Wondering how: Children's and adults' explanations for mundane, improbable, and extraordinary events

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Published online: 7 February 2017
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Abstract Children aged 5 through 9 years and adults judged the reality status of parallel mundane, improbable, and extraordinary events, generated an explanation for each event, and evaluated explanations purportedly generated by other participants. Participants of all ages claimed that mundane and improbable events could happen, whereas extraordinary events could not. Participants also overwhelmingly generated natural explanations for all three types of events but did so most for mundane, less for improbable, and least for extraordinary events. Supernatural explanations followed the reverse pattern, indicating that an event's possibility affects explanation. Participants also evaluated natural explanations most favorably and evaluated claims that there was no explanation for an event least favorably across all story types. However, significant rejection of the “no explanation” claim did not emerge until age 8 years, indicating that age affects acceptance of the idea that some events might be unexplainable.

Keywords Causal reasoning · Cognitive development · Concepts

The way people explain events can provide unique insight into their understanding of how the world works. By age 2 years, children often seek explanations in their everyday conversation, and the proportion of children's speech that pertains to

explanation increases significantly during the preschool years (Hickling & Wellman, 2001). Preschoolers also are sensitive to whether adults' responses to their questions contain explanatory information. For instance, young children prefer statements that contain causal information to statements of equal length with no causal information (Frazier, Gelman, & Wellman, 2009), and they prefer noncircular to circular explanations (Corriveau & Kurkul, 2014). In addition to seeking explanations, young children are adept at providing them. Analysis of preschoolers' everyday conversations indicates that they are quite sophisticated at pairing an entity (e.g., person, animal, or object) with an appropriate domain of explanation (e.g., psychological, biological, or physical; Hickling & Wellman, 2001).

Even very young children are aware of the types of events that are most in need of explanation, namely those that are inconsistent with expectations. Legare, Gelman, and Wellman (2010) familiarized preschoolers with two objects that produced two different outcomes when placed on a light box. After a confirmation trial in which the objects displayed these outcomes, children observed a test trial in which one of the objects produced the expected outcome, while the other object produced an outcome that was inconsistent with expectations. When asked, “Why did that happen?” children were significantly more likely to offer an explanation for the inconsistent outcome than for the consistent one.

This raises the question of whether children's recognition of the fact that inconsistent events need explaining leads them to generate different sorts of explanations for them than they would generate for consistent ones. The focus of the present study is how children and adults explain everyday life events that vary in consistency with knowledge about how the world works. Many life events are entirely consistent with our understanding of how the world works (e.g., a record-high temperature in August), whereas other events, although consistent

Electronic supplementary material The online version of this article (doi:10.3758/s13423-016-1127-1) contains supplementary material, which is available to authorized users.

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with this understanding, violate expectations about how the world usually is and therefore are unexpected or unusual. These include, for example, low probability physical events (e.g., snow falling in July) or biological events (e.g., a sudden medical recovery), or deviations from social norms (e.g., a boy wearing a dress). In addition, we occasionally encounter events or reports of events that appear to violate our understanding (e.g., we read in a tabloid about a baby coming back from the dead). We encounter such violations in a variety of contexts, including books, television, the Internet, and in the fanciful and deceptive testimony of others.

Research shows that, from a young age, children's explanations for mundane events reflect a sophisticated sensitivity to natural forces. For example, research by Wellman and colleagues (Wellman, 1990; Wellman & Liu, 2004) shows that, if asked to explain why a person is looking for her cat under her bed, children will refer to the person's mental state (e.g., she wanted her cat and thought the cat was under there). In contrast, if explaining why a particular person got sick after being sneezed on, children will explain how germs cause illness, thus, in this case, appropriately using a biological explanation for a biological phenomenon (Kalish, 1996).

But what happens when events deviate from these expected patterns, that is, when events are slightly, or even wildly, inconsistent with our expectations? This research is somewhat scarcer but indicates that young children often offer a variety of supernatural explanations for these sorts of events. One line of research indicates that, when children are faced with events that violate their expectations, they appeal to magic or magical forces (Phelps & Woolley, 1994; Subbotsky, 1993). Other research has shown that children appeal to miracles to explain unlikely events (Woolley & Dunham, *in press*). Research by Woolley, Cornelius, and Lacy (2011) shows that children even make distinctions within the realm of supernatural explanations, favoring particular types of explanations for particular types of events. They told 8- to 12-year-old children and adults about unusual events designed to prime three types of supernatural explanations: luck, moral justice, and God. For example, a bad luck event involved an athletic woman tripping at her wedding, and a moral justice event involved a kind-hearted man finding money on the sidewalk. They found that children's supernatural explanations were specific to the primes; for example, they cited bad luck as the cause of the woman tripping, and karma as responsible for the kind man finding money.

Our goal in the present study was to explore whether the consistency between events and world knowledge affects the use of natural versus supernatural explanations. We sought to improve on previous research in two ways. First, we used events that were based on real events that children generated in a previous study and thus were expected to be familiar to children. The items used by Woolley et al. involved adult-centric events that may have been unfamiliar to children

(e.g., a woman tripping at her wedding). A number of previous studies have shown positive effects of familiarity on cognition, including social reasoning (Davidson, Turiel, & Black, 1983), recall of action sequences (Bauer & Shore, 1987), and sentence repetition (Bannard & Matthews, 2008). Thus, we expected that increasing the familiarity of the events would produce more accurate information about children's reasoning. Second, all the events in Woolley et al. were improbable or unusual; instead, we included a range of events to enable us to explore how children explain different types of events and whether the possibility of an event affects the types of explanations children generate.

We expected that, as shown in previous research, both children and adults would provide natural explanations for mundane events, so the critical question was whether children also would do so for events that were unlikely or unusual and for events that were extraordinary. That is, would children's explanations vary according to the possibility of the event? One prediction, based on previous research (Woolley & Dunham, *in press*; Phelps & Woolley, 1994), is that children will explain improbable and extraordinary events by appealing to magic and miracles. This would lead us to expect predominantly supernatural explanations for these sorts of events. At the same time, Woolley et al.'s (2011) research indicates that although children sometimes do use supernatural explanations for unusual events, they also often use natural explanations for these same sorts of events. Woolley et al. also report that the use of supernatural explanations increases with age. Thus, we might expect a mix of natural and supernatural explanations, with increasing use of supernatural explanations with age.

Previous research (Cook & Sobel, 2011; Nolan-Reyes, Callanan, & Haigh, 2016; Shtulman & Carey, 2007; Shtulman & Yoo, 2015) suggests that the patterns we observe also might depend upon children's understanding of the possibility of improbable events. Shtulman and Carey (2007), for example, asked children about the possibility of ordinary events (e.g., eating an apple), improbable events (e.g., eating pickle-flavored ice cream), and impossible events (e.g., eating lightning). Adults in their studies judged both the ordinary and improbable events as possible, yet children between the ages of 4 and 8 years were significantly less likely to do so. Recognition of the possibility of improbable events increased between the ages of 4 and 8 years; however, older children still judged many of the improbable events as impossible. This might lead us to expect that children younger than 8 or 9 years will not judge or explain merely unusual events differently from impossible ones. However, the events used by Shtulman and Carey and others (Nolan-Reyes, Callanan, & Haigh, 2016; Shtulman, 2009), although involving child protagonists, were far removed from children's everyday experience (e.g., painting polka dots on an airplane). We expected that our use of familiar everyday events would lead to earlier recognition of the possibility of unusual or improbable events,

and thus we also expected that children younger than 8 or 9 years would judge and possibly also explain these events differently from extraordinary ones.

A final goal of our research was to probe developmental differences in the extent to which people feel the need to have an explanation for an event. Adults often feel uncomfortable when they lack an explanation (Gopnik, 1998). Children are less in control of their everyday schedules than are adults—they don't know why they go to one school versus another, why their family has spaghetti every Sunday, etc. Thus, it seemed conceivable that events might seem to “just happen” to children more so than to adults and that children could potentially be more comfortable with the idea that not all events have explanations.

Method

Overview

Our primary focus was participants' explanations for events that vary in their possibility. However, because we expected the events we used to lead to earlier understanding of the possibility of the improbable events than has been found in previous studies, we first solicited children's reality status judgments for the events. We then used two methods to assess how participants explained the events: (1) We solicited spontaneous explanations; and (2) We asked participants to rate the three types of explanations that have been shown in previous research to be used most often to explain improbable and extraordinary events: natural explanations, appeals to luck, and appeals to God and/or miracles. We included the rating task, because we expected that spontaneous appeals to luck and God/miracles might be rare but still wanted to obtain some measure of what participants thought of these explanations. Because we also were interested in developmental differences in reactions to the idea that an event might defy explanation, we asked participants to rate the idea that there was no explanation for each event.

Participants

Participants were 24 5-year-olds ($M = 5$ years, 7 months, range = 5.1–5.11; 13 females), 35 6-year-olds ($M = 6$ years, 4 months, range = 6.0–6.11; 22 females), 43 7-year-olds ($M = 7$ years, 4 months, range = 7.0–7.10; 27 females), 48 8-year-olds ($M = 8$ years, 3 months, range = 8.0–8.10; 26 females), 31 9-year-olds ($M = 9$ years, 5 months, range = 9.0–10.0; 17 females), and 60 adults ($M = 19$ years, range = 18–46 years; 35 females). Children were recruited from a participant database at a large southwestern university in the United States. The sample included children from primarily middle-class White, Hispanic, and Asian families. Children were tested

individually in a 30-minute session and received a small toy at the end. Adults were recruited from an introductory psychology subject pool at the same university and received class credit.

Materials

Materials consisted of six stories with colored line drawings of child characters. There were three types of story: mundane, improbable, and extraordinary (see Appendix A for a sample story; the complete set of stories is included in the Supplemental Materials). The stories were created by taking six events from Woolley and Dunham (in press) that a group of children had reported as being personally experienced miracles and creating three versions of each: mundane, improbable, and extraordinary (Table 1). As shown in Appendix A, the three stories were identical with the exception of two to three sentences in the middle. These sentences established each event as mundane, improbable, or extraordinary. Participants received two stories of each type plus two fantastical stories that were included to break potential response sets (one about a child who traveled back in time and one about a child who wished for and obtained a dinosaur).

Procedure for children

Children made reality status judgments about and explained each type of story. The original intent was that all children would receive two instances of each story type. However, pilot testing of 5- and 6-year-olds indicated that very few children this age were able to complete the task. Thus, 5- and 6-year-olds received only one story of each type.

There were three tasks: (1) the *Reality Status task*, in which children were asked to judge whether each event could happen in real life; (2) the *Spontaneous Explanation task*, in which children were asked to explain how the focal event in each story happened; and (3) the *Explanation Rating task*, in which children were asked to rate four explanations purportedly provided by other participants. For the explanation-rating task, participants were told that they would hear some other children's ideas about what had happened and they were to state whether they agreed or disagreed with each explanation. Children heard four explanations: (1) *luck*, in which the outcome of the event was attributed to luck (e.g., “Jordan said it was because Elizabeth was a lucky person—she had really good luck that day.”); (2) *miracle*, in which the outcome was attributed to God (e.g., “Cameron said it was a miracle – that God made it happen.”); (3) *natural*, in which the outcome was said to be due to natural causes (e.g., “Michelle said it was because all that sleeping made the dog better” for the mundane and improbable stories, or “Michelle said that the vet made a mistake—Jackson wasn't really dead” for the

Table 1 Abbreviated versions of stories presented to participants

Mundane	Improbable	Extraordinary
Vase story		
Boy bumps vase. Returns it to shelf. Mom doesn't notice.	Vase breaks in 4 pieces. Boy fixes. Mom doesn't notice.	Vase breaks into many tiny pieces. Boy hides behind couch. When he looks up, the vase is fixed.
Illness story		
Boy sick. Takes medicine. Boy recovers.	Boy very sick. Takes rare drug that works for some people but not others. Boy recovers.	Boy very sick. No one has ever recovered from this illness. No drugs available. Boy recovers.
Skateboarding story		
Girl bruises arm. Is fine.	Girl injures arm. Arm heals in half the expected time.	Girl injures arm. X-ray shows it is broken. Casted. Heals overnight.
Dog story		
Dog gets loose. Runs around a lot. Is fine.	Dog hit by car, severely injured. Sleeps a lot. Recovers.	Dog hit by truck. Vet finds no heartbeat and pronounces dead. Recovers.
Book story		
Girl gets book from desk at library.	Girl unable to find book one day. Book is at front desk the next day.	Girl is at front desk. Closes her eyes for a minute. When she opens her eyes the book appears.
Ice cream story		
Boy wants ice cream. No ice cream at home. Finally buys it at store.	No ice cream at home. Goes to bed. The next morning there is ice cream.	No ice cream at home. Goes to bed. Gets up a few minutes later and finds ice cream.

extraordinary stories.); and (4) *no explanation*, in which the other child said there was no explanation for the outcome (e.g., “Morgan said that it's really hard to explain—there is no way to explain it.”).¹ For each explanation, children indicated their level of agreement using a Likert Scale; 4 represented “completely agree,” 3 represented “agree a little,” 2 represented “disagree a little,” and 1 represented “disagree a lot.” Explanations for all stories can be found in the [Supplemental Materials](#).

Participants first judged the reality status of the focal event in each of the stories. After this, with the exception of the two fantasy stories, we reminded them of the focal event of each story and then solicited explanations for each event. To avoid having our explanations in the rating task bias children's

spontaneous explanations, all spontaneous explanations were solicited before proceeding to the rating task. Stories were presented to each child in a random order created by shuffling the cards, with the constraint that the fantastical stories were always in the third and fifth positions for the older participants and in the second position for the 5- and 6-year-olds. These two stories, which we were quite certain children would claim could not happen in real life, were inserted in these positions to break potential positive response sets. On the rating task, each explanation was presented in each position (first, second, third, or fourth) an approximately equal number of times for each story type.

Procedure for adults

Stories were presented in random orders generated in Qualtrics. For the Reality Status task, adults read the stories and were asked to state whether they thought each event could really happen. They then read each story again and provided an explanation for the focal event. Finally, they read the purported explanations given by other participants and rated those on a scale of 4 (completely agree) to 1 (completely disagree).

Explanation coding Participants' explanations were categorized into three primary categories: (1) *Natural*, in which the participant referred to a physical or biological process (e.g., “I think that the body parts fought the disease...and then when he woke up he felt better”); (2) *Supernatural*, in which the participant referred to magic or a magical process (e.g., “There was magic and it just made the vase go back together”) or to God and/or miracles (e.g., “Well, I think that it was just a miracle from God”); and (3) *Dispute*, in which the participant disputed that the event really occurred (e.g., “The doctors were wrong”). Two-thirds of the explanations were coded by a second coder. Reliability (calculated as number of agreements divided by number of agreements plus number of disagreements) was 99 %.

Results

Overview

Because 5- and 6-year-olds received one story of each type, separate nonparametric analyses were conducted for these youngest children for both the Reality Status and the Spontaneous Explanation tasks. For these two tasks, these analyses are presented first for the 5- to 6-year-olds, with the results for the 7- to 9-year-olds and adults following. Because ratings were the dependent variable for the Explanation Ratings task, all age groups were included in those analyses.

¹ In order to provide a natural explanation for an extraordinary event, a component of the event was disputed. All of the disputes involve natural processes, with the majority referring to human error (e.g., “the vet made a mistake”) or psychological processes (e.g., “he just imagined it”).

Reality status task

Five- and 6-year-olds Judgments that the events could happen were scored as 1; responses that they could not were scored as 0. The majority of 5- and 6-year-olds claimed that both mundane ($M = 0.76$, $SD = 0.43$) and improbable ($M = 0.76$, $SD = 0.43$) events could happen at levels significantly greater than chance, both t 's (62) = 4.84, $p < 0.001$, but were at chance regarding extraordinary events ($M = 0.47$, $SD = 0.50$). Because participants received one story of each type, yielding a dichotomous outcome variable, binary logistic regression was conducted to assess effects of age and story type on children's judgments. Only story type was significant, Wald = 45.73, $p < 0.001$. Follow-up analyses indicated that children judged mundane and improbable events similarly, but judged both mundane, $\chi^2(1) = 9.63$, $p = 0.002$, and improbable, $\chi^2(1) = 9.63$, $p = 0.002$, events as possible more often than extraordinary events.

Older participants Judgments that the events could happen were scored as 1; responses that they could not were scored as 0. Responses were averaged across the two instances of each story type. The majority of older participants claimed that both mundane ($M = 0.89$, $SD = 0.24$, $t(180) = 21.40$, $p < 0.001$) and improbable events ($M = 0.78$, $SD = 0.33$, $t(179) = 11.65$, $p < 0.001$) could happen at levels significantly greater than chance and also judged that extraordinary events ($M = 0.38$, $SD = 0.40$) could not happen at levels significantly below chance, $t(179) = -4.01$, $p < 0.001$. A 4 (age: 7, 8, 9, adult) $\times$ 3 (story type: mundane, improbable, extraordinary) repeated measures ANOVA revealed main effects of story type, $F(2,350) = 123.66$, $p < 0.001$, and age, $F(3,175) = 11.63$, $p < 0.001$. Participants were more likely to judge that mundane events could happen than improbable events could and that both of these could happen more often than extraordinary events, all p 's < 0.001 . Adults ($M = 0.80$, $SD = 0.23$) were more likely to say overall that the events could really happen than any group of children (7-year-olds $M = 0.62$, $SD = 0.19$; 8-year-olds $M = 0.62$, $SD = 0.20$; 9-year-olds $M = 0.63$, $SD = 0.17$; all significant by t test at $p < 0.001$).

Spontaneous explanations

Five- and 6-year-olds Five- and 6-year-olds were more likely to offer natural explanations (61 %) than all other types of explanation. They also were more likely to dispute that the events occurred (12 %) than they were to offer miracle (3 %) or magic (3 %) explanations. Although spontaneous use of supernatural explanations was rare, the number of participants who provided at least one supernatural explanation (miracle or magic; 17 % of the children) varied by story type, with no children providing supernatural explanations for mundane, 1 for improbable, and 10 for extraordinary events ($p < 0.01$ for

the comparisons between extraordinary and both mundane and improbable events).

Inspection of Figs. 1 and 2 indicates that children's explanations varied according to the type of event they were explaining. We conducted a repeated measures logistic regression on children's explanations to assess the effects of age, story type, and explanation type. Results indicated significant effects of explanation type, Wald = 40.98, $p < 0.001$, and story type, Wald = 13.42, $p < 0.001$, and an explanation type $\times$ story type interaction, Wald = 15.64, $p < 0.001$. Cochran's Q test confirmed that 5- to 6-year-olds were more likely to volunteer a natural explanation for the mundane (73 %) than for the extraordinary event (49 %), $\chi^2(1) = 2.84$, $p = 0.005$. They also were more likely to use a supernatural explanation (16 %) to explain the extraordinary event than either the mundane (0 %), $\chi^2(1) = 3.87$, $p < 0.001$, or the improbable event (2 %), $\chi^2(1) = 3.49$, $p < 0.001$. Children were equally likely to dispute all three events (11 %).

Older participants Figures 1 and 2 also indicate that older participants' explanations varied by story type as well. A 4 (age) $\times$ 3 (story type) $\times$ 3 (explanation type) repeated measures ANOVA was conducted on the mean number (out of 2) of each type of explanation offered. This revealed a significant main effect of explanation type, $F(2,1032) = 559.23$, $p < 0.001$, $\eta_p = 0.77$, with older participants also overwhelmingly providing natural explanations ($M = 1.36$, $SD = 0.42$) more often than supernatural ($M = 0.13$, $SD = 0.25$) and dispute ($M = 0.21$, $SD = 0.26$) explanations. There also were significant interactions between explanation type and age, $F(6, 576) = 4.32$, $p < 0.001$, $\eta_p = 0.07$, between story type and age, $F(6, 336) = 3.39$, $p = 0.003$, $\eta_p = 0.06$, and between explanation type and story type, $F(4, 672) = 52.09$, $p < 0.001$, $\eta_p = 0.24$. These were subsumed by the three-way interaction, $F(12, 672) = 6.44$, $p < 0.001$, $\eta_p = 0.10$.

We explored the three-way interaction by assessing whether participants of each age explained the three types of events differently. Regarding natural explanations, participants of different ages displayed similar but slightly different patterns of usage across the three different story types. As shown in Fig. 1, adults used natural explanations most often for mundane ($M = 2.00$, $SD = 0.00$), less often for improbable ($M = 1.72$, $SD = 0.52$), and least often for extraordinary events ($M = 1.03$, $SD = 0.58$; see Table 2 for statistical values).² Seven-year-olds provided natural explanations significantly more often for improbable ($M = 1.49$, $SD = 0.69$) events than for extraordinary events ($M = 0.95$, $SD = 0.74$). Eight- and 9-

² The high proportion of natural explanations for extraordinary events appears to be due to a number of participants essentially reinterpreting events so they could be given a natural explanation. For example, for the book that appeared after the girl closed her eyes, one participant reported that, "Someone put it in front of her" and another replied, "Someone happened to return the book at that very moment."

Fig. 1 Percentage of natural explanations by age and story type

year-olds offered natural explanations more for mundane (8-year-old $M = 1.64$, $SD = 0.61$; 9-year-old $M = 1.68$, $SD = 0.65$) than for both improbable (8-year-old $M = 1.23$, $SD = 0.80$; 9-year-old $M = 1.32$, $SD = 0.70$) and extraordinary (8-year-old $M = 0.98$, $SD = 0.79$; 9-year-old $M = 1.03$, $SD = 0.80$) events.

Similar to the youngest children, spontaneous use of supernatural explanations among older children and adults was rare, and there were no age differences in their overall use. There also was no interaction between age and story type; use of supernatural explanations varied by story type consistently across all ages. As shown in Fig. 2, participants of all ages spontaneously volunteered supernatural explanations most for extraordinary events ($M = 0.27$, $SD = 0.04$), less for improbable events ($M = 0.09$, $SD = 0.03$; $t(171) = 4.92$, $p < 0.001$), and least for mundane events ($M = 0.02$, $SD = 0.01$; $t(171) = 6.41$, $p < 0.001$ for extraordinary vs. mundane events, and $t(171) = 3.05$, $p = 0.003$ for improbable vs. mundane events). The number of participants who provided at least one supernatural explanation also varied significantly by story type: 2 participants provided supernatural explanations for mundane, 16 for improbable, and 60 for extraordinary events, all p 's < 0.001 .

Participants also occasionally disputed the events. Adults disputed extraordinary events most often ($M = 0.78$, $SD = 0.67$), disputed improbable events less often ($M = 0.02$, $SD = 0.13$), and disputed mundane events least often ($M = 0.00$,

Fig. 2 Percentage of supernatural explanations by age and story type

Table 2 Statistical values for spontaneous natural explanation comparisons

Age	Story type	<i>t</i>	<i>df</i>	<i>p</i> value ^c
7 ^a	Mundane vs. improbable	−1.74	36	0.27
	Mundane vs. extraordinary	2.02	36	0.15
	Improbable vs. extraordinary	3.42	36	0.006
8 ^b	Mundane vs. improbable	3.74	43	0.00
	Mundane vs. extraordinary	4.93	43	0.00
	Improbable vs. extraordinary	1.71	43	0.28
9 ^c	Mundane vs. improbable	2.79	30	0.027
	Mundane vs. extraordinary	4.76	30	0.00
	Improbable vs. extraordinary	1.79	30	0.25
Adult ^d	Mundane vs. improbable	4.19	59	0.00
	Mundane vs. extraordinary	12.88	59	0.00
	Improbable vs. extraordinary	7.08	59	0.00

^a Main effect of story type: $F(2, 72) = 6.73$, $p < 0.002$, $\eta_p = 0.16$

^b Main effect of story type: $F(2, 86) = 12.99$, $p < 0.001$, $\eta_p = 0.23$

^c Main effect of story type: $F(2, 60) = 10.30$, $p < 0.001$, $\eta_p = 0.26$

^d Main effect of story type: $F(2, 118) = 75.91$, $p < 0.001$, $\eta_p = 0.56$

^e Bonferroni-corrected

$SD = 0.00$; see Table 3 for statistical values). Seven-year-olds did not dispute the three types of events at different rates, whereas 8-year-olds disputed both extraordinary ($M = 0.23$, $SD = 0.48$) and improbable ($M = 0.23$, $SD = 0.52$) events more often than mundane events ($M = 0.02$, $SD = 0.15$). Nine-year-olds very rarely disputed any events.

In summary, both children and adults offered primarily natural explanations for all the events. However, they also explained events differently depending on their possibility.

Table 3 Statistical values for spontaneous dispute explanation comparisons

Age	Story type	<i>t</i>	<i>df</i>	<i>p</i> value ^c
7 ^a	Mundane vs. improbable	−0.33	36	2.32
	Mundane vs. extraordinary	−2.37	36	0.069
	Improbable vs. extraordinary	−2.17	36	0.11
8 ^b	Mundane vs. improbable	−2.45	43	0.054
	Mundane vs. extraordinary	−2.94	43	0.015
	Improbable vs. extraordinary	0.00	43	3.00
9 ^c				
Adult ^d	Mundane vs. improbable	1.00	59	0.03
	Mundane vs. extraordinary	9.11	59	0.00
	Improbable vs. extraordinary	9.17	59	0.00

^a Main effect of story type: $F(2, 72) = 4.11$, $p = 0.02$, $\eta_p = 0.10$

^b Main effect of story type: $F(2, 86) = 3.42$, $p = .04$, $\eta_p = .07$

^c No main effect of story type

^d Main effect of story type: $F(2, 59) = 81.96$, $p < .001$, $\eta_p = .58$

^e Bonferroni-corrected

Table 4 Explanation ratings: comparisons to neutral midpoint

	Age group					
	5	6	7	8	9	A
Mundane						
Miracle	2.8	2.4	2.3	2.1	2.1	1.9
Luck	2.7	2.5	2.4	2.3	2.4	2.0
Natural	3.0^a	2.9	3.9	3.3	3.1	3.8
No explanation	2.6	2.2	2.3	1.7	1.6	1.4
Improbable						
Miracle	3.3	2.6	2.5	2.2	2.3	2.1
Luck	2.8	2.9	2.7	2.4	2.2	2.0
Natural	3.3	3.1	3.3	3.1	3.2	3.7
No explanation	2.4	2.5	2.5	1.9	1.9	1.5
Extraordinary						
Miracle	2.8	2.8	2.7	2.3	2.4	2.1
Luck	2.4	3.2	2.9	2.3	2.4	2.1
Natural	— ^b	—	—	—	—	—
No explanation	2.5	2.6	2.4	2.0	2.1	2.1

^a Values in bold indicate significant agreement or disagreement (values significantly different from mean of 2.5 by *t* test)

^b Because the natural explanation for impossible events was actually a disputation, we don't include statistics for these cells

Children of all ages used natural explanations more for mundane than for extraordinary events and, conversely, used supernatural explanations more for extraordinary than for mundane events. Whereas the youngest children (5- to 7-year-olds) did not attend to differences between the events in their decision to dispute them, 8-year-olds and adults did, disputing extraordinary more than mundane events.

Explanation ratings

Participants rated each type of explanation on a scale of 1 to 4, with 4 indicating highest agreement. For the older participants, ratings were averaged across the two instances of each story type. To assess general patterns of endorsement or rejection of the explanations across ages, we compared ratings for each age group by story and explanation type to 2.5 (the midpoint on the Likert scale; Table 4). Values significantly above 2.5 represent endorsement of the explanation; values significantly below represent rejection. A number of developmental patterns emerged. Five-year-olds agreed with *natural* explanations for both mundane and for improbable events, and with *miracle* for improbable events, but were at chance for all other explanation types. Six-year-olds similarly agreed with *natural* explanations, and additionally agreed with *luck* explanations for improbable and extraordinary events, but not for mundane events. Seven-year-olds showed the same pattern as 6-year-olds but only endorsed *luck* for extraordinary events. Significant disagreement with the

notion that there was *no explanation* for an event did not emerge until age 8, where it was rejected for all events. By ages 8 and 9 years, children agreed with *natural* explanations and additionally disagreed with the *no explanation* response for all events, and disagreed with *miracle* explanations for mundane events. Lastly, adults disagreed with all explanations except *natural* for all events. For all ages, *no explanation* was the least endorsed option overall.

To parallel the analyses of the spontaneous explanations, we collapsed ratings of *miracle* and *luck* explanations into one *supernatural explanations* category and conducted a 6 (age) x 3 (story type) x 3 (explanation type) repeated measures ANOVA on the average ratings, which revealed a significant effect of explanation type, $F(2, 448) = 114.57, p < 0.001, \eta_p = 0.35$. Consistent with findings from the spontaneous explanation task, participants agreed most strongly with *natural* explanations ($M = 3.08, SD = 0.69$) compared with both *supernatural* explanations ($M = 2.37, SD = 0.70$) and *no explanation* ($M = 2.12, SD = 0.88$), all p 's < 0.001 . There were also significant main effects of story type, $F(2, 448) = 6.41, p = 0.002, \eta_p = 0.03$ and age, $F(5, 224) = 5.47, p < 0.001, \eta_p = 0.11$; these effects were subsumed by an age x explanation type interaction, $F(10, 448) = 11.55, p < 0.001, \eta_p = 0.21$, and an interaction between explanation type and story type, $F(4, 896) = 19.15, p < 0.001, \eta_p = 0.08$. Finally, there was a trend toward a three-way interaction between explanation type, age, and story type, $F(20, 896) = 1.54, p = 0.06, \eta_p = 0.03$.

We explored these interactions by examining whether participants of each age group rated explanations for the three story types differently. (Because the *natural* explanation for the extraordinary stories was actually a disputation, we did not explore story type comparisons for ratings of *natural* explanations.) *Supernatural* explanations were rated uniformly low across age and story type, although ratings decreased significantly with age, $F(5, 231) = 9.20, p < 0.001, \eta_p = 0.13$, with the three youngest age groups (5-, 6-, and 7-year-olds) rating them higher than adults, all p 's < 0.01 by Scheffe tests. Six-year-olds rated *supernatural* explanations higher for extraordinary ($M = 3.00, SD = 0.73$) than for mundane events ($M = 2.38, SD = 1.02, t(37) = 3.41, p = 0.006$)³ and tended to do so for improbable events ($M = 2.65, SD = .98, t(37) = 2.46, p = 0.057$). Seven-year-olds also rated supernatural explanations higher for extraordinary ($M = 2.83, SD = 0.70$) than for mundane events ($M = 2.33, SD = 0.70; t(38) = 2.86, p = 0.021$). Eight- and 9-year-olds and adults rated supernatural explanations similarly for the three types of events.

Participants also rated *no explanation* very low across age and story type, although rating levels also differed by age, $F(5, 226) = 7.33, p < 0.001, \eta_p = 0.14$, with 5- to 7-year-olds rating it higher than adults, p 's < 0.02 by Scheffe tests. The youngest children (5- through 7-year-olds) rated *no explanation*

³ p values for t tests are Bonferroni corrected.

similarly across story types, whereas the older children and adults rated it differently for the different events. Eight-year-olds rated *no explanation* higher for extraordinary events ($M = 2.05$, $SD = 1.03$) than for mundane events ($M = 1.68$, $SD = 0.81$; $t(42) = 3.20$, $p = 0.009$), as did 9-year-olds (for extraordinary events $M = 2.13$, $SD = 0.91$, and for mundane events $M = 1.60$, $SD = 0.61$; $t(29) = 3.28$, $p = 0.009$). Adults also rated *no explanation* higher for extraordinary events ($M = 2.07$, $SD = 0.88$) than for mundane events ($M = 1.37$, $SD = 0.58$, $t(59) = 5.97$, $p < 0.001$) but also rated it higher than for improbable events ($M = 1.47$, $SD = 0.63$, $t(59) = 4.96$, $p < 0.001$). It is important to note that, although participants rarely offered supernatural explanations spontaneously, they consistently rated both *luck* ($M = 2.40$, $SD = 0.82$) and *miracle* ($M = 2.45$, $SD = 0.90$) higher than *no explanation* ($M = 2.02$, $SD = 0.88$), $t(237) = 4.63$, $p < 0.003$ for *miracle* vs. *no explanation*, and $t(237) = 6.32$, $p < 0.003$ for *luck* versus *no explanation*. This suggests that, for most participants, even an explanation that they normally would not endorse very strongly was better than no explanation at all.

In summary, results from the explanation ratings revealed two particular developmental patterns. First, comparisons to chance indicated emerging differences in the acceptance and rejection of the various explanations. The first explanations that children endorsed at greater than chance levels were *natural* and *miracle*, at age 5 years, and the next was *luck* at age 6 years. The first to be significantly rejected were *no explanation* and *miracle*, at age 8 years. Adults endorsed *natural* explanations and rejected all others. Second, story type comparisons indicated that ratings of both *supernatural* explanations and *no explanation* varied by the possibility of the events, but displayed different developmental patterns: younger children rated *supernatural* explanations differently for different events, whereas older children and adults did not. We observed the reverse pattern for *no explanation*: whereas younger children did not rate these differently across story types, older children and adults did.

General discussion

Our primary goal was to explore how children and adults explain events that vary in their consistency with the way the world works, with special attention to events that are improbable or extraordinary. Our findings provide insight into how both the possibility and familiarity of an event affect the use and evaluation of both natural and supernatural explanations.

Use of natural versus supernatural explanations

Both children and adults primarily generated natural explanations for all three types of events. This was expected regarding mundane events (Hickling & Wellman, 2001). Regarding

improbable events, participants of all ages preferred natural explanations to supernatural ones. However, unlike in previous research (Woolley, Cornelius, & Lacy, 2011), supernatural explanations did not increase with age, and the ratings of supernatural explanations were significantly lower in adults than in children of all age groups. What accounts for the differences between these findings? One possible explanation is that Woolley et al. used events that were adult-centric, for example, a man crashing a car shortly after stealing money from his company. Although these were events that adults would clearly find unusual, it is not readily apparent that children, especially younger ones, necessarily found them equally unusual or improbable. These events are unusual to adults because of the close conjunction of the two sub-events: stealing money from one's company is generally unsurprising in and of itself, as is crashing a car. But crashing one's car right after stealing money catches our attention and primes supernatural explanations like karma (Pepitone & Saffioti, 1997; Woolley, et al., 2011). An increase with age in recognizing the unusual nature of the conjunction of those events may have been at least partly responsible for the increase in supernatural explanations with age in that study.

A second related consideration is that the events used by Woolley et al. (2011) were written with the aim of priming certain supernatural beliefs (e.g., karma). It may be that the development toward increasing supernatural explanations with age in that study was due to older children and adults being better at recognizing those primes and responding accordingly, rather than to increased belief. Finally, a third possibility is that our study is unique in asking participants to explain how the events happened rather than to explain why they could or could not happen. When asked why, people tend to search for ultimate explanations and meaning, whereas when asked how, people tend to seek more proximal explanations pertaining to physical causality (Cornelius & Woolley, 2015; Legare, Evans, Rosengren, & Harris, 2012).

The extent to which participants also used natural explanations for extraordinary events was somewhat surprising. These findings, however, are consistent with other research suggesting that children favor natural explanations. Friedman and Nancekivell (2015) similarly presented children with impossible events, albeit somewhat more magical than ours (e.g., a fairy who had a unicorn for a pet). Despite judging these events as magical, when asked to explain them, children more often generated realistic than magical or supernatural explanations.

Effects of event possibility on judging and explaining events

Our findings also indicate that children's reality status judgments and explanations of events are affected by an event's possibility. A number of previous studies have examined

children's reality status judgments of events varying in their possibility (Cook & Sobel, 2011; Nolan-Reyes, Callanan, & Haigh, 2016; Shtulman & Carey, 2007). Previous research by Shtulman and Carey (2007) found that children have difficulty understanding the reality status of improbable events, tending to judge them as impossible or extraordinary. We reasoned that children's difficulties in this and other studies might have been partly due to the improbable events being unfamiliar and far removed from children's everyday experience. To facilitate children's reasoning, we used events that children themselves had generated in a previous study. Our findings differ from these previous findings in that children of all ages judged the reality status of improbable and extraordinary events very differently, indicating a clear awareness of improbability.

Our interpretation of these differences is that using familiar contexts facilitated children's judgments. In addition to similar positive effects of using familiar stimuli in other domains (Bannard & Matthews, 2008; Bauer & Shore, 1987; Davidson, Turiel, & Black, 1983), Weisberg and Sobel (2012) also have found that particular contexts facilitate reasoning about the impossible-improbable distinction. They presented 4-year-olds with a story and asked them to say how it might continue. When presented with a story containing multiple improbable events and presented with the choice of continuing it with additional improbable, or instead, impossible events, children selected the former. They suggest that young children do possess an understanding of the distinction between impossible and improbable events but may only be able to express it in supportive contexts. Lopez-Mobilia and Woolley (2016) also observed increased awareness of this distinction in young children. The stimuli in that study were a set of animals ranging in their possibility. Six-year-old children were more likely to claim that improbable novel animals were real than impossible ones and were more likely to seek testimony about reality status when presented with improbable animals than with impossible ones. Animals are a domain with which young children demonstrate high levels of knowledge and familiarity (DeLoache, Bloom Pickard, & LoBue, 2011).

Identifying exactly what makes different sorts of events yield different possibility judgments is an important task for future research. It is possible that by making the events in our study more familiar, we created improbable events that were easier to conceive of, or more conceptually probable, than those used previously. For instance, Shtulman and Carey (2007) selected improbable events that were not only statistically improbable but also events that violated contingent truths. While our events were statistically rare, it could be argued that fewer contingent truths were violated in our events, making them more conceptually probable. An alternative explanation focuses not on the nature of the events themselves but instead on the general context in which children encounter events. Shtulman and Carey (2007) proposed that

children judge improbable events as impossible because they cannot imagine a circumstance that would allow these events to occur. They propose that, if children were provided with such a context, they might reason more like adults. In a sense, we provided such a context, not only by presenting events in familiar settings, but also by telling children that the events had actually occurred. According to Shtulman and Carey, imagining conditions that could cause improbable events is difficult because the possibility space is the entire world, which is too large and ill defined for children to search and find an instance in which the event could occur. In our study, children explained an event that had already happened, in a context that was familiar, which is a much smaller and well-defined space than the entire world of possibilities.

Fewer studies have addressed how children explain events that vary in their possibility. Shtulman and Carey (2007) found that, in line with their reality judgments, children explained impossible and improbable events similarly; however, Nolan-Reyes, Callanan, and Haigh (2016) found that children justified their judgments about impossible and improbable events differently. Our findings are somewhere in-between: children were equally likely to generate natural explanations for extraordinary and improbable events, but they were more likely to use supernatural explanations for extraordinary than for improbable events. This, together with the fact that children judged improbable events as less likely to really happen than extraordinary events presents a nuanced picture of children's reasoning. It appears that, although children judged the reality status of the improbable events differently from the extraordinary ones, whether they explained them differently depended on the type of explanation on which we focused. Natural explanations were applied freely and equivalently across the two types of events. Supernatural explanations, perhaps lacking the same broad appeal, were used more judiciously.

Are some events unexplainable?

We also sought to examine whether there are developmental differences in endorsement of the idea that some events are simply unexplainable. Both adults and children are driven toward finding explanations, and the lack of an explanation has been argued to produce significant cognitive, and possibly even emotional, tension (Gopnik, 1998). Our results revealed developmental differences, such that by age 8 years, children rejected the idea that there was no explanation for a particular event. Five- to 7-year-olds did not exhibit either significant rejection or endorsement of this idea. This transition was rather sudden, with 8-year-olds rejecting this idea consistently across all three-story types. What was particularly striking was that participants consistently rated *luck* and *miracle* explanations higher than *no explanation*, despite almost never endorsing these two types of supernatural explanations

spontaneously. That both children and adults reacted so negatively to the idea that certain events might be unexplainable provides empirical support for the proposals of Gopnik (1998) and others that the drive to explain is a very basic one.

In conclusion, mundane, improbable, and extraordinary events are regularly encountered by both children and adults, whether in their daily lives, in the media, or in the testimony of others. Investigating how people make sense of events that vary in their possibility provides important insight into the explanatory frameworks that both adults and children find most valuable. Our results indicate that children and adults alike find natural explanations the most effective way to make sense of most events. Even when faced with an extraordinary event, rather than generating a nonnatural explanation, participants often distorted the event to facilitate a natural explanation or simply disputed the event's occurrence. Gopnik (1998; see also Keil, 2006; Lombrozo, 2006) argues that humans have a “fundamental explanatory drive” (p. 107), and our findings suggest that this drive prioritizes natural explanations over supernatural ones. The persistence with which both children and adults pursued finding a natural explanation perhaps even argues for a stronger claim—that there is a fundamental drive toward finding natural explanations for events in our world, no matter how unusual. Our findings also indicate that any explanation, even a supernatural one, is better than none at all.

Acknowledgments Jacqueline D. Woolley and Chelsea A. Cornelius, Department of Psychology, The University of Texas at Austin. The authors thank Irene Rodriguez for her leadership on the project, special thanks to Amanda Proctor for being in charge of the adult portion of the project, and to Erin Anderson, Casey Margules, and Katherine Plevka for their roles in data coding and analysis. The authors thank the following students who assisted with data collection: Alexander Almanza, Danielle Bice, Lily Choi, Alexandra Delgado, Mary Grady, Erik Herbst, Michelle Jackson, Melissa Leva, Jasmine Lo, Sean Minns, and Chi Vu. Preliminary results were presented at the biennial meetings of the *Society for Research in Child Development* in April 2015.

Appendix A

Sample Story

Mundane This is Elizabeth. When she was little she got a dog named Jackson. He was a great, fun dog, but one day he got off his leash. **He was loose for 3 hours and was running all around the neighborhood. By the time they caught him and put him in their car, he was so tired he fell right asleep. When they got home to their house though,** he woke up and he was fine! Elizabeth took Jackson into the back yard to play when she got home.

Improbable This is Elizabeth. When she was little she got a dog named Jackson. He was a great, fun dog, but one day he

got off his leash **and got hit by a car. Her family took Jackson to the vet, but the vet said he had serious internal injuries and probably wouldn't live. Jackson stayed at the vet asleep for two whole weeks, and when** he woke up he was fine! Elizabeth took Jackson into the back yard to play when she got home.

Extraordinary This is Elizabeth. When she was little she got a dog named Jackson. He was a great, fun dog, but one day he got off his leash and **got hit by a big truck. Her family took Jackson to the vet, but the vet could not find a heartbeat, and so he told Elizabeth that Jackson was dead. The family decided to take Jackson home to bury him in the back yard. When they got home to their house though,** he woke up and he was fine! Elizabeth took Jackson into the back yard to play when she got home.

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