience with the apparatus beforehand (in the relevant experience condition of Study 4), did they come to weight their own beliefs more heavily.

These results are noteworthy for several reasons. First, they demonstrate the power of testimony to influence children's beliefs, even in a domain that does not normally require input from other people. Compared to knowledge in domains that are a matter of convention (e.g., vocabulary) or that have a non-obvious basis (e.g., category membership), knowledge about the visible physical world seems less dependent on input from other people. Presumably, an individual who did not have access to testimony would have many of the same expectations and make many of the same predictions about events involving inanimate objects as an individual who did. Indeed, everyday visual experience tends to confirm expectations about the physical world. One might therefore expect beliefs in this domain to be particularly robust against unexpected testimony. And yet, in the studies here, this was not the case. Many children seemed to trust what they were told despite the fact that it conflicted with their initial expectations.

There has been some previous work investigating how children make sense of physical events that violate their expectations, but this work has focused primarily on anomalous events they actually witnessed rather than those they merely heard about (Chandler & Lalonde, 1994; Rosengren & Hickling, 1994; Subbotsky, 2004). For example, in Chandler and Lalonde (1994), most 3- and 4-year-olds who earlier denied the possibility that a screen could pass through a block decided that it was possible (by "magic") once they actually saw the event (though with repeated presentations, they came to see it as a trick). Testimony about fantasy characters, such as Santa Claus or the Easter Bunny, can lead children to believe that these characters can behave in ways that violate physical principles (e.g., fly, travel down chimneys). But this testimony is usually supplemented by physical evidence that at least indirectly supports the testimony (e.g., presents, half-eaten cookies, etc.; Woolley, Boerger, & Markman, 2004). The present studies are unique in that they provided only testimony and, in Studies 2–4, testimony that was actually disconfirmed by the evidence (i.e., the ball was never found where the experimenter claimed it was). Despite this, many children remained credulous.

A second important aspect of the results is that toddlers in Study 2, who heard testimony that conflicted with an event they had just witnessed, were as deferential as those in Study 1, who heard testimony that conflicted with a naive bias. This is a surprising result because information acquired from another person seems qualitatively different from—somehow inferior to—information acquired through personal experience (e.g., Coady, 1992; Fricker, 2006). Locke (1689/1964) articulated this position when he wrote that, "The floating of other men's opinions in our brains makes us not one jot the more knowing, though they happen to be true. What in them was science is in us but opiniatrety" (p. 58). Hume (1748/2007) acknowledged the importance of testimony, but he too argued that personal observation was primary. Indeed, on his view, testimony becomes a source of knowledge through repeated exposure to situations in which it matches one's own experience. Philosophical considerations aside, it seems a reasonable intuition that information acquired through observation would be more compelling than conflicting information obtained through testimony (e.g., Gelman, 2009). Why, then, were the toddlers in Study 2 so deferential to the misleading testimony?

One possibility is that their deference reflects the fact that the testimony was consistent with the gravity bias, a bias that even older children sometimes have difficulty inhibiting (e.g., Hood et al., 2006). However, as Study 2A showed, children were as deferential to testimony that indicated the non-gravity incorrect location as to testimony that indicated the gravity location. Another possibility is that children in Study 2 were deferential because there was so little cost to looking where the experimenter claimed the ball was, not because they actually believed that it would be found there. Perhaps they viewed the task as a collaborative game where their role was to play along with the experimenter. However, as the goldfish condition of Study 3 showed, children were deferential even when there was a cost for searching in the incorrect location: They consistently deferred to the experimenter's misleading testimony even though doing so kept them from obtaining a tasty goldfish cracker—a highly desirable object for most children (e.g., Repacholi & Gopnik, 1997). Of course, it is possible that if we had used something even more desirable, they would have evaluated the misleading testimony more critically. The important point for our purposes is that even when they were highly motivated to locate an object, many children continued to place more weight on where someone told them it was than on where they had just seen it disappear.

Another possible explanation for why children were deferential to testimony in Study 2 is that they felt obligated to comply with an unfamiliar adult. This seems unlikely for three reasons. First, the experimenter did not instruct them to look in a particular location; he merely asserted that the ball had landed there ("It's in the X cup."). Additionally, in the clear cup condition of Study 3, which maintained all of the social demands of Study 2, toddlers were not compliant: They did not defer to the experimenter when they could see that he was referring to a cup that was empty. If their deference in Study 2 had been the result of mere compliance, they should have been compliant in this clear cup condition as well. Finally, as most parents (and developmental psychologists) will attest, 2.5-year-olds do not have a reputation for being particularly compliant. Indeed, some research on compliance suggests there is little consistency in whether a given child will be compliant across situations, or whether a given situation will elicit compliance across children (e.g., Landauer, Carlsmith, & Lepper, 1970).

One could argue that children's deference to testimony actually represented a recency effect. That is, perhaps what we have been calling "deference" is really just children responding on the basis of the last piece of information they had access to. It is important to point out, however, that this is precisely the situation that we were interested in: How do children reconcile an initial, self-generated belief with socially provided information that conflicts with that belief? Moreover, two pieces of evidence suggest that children could have responded on the basis of their initial belief had they been so inclined. First, the testimony did not over-write or delete children's initial belief: When children in Study 2 indicated the correct cup pre-testimony and the gravity cup on their initial post-testimony response, their second post-testimony response on that trial was more likely than expected by chance to be correct. Thus, children continued to have access to their initial belief even though they were initially persuaded to look in the location indicated by the testimony. Second, the relevant experience condition of Study 4 demonstrated that children could ignore the misleading testimony even though it was the last piece of information they had access to. In that condition, children responded in a manner consistent with the testimony on the first three trials, but by the last three, they were significantly less likely to do so (and significantly more likely to respond in a manner consistent with their initial, correct belief).

We suggest that toddlers' deference across the studies described here reflected a genuine belief that the dropped object could be found in the location indicated by the experimenter's testimony, which was the manifestation of a default bias to trust what an adult says (e.g., Reid, 1764/1997). Because the current studies focused on 2.5-year-olds, they cannot offer insight into whether children had learned through experience to weight adult testimony more heavily than their self-generated expectations (e.g., Mareschal, 2003; Sloutsky, Lo, & Fisher, 2001), or whether this trust in testimony would be evident even without experience (e.g., Dawkins, 1995; Reid, 1764/1997). However, the data demonstrate clearly that 2.5-year-olds did not have to learn to trust the particular individual who offered testimony in these studies. Consider Study 1, where the experimenter's testimony was correct and conflicted with the gravity bias. If they had to learn to trust the particular individual offering testimony, one would expect that with repeated experience in which the experimenter's testimony was correct (as was the case in Study 1), they would become more likely to defer to it as the session went on. In fact, children in Study 1 were deferential from the very beginning: On the very first trial of Study 1, no child correctly indicated the location where the ball had fallen in their pre-testimony response, but over three-quarters did so in their initial post-testimony response.

Furthermore, this trust in the experimenter's testimony was extremely robust. In Study 2 and the goldfish condition of Study 3, children did not become more skeptical of the experimenter's claims as the session went on, despite the fact that he was incorrect on each of the six trials. In fact, in the irrelevant experience condition of Study 4, children actually came to rely more heavily on the experimenter's (incorrect) testimony on the later trials than on the early ones. The fact that children did not lose faith in the experimenter's repeatedly incorrect testimony in these studies is somewhat surprising given previous work showing that children can keep track of whether an individual has provided accurate or inaccurate testimony, and prefer information from a source that has been correct in the past over one that has been incorrect (e.g., Birch et al., 2008; Jaswal & Neely, 2006; Jaswal et al., 2008; Koenig et al., 2004). There are, however, some important differences between this earlier work and the current studies.

First, many previous studies investigating children's sensitivity to accuracy have used 3-to 5-year-old children, whereas the present work focused on 2.5-year-olds. Some of the previous studies have found that 3-year-olds' ability to track reliability is fragile relative to the older children (e.g., Koenig et al., 2004; but see Birch et al., 2008; Corriveau, Meints, & Harris, 2009; Pasquini, Corriveau, Koenig, & Harris, 2007). If 2.5-year-olds have such an ability, it stands to reason that it may be even more fragile. Additionally, much of the previous work has made use of a procedure in which two speakers (one formerly accurate and one formerly inaccurate) offer conflicting testimony, and children have to decide which one to trust. In contrast, in the present work, a single speaker offered unexpected testimony; children had no alternative source of information to which to turn other than their self-generated belief.

There is some research suggesting that 3-year-olds, like the 2.5-year-olds here, also have difficulty discounting testimony from a single speaker. For example, Jaswal and Malone (2007) found that when a single speaker claimed that, for example, a key-like object was a "spoon," 3-year-olds remained credulous even if that individual had made a mistake in the past or seemed distracted. Similarly, Vanderbilt, Liu, and Heyman (2009) found that 3-year-olds were generally trusting of an informant who offered advice about the location of a hidden sticker, even if they had observed that individual tricking another person several times in the past. In fact, Mascaro and Sperber (2009) recently reported that 3-year-olds continued to trust an informant even when the children themselves had been deceived by that person about the location of a hidden sweet. In short, before about four years of age, children seem to have difficulty inhibiting the normally reasonable expectation that what an adult says is true. This is consistent with the large literature on the development of inhibitory control in a number of other domains, which suggests a major shift between three and five years of age in children's ability to make a response different from the conventional or well-practiced one (e.g., Carlson, Moses, & Hix, 1998; Carlson, 2005; Gerstadt, Hong, & Diamond, 1994; Zelazo, Frye, & Rapus, 1996).

Another reason children in many of the studies here may have continued to believe the experimenter despite his repeated errors could be that they failed to recognize that the errors were his.[2] In previous work on children's ability to track accuracy, children could evaluate the veracity of a statement by the inaccurate speaker at the moment it was uttered (e.g., the speaker referred to a visible picture of a duck as a "shoe"). In contrast, in most of the studies here, this was not possible because the experimenter testified to the location of an object that was concealed in an opaque cup. Children had clear evidence that he was wrong only after they failed to find the object there or when they found it in a different location. Given young children's well-known difficulty with identifying the source of their knowledge (e.g., Gopnik & Graf, 1988;O'Neill, & Gopnik, 1991;Wimmer, Hogrefe, & Perner, 1988), an intriguing possibility is that when they failed to find the object in the gravity location, they were unable to remember how they came to believe that it could be found there. If they did not recognize that the source of an error was E2, then there would be no reason for them to discount his later testimony.

Recall that our primary interest in these studies was the role that children's confidence in their initial beliefs played in how they responded to unexpected testimony. We held constant two other variables that we know affect children's (and adults') receptiveness to persuasive messages—namely, their confidence in the speaker and the size of the discrepancy between what they are told and what they initially believed. Study 1 showed that children deferred to testimony that conflicted with the gravity bias, suggesting that they were not particularly confident in their expectations about the physical world, contrary to our initial hypothesis. Study 2 showed that they also trusted unexpected testimony about an event they had just witnessed, suggesting that they were not particularly confident in their self-generated belief even when it was obtained through direct observation.

The two cases in which the unexpected testimony was less persuasive (or became less persuasive) were the clear cup condition of Study 3 and the relevant experience condition of Study 4. Although we did not have an independent measure of children's confidence, we designed these conditions to increase children's confidence in their initial beliefs. In the clear cup condition of Study 3, there was no uncertainty about where the ball had landed. Children could see it sitting in a cup different from the one the experimenter named—they did not have to infer that the ball could be found in the cup in which they saw it disappear. In the relevant experience condition of Study 4, there was an element of uncertainty about where the object was, but children in this condition had the unique opportunity to confirm their expectations that an object that disappeared in one location in this particular apparatus would be found there before the experimenter began suggesting otherwise.

It is interesting that children in the relevant experience condition of Study 4 were initially deferential when the experimenter began offering unexpected testimony, but came to weight their own beliefs more heavily later in the session. The initial deference likely reflects both the fact that the cracker had disappeared into an opaque cup and the default expectation that what adults say is true. They were apparently willing to "try out" the experimenter's unexpected testimony a few times, on the off-chance that he knew something they did not. But given that he was wrong each time, they reverted to their earlier, more successful strategy of searching in the cup where they had seen it disappear. The experimenter was also wrong on each trial in

[2]Thanks to an anonymous reviewer for this suggestion.

the closely matched irrelevant experience condition, but children in this condition did not have experience with an alternative, more successful strategy.

One important issue that we have touched on only briefly so far has to do with individual differences. As noted earlier and as shown in Table 1, some children in each study were more receptive to unexpected testimony than others (except in the clear cup condition of Study 3, in which nearly all children were skeptical). The current studies were not designed to account for individual differences, so our discussion of this issue is necessarily speculative. As alluded to earlier, one factor that likely influences children's receptiveness to unexpected testimony is inhibitory control. Perhaps inhibitory control is required to inhibit the expectation that what an adult says is true. On this account, the more inhibitory control children can exert, the better able to resist unexpected testimony they may be. An intriguing alternative is exactly the reverse: Perhaps inhibitory control is needed to keep from acting on one's own beliefs, in which case the more inhibitory control children have, the more deferential to unexpected testimony they may be.

Another factor that may account for some of the individual differences in deference is temperament or attachment status. Corriveau et al. (2009) have shown that children's attachment status at 15 months is related to how likely they are at four years of age to endorse information from their mothers versus a stranger. In that study, children who were classified as securely attached preferred labels for novel objects given by their mothers over those given by a stranger. But when their mothers offered an unexpected label for an object (e.g., called a horse-like animal a "cow") and the stranger offered the expected label, these children endorsed the stranger's label. In contrast, those children classified as insecure-avoidant did not show a preference for the labels their mothers offered over those of the stranger even in the novel object case. Those children classified as insecure-resistant preferred their mothers' labels in all cases, and those who were classified as disorganized showed no consistent pattern. Although the present studies did not pit the testimony of a child's mother against that of a stranger, one could imagine that a child's internal working model might influence his or her trust in a stranger's testimony given on its own, particularly when it is unexpected. We leave these intriguing possibilities for future research.

We began by suggesting that children are routinely faced with conflicts between what they are told and what they already believe. The current studies suggest that toddlers tend to trust what they are told in these situations, even in a domain that is largely knowable autonomously: They were generally receptive to unexpected testimony about the behavior of a solid object unless they could see that it was wrong or unless they had built up confidence in their initial belief. A willingness to trust socially provided over privately acquired information is adaptive in cooperative situations, where teachers are normally looking out for their pupils' best interests. It allows children to extend their own knowledge, to take advantage of what other people know. The studies here show that an important challenge for development involves learning to recognize when a more skeptical approach to testimony is warranted (e.g., Csibra & Gergely, 2006; Dawkins, 1995).

Acknowledgments

Thanks to the children and parents who participated in these studies. Thanks also to Heather Burns, Christin Chambers, Lindsay Goldman, Lauren Malone, Carrie Palmquist, and Anna Walters for assistance in collecting and coding data, and to Nameera Akhtar, Andrei Cimpian, Amy Joh, Angel Lillard, Rachel Keen, Koraly Perez-Edgar, and members of the Child Language & Learning Lab for helpful comments on a previous draft. The research was supported by NICHD Grant HD-053403.

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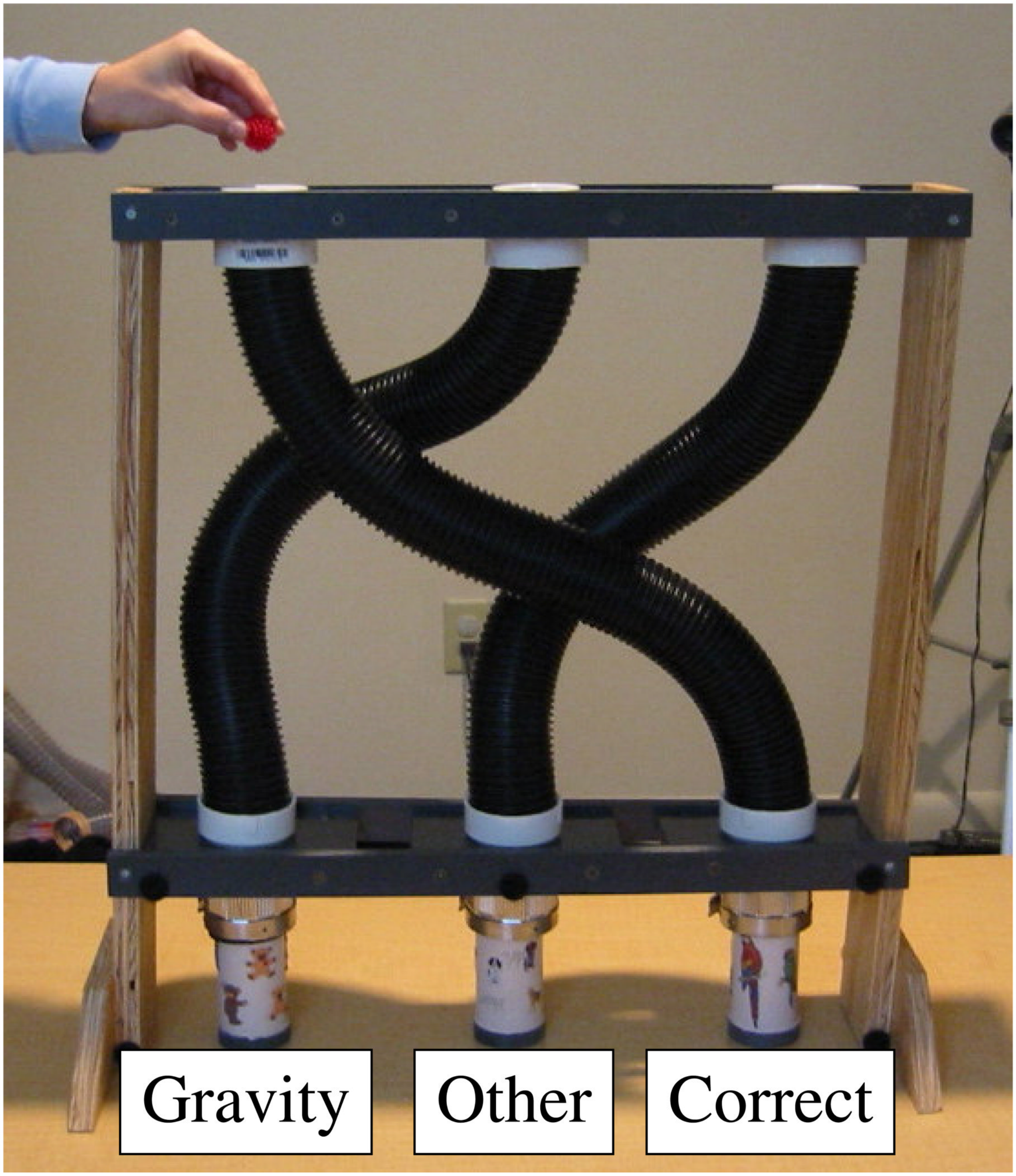

Figure 1.
Chimney apparatus used in Study 1. Subsequent studies used the same frame and configuration of tubes, but clear (rather than opaque) tubes.

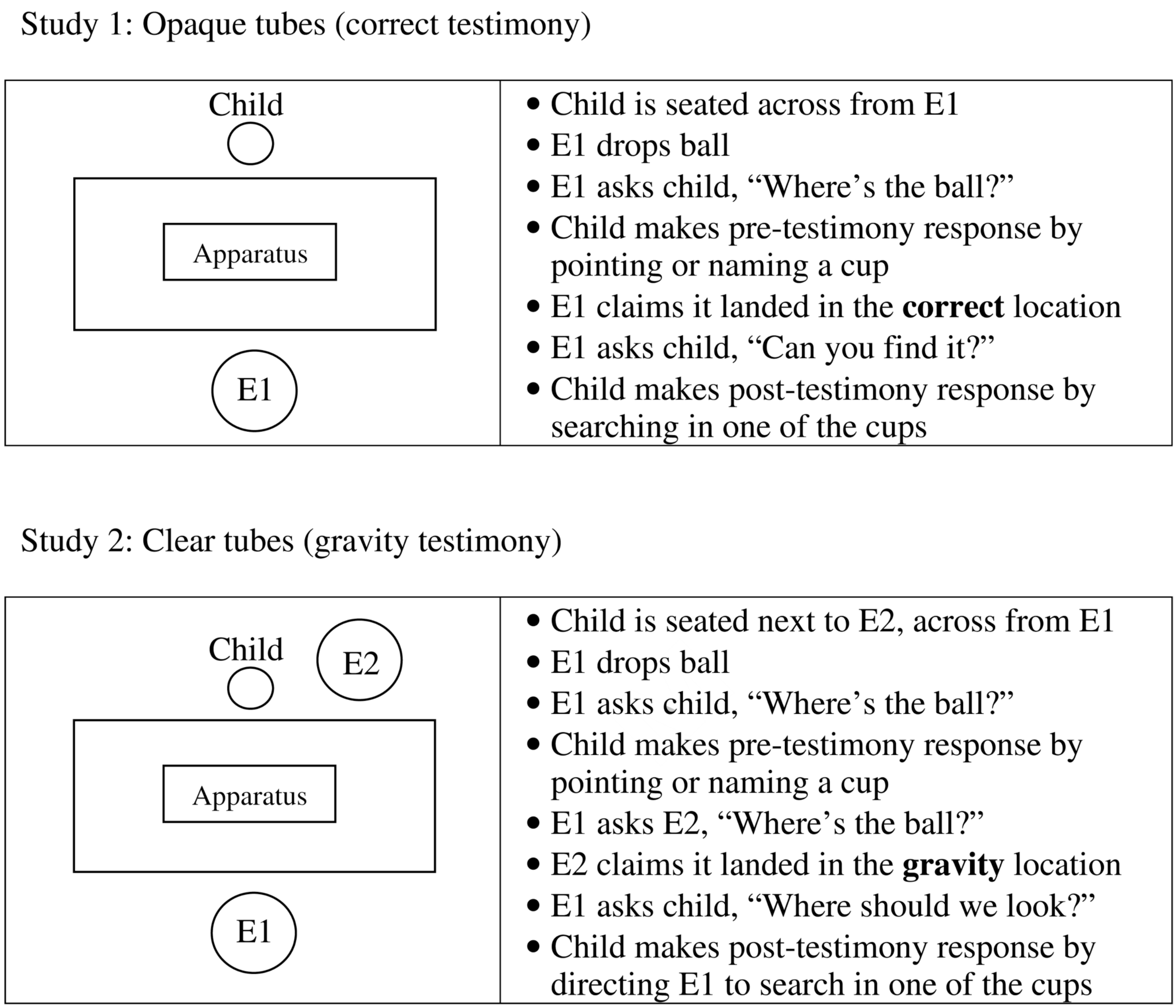

Figure 2.
Summary of the sequence of events on test trials for Studies 1 and 2.

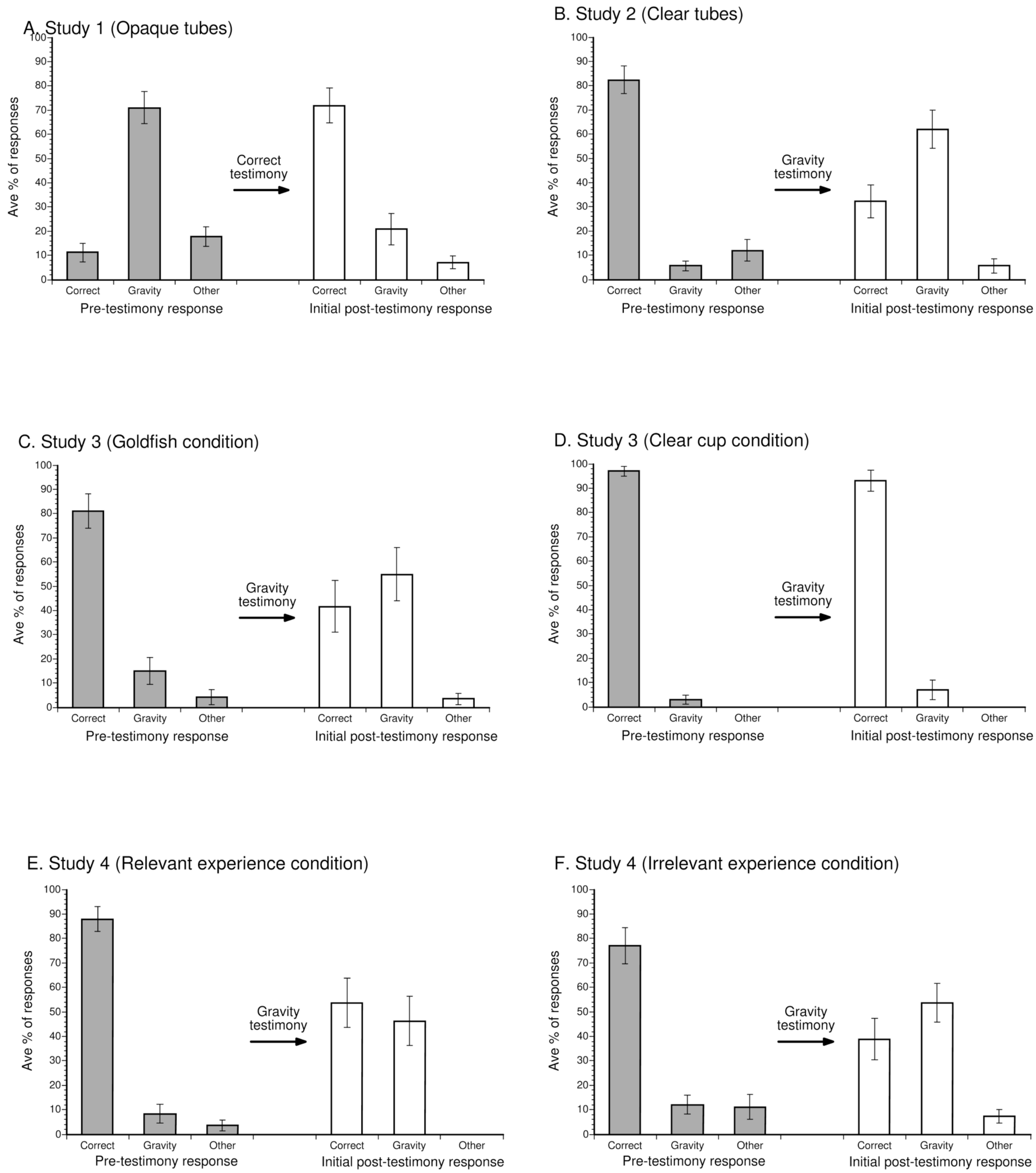

Figure 3.

Average percentage of trials on which children selected the correct, gravity, and other cups on their pre-testimony response and initial post-testimony response in each study. Error bars show SEM.

Table 1

Percentage of children in Studies 2–4 indicating the gravity location in their initial post-testimony response on 0, 1–2, 3–4, or 5–6 of the six test trials. Number in parentheses shows frequency.

	Number of trials			
	0	**1–2**	**3–4**	**5–6**
Study 2 (n=18)	6% (1)	23% (4)	28% (5)	44% (8)
Study 3 (Goldfish; n=12)	8% (1)	33% (4)	24% (3)	33% (4)
Study 3 (Clear cup; n=12)	75% (9)	17% (2)	8% (1)	0
Study 4 (Relevant experience; n=18)	28% (5)	28% (5)	6% (1)	39% (7)
Study 4 (Irrelevant experience; n=18)	11% (2)	28% (5)	28% (5)	33% (6)