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Children's Competence or Adults' Incompetence: Different Developmental Trajectories in Different Tasks

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Abstract

Dual-process theories have been proposed to explain normative and heuristic responses to reasoning and decision-making problems. Standard unitary and dual-process theories predict that normative responses should increase with age. However, research has focused recently on exceptions to this standard pattern, including developmental increases in heuristic or intuitive responses. Developmental trends for normative and heuristic responses were investigated for two kinds of causal reasoning (*if-only* and covariation) problems in two experiments. To investigate the role of superstitious thinking in these developmental trends, in both experiments a superstitious element was added to the problem solved by half the participants. In the first experiment, 90 fifth graders, 99 seventh graders, and 153 adults responded to an *if-only* problem. Children performed better than adults, with normative responses decreasing and heuristic responses increasing with age. A superstitious jinx intended to reduce heuristic responses had little effect for all age groups. In the second experiment, 276 fifth graders, 344 seventh graders, and 90 adults responded to a covariation-detection problem. When win-loss ratios were equal, adults performed better than children, with normative responses increasing and heuristic responses decreasing with age. When win-loss ratios were strikingly different, however, even the youngest children were able to solve the problems correctly; participants of all ages responded about equally well. When the normative response required recognizing that a good-luck ritual led to better team performance, participants in all age groups responded skeptically that the ritual had no effect, illustrating belief bias. These results are discussed in terms of dual process theories and the development of heuristic (or intuitive) and analytical processes.

Keywords

dual-process theory; fuzzy-trace theory; cognitive development; counterfactual reasoning; covariation detection; magical thinking

Suboptimal decisions are costly for individuals, families, organizations and society. Even when the stakes are high, such as life and death (Swets, Dawes & Monahan, 2000), errors occur systematically. Decisions made by adults are strongly affected by heuristics and biases (Kahneman, 2003) that are resistant to both formal education and specific training. Milkman, Chugh and Bazerman (2009) asked how decision making can be improved in light of extensive research on errors in decision making and they argued that dual-process approaches offer a useful framework for understanding and improving judgment and decision making. However, the fundamental assumptions of dual-process approaches have come under scrutiny (Evans, 2009; Keren & Schul, 2009). In this article, we argue, and present relevant evidence, that developmental trajectories in important reasoning domains provide crucial evidence about core assumptions of dual-process approaches.

A potential avenue for identifying ways to improve decision making is to investigate its developmental trajectory. Understanding how and when error-prone processes develop may suggest novel interventions that reduce error frequency. Studies of reasoning development, however, have emphasized formal reasoning and have only recently begun to focus on

development of judgment and decision making (Jacobs & Klaczynski, 2005). Recent developmental research has emphasized the surprising competence of young children in decision making tasks, whereas adult research has emphasized incompetence, yielding apparently contradictory conclusions about human judgment and decision making. A comprehensive theory of reasoning must account for adult behavior and its development (Jacobs & Klaczynski, 2005; Reyna & Farley, 2006).

A large corpus of research in decision making has undermined the view of an adult as a rational decision maker capable of maximizing gains and minimizing losses (for a review see Hastie & Dawes, 2010). However, very young children have some correct intuitions about probability (e.g., Reyna & Brainerd, 1994; Schlottmann & Christoforou, 2005). Paradoxically, older children, adolescents, and adults are more likely than young children to commit many reasoning fallacies (Davidson, 1995; Jacobs & Potenza, 1991; Reyna & Ellis, 1994). Classical theories of cognitive development that posit a unidirectional progression from intuitive to formal and abstract reasoning cannot predict these counterintuitive findings.

Standard dual-process theories (Amsel et al., 2008; Evans & Frankish, 2009; Kahneman, 2003) propose two types of mental processes that have different developmental trajectories and involve different brain areas (Houdé et al., 2000; Frank, Cohen & Sanfey, 2009). Some have attributed these processes to two different mental systems (System 1 and System 2 are among the names assigned to these systems); we will adopt Evans's (2009) terminology and simply call them Type 1 and Type 2 processes.

Type 1 processes are fast, automatic, and are cognitively economical. Many Type 1 processes may be described as intrinsic or learned heuristics, and many adult judgment biases are considered to be a consequence of Type 1 heuristic responses. According to standard dual-process theories, intuitive processes are ascribed to Type 1 processes. Although intuitive processes are non-conscious, their products may pop into mind spontaneously resulting in an intuition, such as a conscious impression that is difficult to justify verbally. Connections between intuitive thinking and paranormal beliefs have also been reported (Aarnio & Lindeman, 2005; Epstein, Pacini, Denes-Raj, & Heier, 1996; King, Burton, Hicks, & Drigotas, 2007), and paranormal believers are poor at judging probabilities (Bressan, 2002; Rogers, Davis, & Fisk, 2009). Superstitious beliefs (e.g., black cats and breaking mirrors cause bad luck) are typically seen as prominent examples of irrationality (Gilovich, 1991). In gambling situations, people perceive luck as a real cause of events (Keren & Wagenaar, 1985; Wagenaar & Keren, 1988). People activate good-luck related superstitions via common sayings or actions. For example, Damisch, Stoberock and Mussweiler (2010) found that activation of the superstition "keep your fingers crossed" improved the performance of 51 university students in a motor-dexterity task.

Type 2 processes, in contrast, are slow, deliberate, analytic, engage working memory, and involve formal-logical rules. Both types of processes operate concurrently in problem solving and decision making tasks (Brainerd & Reyna, 2001). Evans (2009) proposes the term Type 3 processes to describe the executive processes required to resolve conflicts between the outcomes of Type 1 and 2 processes. The standard view has been that Type 1 processes persist into adulthood (explaining biases and also correct performance produced by heuristics), but these are evolutionarily old processes that are increasingly displaced (in performance) by more advanced information processing (Type 2 processes) as development proceeds (but see Evans, 2009, for a recent qualifications to this fundamental assumption).

Another dual-process account, fuzzy-trace theory, assumes that two types of processes operate concurrently (as opposed to sequentially) in problem solving and decision making

tasks (Reyna, 2004; Reyna & Brainerd, 1995). The tenets of fuzzy-trace theory integrate evidence from memory, reasoning, and their development. According to this theory, judgments are a function of knowledge (e.g., reasoning competence), representation (i.e., the level of precision of mental representations along a verbatim-to-gist continuum), retrieval (i.e., whether cues in the context prompt retrieval of knowledge), and, last, processing, which is the application of retrieved knowledge to the representation of information in a problem. Processing based on gist representations is intuitive in the sense that it is fuzzy, impressionistic, parallel, and often unconscious (e.g., Reyna, 2012). In contrast to standard dual-process theories, however, intuition in fuzzy-trace theory is not conceived as impulsive or primitive (Reyna, in press; Villejoubert, 2011).

These tenets of fuzzy-trace theory are needed to account for myriad effects that are not predicted by standard developmental or dual-process theories (Reyna, in press; 2012). For example, many experiments have shown that memory for problem information (e.g., the premises in a syllogistic reasoning problem) is stochastically independent of reasoning accuracy, contrary to predictions of standard theories that posit memory dependency (Reyna & Brainerd, 1995). This memory-reasoning relation can be transformed by manipulating reasoners' reliance on verbatim versus gist memory representations of problem information to also produce positive and negative dependency under theoretically predicted conditions (e.g., Reyna & Kiernan, 1994; 1995). Standard theories cannot produce these reversals of the relation between memory and reasoning without adding unmotivated post hoc assumptions. In addition, fuzzy-trace theory predicts specific developmental reversals in judgment and decision making (as well as in memory) owing to the expected greater reliance on gist memory representations with advanced development (Reyna & Ellis, 1994; Reyna & Brainerd, 2011).

Of special relevance to the current research, the ratio concept (competence to know that probabilities are based on ratios) has been shown to be present early in development, but the retrieval of that knowledge depends on cues in the problem (e.g., Reyna, 1991; Reyna & Brainerd, 2008). Although children as young as six correctly judge probabilities based on differing numbers in numerators and denominators of ratios, both children and adults will tend to neglect denominators unless reminded of their importance by strikingly different ratios in which numerators are misleading (e.g., $1/3$ vs. $2/8$; Figure 11.3, Reyna & Brainerd, 1994).

Reliance on representations toward the gist end of the continuum increases with development, as reasoners gain experience with a judgment task. Mature reasoning involves connecting the dots and moving away from the literal (verbatim) stimulus (e.g., Brainerd, Reyna, & Ceci, 2008; Lloyd & Reyna, 2009; Reyna & Lloyd, 2006). Hence, when reasoning biases are based on gist-based intuition, they are predicted to increase with age (e.g., Reyna & Farley, 2006), although some individuals are better able to inhibit such biases than others (Reyna & Mills, 2007). Both verbatim-based analysis of details (e.g., of numerical quantities) and gist-based intuition improve with development according to fuzzy-trace theory (e.g., Reyna & Brainerd, 1994; 2008; Reyna & Kiernan, 1994). Research has shown that such intuitions represent advanced reasoning and, thus, are more likely to characterize the cognition of experts (compared to novices) and adults (compared to children).

Although dual-process theories have been widely accepted within social and cognitive psychology, developmental psychologists have made limited use of standard dual-process theories and more empirical evidence is needed regarding the development of these two types of reasoning processes and their interactions (Klaczynski, 2003). Standard dual-process theories do not describe the developmental course of Type 1 processes whereas fuzzy-trace theory predicts that Type 1 processes develop in parallel with Type 2 processes

(e.g., Reyna & Brainerd, 2008; see also Klaczynski 2000, 2001a); the latter Type 2 processes develop with age at least until late adolescence (Brainerd, Reyna, & Howe, 2009; Daniel & Klaczynski, 2006; Evans, 2008; Evans & Frankish, 2009; Kokis, MacPherson, Toplak, West, & Stanovich, 2002).

The goal of the present research is to examine the development of these two types of processes by constructing problems and manipulating problem characteristics that are expected to bias the type of process employed in decision making. According to dual-process theories, context influences the strength of the representation generated by Type 1 processing. The strength of heuristic representations should increase with age as a consequence of increased experience (Klaczynski, 2000, 2004). As De Neys and Vanderputte (2011) point out, Type 1 thinking develops with age, but how it develops has been scarcely investigated by dual-process theorists.

In previous research the roles of Type 1 and Type 2 processes were assessed indirectly; participants' computational abilities (reflecting the development of Type 2 processes) were measured by standardized tests (e.g., WISC), and the role of Type 2 processes were evaluated through correlations between these abilities and the total number of analytic responses in a series of reasoning problems (e.g., Kokis, et al., 2002). These correlations are unlikely to represent the roles of Type 1 and 2 processes accurately because reasoning problems vary greatly in the extent to which they invoke each type of process. In this research, instead, we examine the developmental course of Type 1 and 2 processes within individual problems.

We employed two problems requiring judgments about causal relationships. A counterfactual-reasoning problem in Experiment 1 required judging the degree to which a protagonist was responsible for a negative outcome, and in these problems adults nearly always give a heuristic response. A covariation-detection problem in Experiment 2 required deciding whether numeric data were evidence of a causal relationship, and in these problems adults generally give analytic responses. We expected to see strikingly different developmental trajectories for these two problems, with the frequency of heuristic responses increasing with age for the counterfactual-reasoning problem and the frequency of normative responses increasing in age for the covariation-detection problem.

Both Type 1 and Type 2 processes may be active when solving a problem, with the processes that Evans (2009) labels Type 3 ultimately determining the response. We also manipulated characteristics of each problem to influence the type of process participants will employ. We know that instructional emphasis on logical reasoning, for example, can be an effective way to encourage Type 2 responses (Agnoli, 1991; Agnoli & Krantz, 1989) and instructional emphasis on speed encourages Type 1 responses (Evans & Curtis-Holmes, 2005). Features of the problem itself may engage, activate, or inhibit either heuristic or analytic reasoning and thereby influence the type of processes that generate the response.

The manipulation we employed in this research was to introduce problem elements intended to invoke superstitious reasoning or magical thinking, characteristic of Type 1 "primitive" thinking (e.g. Nisbett & Ross, 1980). When adults engage in gambling and related probabilistic activities they often employ heuristics. Many people view luck as a causal factor, referring to a lucky day, lucky number, or lucky color (Wagenaar, 1988). Problem elements that invoke this kind of superstitious reasoning can be expected to activate the heuristic system when making judgments or decisions about causality. Little is known about the development of concepts of luck, but we know that it influences adult behavior (André, 2006; Pritchard & Smith, 2004; Teigen, Evensen, Samoilow & Vatne, 1999; Wagenaar & Keren, 1988). In both experiments we manipulated the presence or absence of information

intended to trigger superstitious beliefs related to luck. Its predicted effect depends on the role of luck or superstition in the problem.

Experiment 1: The *If-only* Problem

Counterfactual thoughts concern states of affairs that were once possible but never came to pass. They are thoughts about “what might have been” and they usually emerge when something bad happens or is going to happen. Kahneman and Tversky (1982) observed that when bad things happen people seem to replay or simulate the situation in their minds, seeking ways that the negative outcome could have been different. Consider, for example, a situation in which two men arrive at an airport 30 minutes after the scheduled departure time of their flights. One learns that his flight left on time, whereas the other learns that his flight was delayed and left just five minutes ago.

People generally agree that the man who missed his flight by only five minutes should be more upset, because the modification to reality needed to be on time for the flight is smaller. As Kahneman and Tversky (1982) noted, there is an “Alice-in-Wonderland quality” to counterfactual thinking. Analytic reasoning should recognize that both men had the same outcome, a missed flight, and the time when the flight left is irrelevant. Instead, people apparently evaluate the situation heuristically by considering the magnitude of the change needed to avoid the bad outcome, and a 5-minute delay is easier to avoid than a 30-minute delay.

The Type 2 processes required to reach the normative or analytic response to this problem are relatively simple. Both men acted the same (arriving 30 minutes late) and both experienced the same outcome (missing their flights), so they are similar at the verbatim level. The actions of both men were the apparent cause of the missed flights. One might reasonably conclude that they should feel equally responsible for the outcome and thus equally upset.

Subtle heuristics are involved when concluding that the man who barely missed his flight should be more upset (the *if-only* or IO response). The cognitive processes include thinking of ways that actions might have been altered to change the outcome. Such counterfactual thinking is adaptive (Roese, 1997), helping to avoid bad outcomes in future similar situations. This response also involves a judgment about emotions such as regret or disappointment (Guttentag & Ferrell, 2004; Zeelenberg, 1998). These processes are also characterized as “connecting the dots” (i.e., extracting the gist of events), as opposed to responding to the literal superficial details, such as identical outcomes (e.g., Reyna, 2008). Epstein, Lipson, Holstein and Huh (1992) observed that adult counterfactual thinking appears to be an emotional response mediated by *if-only* reasoning. They also used the terms IO effect, IO phenomenon, and IO response to describe *if-only* thinking and the associated emotional responses. Others have used the term *if-only fallacy* (Klaczynski, 2001b; Morsanyi & Handley, 2008). Participants in Epstein et al. (1992, p. 336) “agreed that they, themselves, as well as most people ... would consider behavior that preceded an unfortunate outcome as more foolish if it involved a near miss, an unusual response, an act of commission, or a free choice that was not present in a matching opposite condition.”

Another option, of course, is to respond that the man who missed his flight by 30 minutes should feel more upset. None of the theories predict this response, and we expected it to occur rarely if at all. We consider this an atypical response, a term used in prior research to describe responses that are uncommon among adults (Klaczynski, 2001b).

Problems that reveal counterfactual thinking require comparing two similar stories in which protagonists experience the same bad outcome but their situations differ on some dimension.

Epstein, Lipson, Holstein, and Huh (1992) studied adult responses to four such problems. One problem was adapted from the airport incident described above in which the protagonists were close to or far from avoiding the bad outcome, and the closest protagonist was judged more foolish. In another problem two people have automobile accidents, one driving an unusual route and the other a routine route, and the driver following the unusual route was judged more foolish. In a third problem two people missed an opportunity to make money due either to an act of commission or omission, and the act of commission was judged more foolish. In the fourth problem one protagonist acts contrary to advice and the other without advice (constrained and unconstrained), and the person who ignored advice was judged more foolish. The normative response to all four problems is no difference in responsibility for the bad outcome because their actions did not cause the outcomes, but only about 20% gave this response; most people gave IO responses and only a few responded atypically.

In Experiment 1 we investigate the developmental trend of the *if-only* effect. There is some disagreement in the literature regarding the age at which children begin to think counterfactually, but recent studies (Beck, Robinson, Carroll, & Apperly, 2006) have shown that children about 5 or 6 years old can acknowledge multiple possibilities and “only by this age can children’s thinking about the future and counterfactual possibilities have the mature quality of speculation about genuinely alternative worlds” (p. 425). Moreover, children 7 or 8 years old appear to understand the essence of regret as well as adults when an alternative outcome is better than an actual event (Guttentag & Ferrell, 2004). Therefore, school age children and adolescents (such as those in the current experiment), would be expected to possess rudimentary competence in if-only reasoning (Reyna, Lloyd, & Brainerd, 2003).

These skills are critical elements of the heuristic processes underlying the non-normative or *if-only* response to counterfactual problems, and these studies suggest that children 8 years or older have at least some of the mental capabilities required to employ these processes. Of course, children have had fewer experiences than adults missing events such as airplane flights, and young children are unlikely to have had experiences in which their own behavior was the recognized cause of missing events. The *if-only* response may depend, in part, on Type 1 processes that retrieve similar experiences from memory.

Morsanyi and Handley (2008) studied the development of heuristic responses to reasoning tasks, including a counterfactual reasoning task, in children ranging from 5 to 11 years old. They constructed an age-appropriate problem in which two boys went camping and put their bikes inside a caravan where they were broken. One boy was told to put his bike on a roof rack instead but didn’t listen, and the other boy received no instructions (a constrained and unconstrained problem). The problem asked which boy made a worse decision or whether it was just bad luck (the normative response). Children in Years 1 and 2 of elementary school made more normative than heuristic responses, children in Years 3 and 4 made both responses about equally often, and children in Years 5 and 6 made more heuristic than normative responses, providing evidence that the choice of IO responses increases during these years of childhood.

The *if-only* response may also require imagining other potential worlds, evaluating their likelihood and emotional content, and making comparisons with the world described in the problem. Younger children may not have fully learned or automated these heuristics, whereas adults practice them as an adaptive strategy (Roese, 1997) for avoiding similar situations in the future. In simpler problems requiring assessment of blame for a bad outcome, very young children do not even consider the actor’s intentions. They assign greater blame to the person who experienced the worst outcome regardless of intention, which is similar to the analytic response in counterfactual problems. For these reasons we

predict that children in elementary school will generally respond analytically, older children will give both heuristic and analytic responses, and adults will generally respond heuristically to *if-only* problems.

We also investigated how a superstitious belief – Type 1 thinking – influences the counterfactual reasoning of both children and adults. Concepts such as good luck and bad luck are strongly related to counterfactual events (Teigen, Evensen, Samoilow, & Vatne, 1999). Events are considered lucky or unlucky when the outcome could easily have been dramatically different (Teigen, 2005). We examined a different element of superstitious thinking, the concept of a jinx that tempts fate, thereby bringing bad luck. This research was conducted in Italy where superstitions are deeply rooted in the culture and well known and believed by children; most Italians (Di Nola, 1993), including adults, are careful to avoid sources of bad luck defined by superstitions. In Experiment 1 the problem presented to some participants included an element suggesting that the bad outcome was foretold, which is widely viewed in the Italian culture as a jinx. If a person suffers a bad outcome after having been jinxed, then superstitious thinking should diminish their responsibility for the outcome and transfer some of that responsibility to the person who caused the jinx. If our participants believe in the power of a jinx, then the presence of such a jinx should reduce the frequency of heuristic responses and increase the frequency of normative responses because the jinxed protagonist has reduced responsibility for the missed event.

Method

Participants—Participants were 90 fifth graders (mean age = 10.55 years, $SD = 0.40$ years), 99 seventh graders (mean age = 12.67 years, $SD = 0.46$ years) and 153 adults (mean age = 23.40 years, $SD = 2.24$ years). Fifth graders and seventh graders were recruited from public schools in the northeast part of Italy; all participants were typically developing children of middle socioeconomic status. Adults were undergraduate students majoring in Psychology at the University of Padova.

Material and Procedure—An *if-only* problem was constructed following the same pattern used by Morsanyi and Handley (2008). The problem presents two sequential stories in which the protagonists experience a negative outcome (missing a train). These stories differ in whether the protagonists could mistakenly be considered responsible for this negative outcome. In one story, the bus to the station was delayed by an accident, and, in the other story, the protagonist takes the bus to the station but discovers too late that it is going to the wrong station. As in Morsanyi and Handley's (2008) study, participants responded by choosing among three alternatives corresponding to the heuristic, atypical, and normative responses. Participants were given one of two versions of this problem: text was added to one version to invoke a superstitious belief that a friend had jinxed the protagonist, and this text was removed from the other version. The problem appeared as follows (translated from Italian to English), with the text intended to invoke a superstitious belief set in brackets:

Marta goes to Rome to visit a friend. On her last day in Rome they take a long walk [and Marta's friend repeatedly kids her by saying, "You're going to miss the train to go home today". Marta laughs in disbelief; her train doesn't leave for many hours]. Later, calmly, they go to catch the bus for the train station, purchase the bus ticket, board the bus, and are reassured to see that everyone has luggage with them. After awhile they realize that the bus is taking much more time than expected, and they ask the bus driver whether they have taken the right bus. They discover that this is the bus to the train station, but to the wrong train station! It is too late to go back and Marta really misses the train!

Now read the next story.

Anna goes to Rome to visit a friend. On her last day in Rome they take a long walk [and Anna's friend repeatedly kids her by saying, "You're going to miss the train to go home today". Anna laughs in disbelief; her train doesn't leave for many hours]. Later, calmly, they go to catch the bus for the train station, purchase the bus ticket, board the bus, and are reassured to see that everyone has luggage with them. After a while the bus stops and they realize that an accident has just happened. It is too late to go back and Anna really misses the train!

What do you think about the two stories? Mark your answer with a cross.

- a. Marta, compared to Anna, could have avoided missing the train: heuristic response
- b. Anna, compared to Marta, could have avoided missing the train: atypical response
- c. Missing the train was not their fault; these things happen: normative response

In a single 20-min session, participants were presented only one version of the problem. Some participants in each age group received the problem version intended to trigger a superstitious belief (54 fifth graders, 58 seventh graders, and 75 adults). The remaining participants (36 fifth graders, 41 seventh graders, and 78 adults) received the problem version without these triggers. Participants were instructed to read the problem carefully, compare the two stories, and choose one of the three responses, taking their time to respond. Fifth and seventh graders performed the task in their classrooms, and adults performed the task at the beginning of a university class lecture.

Results

Figure 1 presents the proportion of each type of response (normative, heuristic, and atypical) for each age group without the jinx and Figure 2 shows the proportions with the jinx. As Figures 1 and 2 show, the proportion of heuristic responses increased with age and the proportion of normative responses decreased with age for both problem versions. Atypical responses were uncommon for both problem versions at all ages.

The results were analyzed using multinomial logistic regression because the dependent variable is polytomous (Agresti, 2007; Yee & Mackenzie, 2002). The results should not be analyzed via the widely used techniques appropriate for continuous scales (Jaeger, 2008). As in logistic regression, one value of the dependent variable is designated as the comparison or reference category. In the analysis, the normative response is the comparison category and both the heuristic and atypical responses are each compared with the normative responses, yielding estimates of the effects of the predictor variables (age and presence of the jinx) on the probabilities of the responses.

The Akaike information criterion AIC (Akaike, 1974; Burnham & Anderson, 2002) was employed as the model-selection method (Myung, Forster, & Browne, 2000; Wagenmakers & Waldorp, 2006). A baseline model was constructed (with all the possible interactions and main effects), and the best-fitting model was defined as the one minimizing the AIC. This approach finds the model that explains the data with a minimum of free parameters; the AIC selection criterion balances between a good fit and a simple model. The best-fitting model was the main effects model, eliminating all interaction effects. We also compared the three age levels by fixing the fifth graders as the reference and comparing seventh graders and adults with the fifth graders.

The best-fitting model is summarized in the left side of Table 1, including the regression coefficients, their standard errors, and the corresponding Z scores. The right side of Table 1 shows the odds ratios, which measure effect size, and their 95% confidence interval (CI). The odds ratios are the antilog (i.e., exponentiated values) of the model coefficients.

The top half of Table 1 compares heuristic and normative responses; both seventh graders ($B = .63$, $Z = 1.98$, $p < .05$) and adults ($B = 1.78$, $Z = 5.86$, $p < .01$) gave significantly more heuristic responses than fifth graders. Adults were far more likely (5.93 times more likely) than fifth graders to give a heuristic response compared to a normative response. Seventh graders were 1.86 times more likely than fifth graders to give a heuristic response compared to a normative response.

The bottom half of Table 1 compares atypical and normative responses; neither seventh graders ($B = .005$, $Z = .01$) nor adults ($B = -.32$, $Z = -.53$) gave significantly more atypical responses than fifth graders.

The jinx had no significant effect on the heuristic versus normative responses ($B = .09$, $Z = .39$), but it significantly reduced the probability of giving an atypical versus normative response ($B = .97$, $Z = 2.02$, $p < .05$). These atypical responses were, however, relatively rare in all conditions.

Discussion

Virtually all theories of cognitive development predict that normative responses increase with age. Regardless of the specific mechanisms responsible for performance (e.g., executive processes, logical reasoning, knowledge and practice, metacognition, and so on), development is typically characterized as progress. Standard dual-process theories, in particular, assume that Type 1 processes are evident early in development and Type 2 processes become more prominent as development progresses (but, again, see Evans, 2009; Reyna et al., 2003, for recent counterexamples). Two patterns of results that were obtained here disconfirmed usual expectations.

First, normative responses to the *if-only* problem decreased with age and heuristic responses increased with age, a pattern that has been called “developmental reversal” in fuzzy-trace theory (e.g., Brainerd, Reyna, & Ceci, 2008; Reyna & Brainerd, 1995). More than half the fifth graders and about half the seventh graders responded that missing the train was not Marta’s fault (the normative response) but a large majority of adults said that Marta was at fault because she could have avoided missing the train (the heuristic response). Other studies have found similar developmental trajectories (decreasing normative responses and increasing heuristic responses) for judgment biases that had previously been studied in adults. For example, Davidson (1995) found that susceptibility to the conjunction fallacy (i.e., judging the probability of a conjunction of events as greater than the probability of either event alone) increased during the elementary-school years. Reyna and Ellis (1994) found that the framing effect (greater risk seeking when the outcome is a possible gain than when the outcome is a possible loss) is not seen in children until they reach the fifth grade. Markovits and Dumas (1999) report that the use of heuristics increases with age when solving transitive inference problems (i.e., $A = B$ and $B = C$, therefore $A = C$) involving friendship relationships, even though the performance that underlies normative inferences is improving over this same age range (Jacobs & Klaczynski, 2002; Klaczynski, 2003; Reyna & Kiernan, 1994). Morsanyi and Handley (2008) found the same age trends of increasing heuristic responses and decreasing normative responses to *if-only* problems with much younger children (ages 5 to 11).

Taken together, their results and ours confirm that the cognitive processes responsible for the heuristic response develop throughout childhood and adolescence. Kahneman and Tversky (1982) suggest that a simulation heuristic is the source of these responses. They argue that adults produce heuristic solutions to *if-only* problems by generating and evaluating scenarios that lead to the observed outcome. The *if-only* problem in this experiment required making judgments about fault and responsibility, which require assessing intentionality (Malle & Knobe, 1997). Mull and Evans (2010) found that the concept of intentionality develops gradually, but by age 10 (the age of our youngest participants) children appear to grasp the mental processes that underlie reasoning, consciousness, and thinking. People grapple with issues of fault and responsibility throughout their lives and develop increasingly sophisticated ways of evaluating them. It is no surprise that adults are more likely to judge someone at fault who could have taken more care to establish the destination of the bus.

Second, magical thinking did not decrease with age as most developmental theories predict. The jinx introduced in half the problems did not have the expected effect of decreasing heuristic responses. Indeed, it had no effect other than to decrease slightly the frequency of the already rare atypical responses. If participants had engaged in magical thinking, the jinx should have interfered with judgments of responsibility by causing some participants to think that the jinx, not the traveler, was at fault. Perhaps this explains the reduction in atypical responses; some participants may have judged a jinx combined with an accident as unavoidable bad luck. Participants' superstitious beliefs apparently had little influence on their reasoning in this *if-only* problem.

Experiment 2: The *Covariation Detection Problem*

In Experiment 1, the heuristic response required generation and comparisons of alternative possible outcomes, that is, judgments involving more than superficial features of the problem. In Experiment 2 we investigate the development of responses to covariation detection problems, with the expectation of a reversal of the developmental trajectories of the normative and heuristic responses obtained in Experiment 1. The normative response to covariation-detection problems requires comparing ratios, whereas the heuristic response involves the well-known numerosity bias, comparing the magnitudes of numerators and neglecting denominators of ratios (see Reyna & Brainerd, 2008, for a review). In contrast to Experiment 1, children faced with a covariation detection problem should be more likely than adults to make heuristic responses.

A covariation problem requires judging the relationship between two dichotomous variables such as the presence or absence of a disease and a symptom. For example, De Neys and Gelder (2009) asked participants to assess the relationship between a new therapy and patients' improvement from depression symptoms given that 10 of 16 people improved who received a new therapy and 6 of 8 people improved who received a traditional therapy. These problems are often presented in a 2×2 contingency table, as shown in Table 2. The normative response, of course, requires relatively complex Type 2 processing, comparing the ratio 10/16 for the new therapy with 6/8 for the traditional therapy. Instead, participants frequently fail to consider joint event nonoccurrences; they employ a Type 1 heuristic, responding that there is a positive relationship when cell A is the largest in the contingency table and a negative relationship when cell A is the smallest (Shaklee & Mims, 1981; Wasserman, Dornier, & Kao, 1990).

This tendency to respond based on frequencies instead of ratios (denominator neglect) is present early in development (as early as first grade) and persists in adolescence and adulthood (Reyna & Brainerd, 1994). Although young children have the competence to

compare ratios, they tend to focus on target classes, contained in numerators, especially when ratios are equal (and differences in probability are, therefore, not salient). However, when ratios differ, performance has been found to improve for both children and adults because the problem cues the underlying competence to compare ratios (see Acredolo, O'Connor, Banks, & Horobin, 1989; Callahan, 1989; Reyna & Brainerd, 1994).

For Experiment 2 we constructed a covariation detection problem in which a coach instructs one of two teams to adopt a new behavior, and participants must decide whether the win-loss record is evidence that the coach's manipulation was effective. In one version of the problem the ratios of wins and losses are strikingly different for the two teams, providing strong evidence that the new behavior was effective. Indeed, the ratios were qualitatively different: one-half (or 50-50) versus clearly greater than one-half (9-1) (Spinillo & Bryant, 1991). In another version the ratios were identical (50-50 vs. 2-2), implying that the new behavior had no discernable effect.

We expected that adults would generally understand how to compute the ratios and judge the effect of the new behavior regardless of whether the ratios were equal or different. When the ratios are different, children should also often correctly judge the effect of the new behavior because the ratios of wins and losses are strikingly different, making this a relatively easy problem. When the ratios are equal, however, younger children should have difficulty recognizing their equality and instead often respond that the new behavior benefited the team that played the most games. Older children and adults, who have been shown to better inhibit this intuitive default and who have more experience solving covariation detection problems, are likely to give more normative and fewer heuristic responses, especially when ratios differ dramatically.

The ability of superstitious beliefs to encourage or trigger Type 1 reasoning was investigated in Experiment 2 by manipulating the type of new behavior that the coach introduced to his team. In one version of the problem, the coach instructs the team to employ a new strategy, and in the other version the coach instructs them to cross their fingers as a good luck ritual each time they score. Both professional and amateur athletes are frequently cited in the media as having good luck rituals, such as wearing particular clothing or repeating a gesture. Furthermore, there is abundant evidence that people attribute sports outcomes to luck, such as lucky streaks (Gilovich, Vallone, & Tversky, 1985).

How will this simple change in the covariation detection problem change performance? If participants consider the good luck ritual to be equivalent to other coaching strategies, then they should respond the same way for both versions of the problem. If participants believe in superstitions and engage in superstitious reasoning, then the good luck ritual may help activate their Type 1 reasoning, leading to more heuristic responses. If participants are skeptical of superstitions, however, then they may be unwilling to conclude that the behavior caused a team to win more and respond that the behavior was ineffective despite data that strongly support its effectiveness. Belief bias may override empirical evidence, which would represent a heuristic process not an analytical one.

Method

Participants—Participants were 276 fifth graders (mean age = 10.57 years, $SD = 0.41$ years), 344 seventh graders (mean age = 12.68 years, $SD = 0.48$ years) and 90 adults (mean age = 23.73 years, $SD = 2.53$ years). Fifth graders and seventh graders were recruited from public schools in the northeast part of Italy; all participants were typically developing children of mixed socioeconomic status. Adults were undergraduate students majoring in Psychology at the University of Padova.

Material and Procedure—We constructed four versions of a contingency detection problem involving a series of volleyball matches. Each version described the relationship between two variables: strategy (old or new) and outcome (wins or losses), and participants decided which strategy was better or if they were equally good. The ratios of wins and losses were equal in half the versions and different in the other half. The strategy was undefined in half the problem versions and was a good luck ritual in the other half. Participants were given only one version of this problem. The problem with equal ratios appeared as follows (translated from Italian to English), with the superstitious element in brackets:

Giuseppe is a volleyball coach and trains two different teams: Red Team and Blue Team. He wants to find a way to win as many matches as possible. He decides to do a little experiment and try a new strategy only with the Red Team [to try a good luck ritual: all the members of the Red Team have to cross their fingers each time they score a point]. After six months the Red Team has participated in a total of 10 games while the Blue Team has participated in a total of 100 games. Giuseppe looks at the table below and decides that if the Red Team has won more, then the new strategy works.

Now, look carefully at the table.

	Wins	Losses
Red Team (New strategy)	50	50
Blue Team (Old strategy)	2	2

What do you think? Mark with a cross one of the three answers

- a. The new strategy used by the Red Team has caused them to win more:
heuristic response
- b. The new strategy used by the Red Team has caused them to lose more:
atypical response
- c. Using the new strategy or not using the new strategy makes no difference:
normative response

In problems with different ratios the frequency of the Red Team wins and losses were 9 and 1, and the frequency of the Blue Team wins and losses were 50 and 50. In a single 20-min session, participants were presented only one version of the covariation detection problem. They were instructed to read the problem carefully and take their time responding. Some participants in each age group received the problem with equal ratios and no superstition (59 fifth graders, 92 seventh graders, and 21 adults), some received the problem with equal ratios and the superstition (67 fifth graders, 79 seventh graders, and 22 adults), some received the problem with different ratios and no superstition (75 fifth graders, 93 seventh graders, and 23 adults), and the remaining participants received the problem with different ratios and superstition (75 fifth graders, 80 seventh graders, and 24 adults). The positions of the two teams in the contingency tables and the order of the response alternatives were randomized. Fifth and seventh graders performed the task in their classrooms, and adults performed the task at the beginning of a university class lecture.

Results

The responses were categorized as normative, heuristic, or atypical as follows. For problems with equal ratios the normative response is that the manipulation (new strategy or good luck

ritual) made no difference, the heuristic response was that the manipulation caused the Red Team to win more, and the atypical response was that the manipulation caused them to lose more. For problems with different ratios the normative response is that the manipulation caused the Red Team to win more, the heuristic response is that the manipulation caused the Red Team to lose more (win less), and the atypical response is that the manipulation made no difference.

Figures 3 and 4 show the relative proportion of normative, heuristic and atypical responses for the problems without the good luck ritual. When the win-loss ratios were equal (Figure 3), nearly all adults gave the normative response that the coach's strategy did not matter. In contrast, fifth graders made more heuristic than normative responses, apparently basing their response on the number of wins instead of the ratios of wins to total games played. Seventh graders gave more than twice as many normative responses than fifth graders.

The results were strikingly different when the win-loss ratios were different (Figure 4). About 80% of participants in every age group gave the normative response that the coach's strategy improved Red Team performance. Both fifth and seventh grade children recognized that the 9:1 ratio was strong evidence favoring the new strategy in contrast to the 50 wins and 50 losses of the Blue Team.

Figures 5 and 6 show the relative proportion of normative, heuristic, and atypical responses for the problems involving a good luck ritual. When the win-loss ratios were equal (Figure 5), the responses were nearly identical to those in Figure 3. Normative responses that the good luck ritual did not affect team performance increased with age to a unanimous choice of this option by adults. Fifth graders chose the heuristic response (that the ritual caused the Red Team to win more) as often as the normative response, but few seventh graders and no adults chose this response.

However, when the win-loss ratios were different (Figure 6) the selected response varied little with age. Only about 40% of participants in every age group gave the normative response that the good luck ritual improved Red Team performance, about half the percentage when no ritual was involved (Figure 4). Instead, the modal response in each age group was that the good luck ritual had no effect on Red Team performance, despite their win-loss ratio of 9:1. It appears that a majority of participants were unwilling to attribute performance improvements to a superstitious ritual, regardless of age.

A multinomial logistic regression was performed on the responses (normative, heuristic or atypical) with age group (fifth graders, seventh graders and adults), probability ratios (equal or different), and superstition (present or absent) as independent variables. The best-fitting model is summarized in the left side of Table 3, including the regression coefficients, their standard errors, and the corresponding *Z* scores. The right side of Table 3 shows the odds ratios and their confidence intervals.

Comparing heuristic and normative responses (the top half of Table 3), fifth graders gave more heuristic responses than both seventh graders ($B = -1.39$, $Z = -2.66$, $p < .01$) and adults ($B = -3.11$, $Z = -2.39$, $p < .01$) when ratios were equal compared to when ratios were different. Atypical responses were relatively rare in all conditions except when ratios were different and the team adopted a good luck ritual (the results shown in Figure 6), resulting in a significant ratio by superstition interaction ($B = -4.02$, $Z = -7.41$, $p < .01$) when comparing atypical and normative responses (the bottom half of Table 3). In addition, fifth graders gave a greater proportion of atypical responses than seventh graders when the win-loss ratios were equal but about the same proportion when win-loss ratios were different ($B = -1.02$, $Z = -2.06$, $p < .01$).

Discussion

Research on numeracy indicates that ratio concepts can elicit denominator neglect for people of all ages (e.g., Reyna & Brainerd, 2007). The most common heuristic response is the team with the largest number of wins, ignoring the total number of games played. This response results from Type 1 processes (perceptual estimation of relative magnitudes; Reyna & Brainerd, 1994). Correctly computing and comparing ratios when denominators differ requires Type 2 processes, as well as inhibition of intuitive Type 1 processes or gist. Virtually all theories of cognitive development assume that Type 2 or analytical processes increase throughout childhood and adolescence. Thus, we expected the frequency of normative responses to increase with age.

When the covariation-detection problem had equal win-loss ratios the frequency of normative responses increased with age as expected by most theories. Fifth grade children gave normative and heuristic responses about equally often, whereas almost every adult gave the normative response. Contrary to most developmental theories, however, these responses were unaffected by the presence or absence of superstitious behavior in the story, as shown by comparing Figures 3 and 5. If participants believe in and engage in superstitious reasoning, then the coach's use of a good luck ritual should have activated Type 1 processes and increased the frequency of heuristic responses, but there was no evidence that it had such an effect.

When the covariation-detection problem had different win-loss ratios, there were no significant effects of age but the presence or absence of a superstitious behavior strongly influenced the results, as shown by comparing Figures 4 and 6. Ironically, however, the effect was not to encourage superstitious responses, but, rather, to elicit rejection of such responses across age groups. About 80% of participants in all three age groups gave the normative response when ratios were different and there was no good luck ritual. When the outcomes were attributed to a good luck ritual, however, so-called normative responses declined, apparently because participants rejected the conclusion that the superstitious ritual mattered.

Comparing performance with equal and different win-loss ratios and no good luck ritual (Figures 3 and 4), we find that fifth graders made substantially more normative responses in the different-ratio condition and adults, surprisingly, made more normative responses in the equal-ratio condition. Why did children give the normative response more often when the win-loss ratio was different? Possibly the 9:1 win-loss record drew their attention to the importance of comparing wins and losses. This problem was easier to solve than many covariation detection problems, including the problem shown in Table 2. Children could obtain the normative answer by comparing either the differences or the ratios between wins and losses of the two teams without computing the total number of games. Why did about 15% of adults give the atypical response that the change in coaching strategies made no difference? Possibly these students, all majoring in Psychology, had learned to be suspicious of experiments with few observations and were avoiding a Type 1 error by concluding that the new strategy had made no difference.

When the win-loss ratios were different and the coach's manipulation was a good luck ritual (Figure 6) nearly 60% of participants in all age groups gave the atypical response that the manipulation made no difference and about 35% of participants in all age groups gave the normative response. Those who gave the normative response presumably reasoned in much the same way as those in the condition without the superstition. They noted the 9:1 win-loss record and compared the win-loss difference or ratio for the two teams. They apparently viewed the good luck ritual to be equivalent to other coaching strategies. The majority of participants who gave the atypical response in all three age groups could be viewed as

skeptics, unwilling to accept that a good luck ritual would influence the performance of a team.

Summary and Conclusions

The developmental trends of normative and heuristic responses were strikingly different for the *if-only* and covariation detection problems. Adults were almost six times more likely than fifth graders to give a heuristic response compared to a normative response in the *if-only* problem, whereas adults were more likely than children to give the normative response in the covariation detection problem when win-loss ratios were equal. Clearly, these results cannot be explained by a dual-process theory in which heuristics are the by-default responses and analytical processes develop with age. Instead, both heuristic and analytical processes continue to develop between age 10 and adulthood. A coherent theory of reasoning must account for developmental changes in performance as well as adults' reasoning errors. Such a theory must explain, in particular, the surprising pattern of "developmental reversals" in which children outperform adults, as shown here in Experiment 1 (e.g., Brainerd et al., 2008; De Neys & Vanderputte, 2011; Markovits & Dumas, 1999; Reyna & Farley, 2006).

Indeed, these two experiments demonstrate that developmental trends are different for different kinds of reasoning problems, that is, they show biases increasing and decreasing with age. They also demonstrate that relatively minor elements of the problems can substantially influence performance. The jinx introduced in the *if-only* problem was expected to reduce heuristic responses by diminishing the perceived responsibility of the protagonists, but the jinx had little or no effect on performance. In contrast, a good-luck ritual in the covariation-detection problem strongly influenced performance, causing some participants to respond based on world knowledge and beliefs rather than the data presented in the problem.

Taken together, these observations complement the approach (e.g., Kokis, et al., 2002) of assessing the role of Type 2 processes by correlating standardized test performance and total performance on a series of reasoning problems. If developmental trends are different for different problems, then it would not be surprising if problems differ in their demand for cognitive ability among people of roughly the same age. Indeed, Stanovich (1999) found that SAT scores were positively correlated with covariation detection performance but negatively correlated with *if-only* performance (see also Stanovich & West, 2008). These results suggest that changes in the content of problems influence solution strategies, cuing retrieval of beliefs about responsibility in Experiment 1 and cuing beliefs about superstitious rituals in Experiment 2, adding to performance variance. In both of these instances, reasoners go beyond the data in front of them to make inferences about causation, increasingly relying on beliefs about personal responsibility in Experiment 1.

Although heuristic responses are often associated with Type 1 processes and normative responses with Type 2 processes in the literature, the role of each type of process in these problems is complex. Evans (2009) suggests that Type 1 processes are fast, automatic, and associative; Type 2 processes use working memory to perform rule-based reasoning; and Type 3 processes resolve any conflicts between the results of Type 1 and 2 processes. The heuristic response seems intuitively correct to adults, suggesting that it results from Type 1 processes in dual-process theory and gist-based intuition in fuzzy-trace theory. The observation that this response increases significantly with age is incongruent with standard dual-process theory but congruent with fuzzy-trace theory (e.g., Reyna & Ellis, 1994).

Standard dual-process theory assumes that the normative response to the covariation-detection problem is difficult to compute and is learned through formal education, a hallmark of Type 2 processes. It requires summing the rows, dividing cell entries by the corresponding sum, and comparing the resulting ratios. Experiment 2 found clear evidence of a developmental trend in these Types 2 processes when win-loss ratios were equal, the numerosity or denominator neglect effect (Reyna & Brainerd, 1994, 2008). When ratios were different, the normative response could be computed by Type 2 processes or simpler heuristics involving some combination of Type 1 and 2 processes (Spinillo & Bryant, 1991). Participants could obtain the normative response by simply comparing either the ratios or the differences of the wins and losses for each team without considering the sum. These two calculations yield the same answer for this problem. When ratios were unequal, a substantial majority of children were able to display their competence in evaluating ratios, taking into account both numerators and denominators. This finding adds another pattern to the overall picture of developmental variability in reasoning performance: early competence with little developmental change (Figure 4), joining the pattern of increases in heuristic or intuitive processes found in Experiment 1 (Figures 1 and 2).

We expected but did not find development differences in the effects of superstitious elements in these problems. Magical ideas play an important role in children's lives, and some but not all of these magical ideas are discarded over time (Klaczynski, 2009). For this reason, we expected young children to believe that a jinx was partly responsible for the outcome in Experiment 1 and believe that a good-luck ritual could improve a team's performance in Experiment 2. Instead, the jinx had little or no effect on the responses of any age group, suggesting that all age groups rejected it as a cause of the bad outcome. Similarly, in Experiment 2 participants of all ages rejected data suggesting that a good-luck ritual had improved team performance. Subbotsky (2000) found that children and adults reject magic at the verbal, conscious level while their actions are influenced by magical thinking. The problems posed in these experiments apparently engaged the participants' verbal, conscious thinking. These findings also illustrate belief bias in that reasoners rejected evidence supporting the effectiveness of the superstitious ritual (Evans, Barston, Pollard, 1983; Klaczynski, 1997; Klaczynski & Narasimham, 1998), showing that an intuitive process was retained in adulthood.

These experiments demonstrate that categorizing normative answers as analytic and other answers as heuristic leads to contradictory conclusions, especially when considering developmental trajectories. According to fuzzy-trace theory (Reyna & Brainerd, 1995), which proposes degrees of rationality (Reyna, Lloyd, & Brainerd, 2003), rationality is not an immutable trait but changes from task to task and from one stage of development to another. Development is not achieved by a shift from experiential (Type 1) to analytic (Type 2) processing. Understanding the trajectory of development requires analysis of the underlying processes that people of different ages employ when solving individual problems, and how these processes are elicited.

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Figure 1.
Proportion of responses (normative, heuristic and atypical) across age groups for Experiment 1 with no superstitious jinx.

Figure 2.
Proportion of responses (normative, heuristic and atypical) across age groups for Experiment 1 with a superstitious jinx.

Figure 3.
Proportion of responses (normative, heuristic and atypical) across age groups for Experiment 2 with no good-luck ritual and equal win-loss ratios.

Figure 4. Proportion of responses (normative, heuristic and atypical) across age groups for Experiment 2 with no good-luck ritual and different win-loss ratios.

Figure 5.
Proportion of responses (normative, heuristic and atypical) across age groups for Experiment 2 with a good-luck ritual and equal win-loss ratios.

Figure 6.

Proportion of responses (normative, heuristic and atypical) across age groups for Experiment 2 with a good-luck ritual and different win-loss ratios.

Table 1
Multinomial logistic regression model parameters and effect sizes for Experiment 1 (N = 342)

Best-fitting model	B (SE)	Z	OR	95% CI
<i>Heuristic Response vs. Normative Response</i>				
Age (Seventh graders)	0.63 (.32)	1.98 *	1.86	[1.00, 3.52]
Age (Adults)	1.78 (.30)	5.86 **	5.93	[3.29, 10.68]
Jinx (Present)	0.09 (.24)	.39	1.09	[.68, 1.75]
<i>Atypical Response vs. Normative Response</i>				
Age (Seventh graders)	.005 (.53)	.01	1.00	[.36, 2.84]
Age (Adults)	-.32 (.60)	-.53	.73	[.22, 2.35]
Jinx (Present)	.97 (.48)	2.02 *	2.63	[1.03, 6.76]

Note. OR = odds ratio; CI = confidence interval.

*
 $p < .05$

**
 $p < .01$

Table 2
Example contingency table for type of therapy and improvement of symptoms

	Improvement	No improvement
New therapy	A: 10	B: 6
Traditional therapy	C: 6	D: 2

Table 3
Multinomial logistic regression model parameters and effect sizes for Experiment 2 (N = 710)

Best-fitting model	<i>B</i> (SE)	<i>Z</i>	OR	95% CI
<i>Heuristic Response vs. Normative Response</i>				
Age (Seventh graders)	-.50 (.43)	-1.17	.60	[1.41, .26]
Age (Adults)	-.81 (.79)	-1.02	.44	[.09, .2.09]
Ratio (Equal)	2.42 (.43)	5.70**	11.33	[4.84, 26.12]
Superstition (Present)	.62 (.41)	1.51	1.87	[.83, 4.15]
Age (Seventh graders) × Ratio (Equal)	-1.39 (.52)	-2.66**	.25	[.09, .69]
Age (Adults) × Ratio (Equal)	-3.11 (1.30)	-2.39**	.04	[.00, .57]
Ratio (Equal) × Superstition (Present)	-1.09 (.51)	-2.16	.33	[.12, .91]
<i>Atypical Response vs. Normative Response</i>				
Age (Seventh graders)	-.25 (.28)	-.88	.78	[.45, 1.35]
Age (Adults)	.08 (.41)	.19	1.08	[.49, 2.42]
Ratio (Equal)	1.50 (.43)	3.47**	4.49	[1.93, 10.41]
Superstition (Present)	2.42 (.28)	8.60**	11.26	[6.50, 19.47]
Age (Seventh graders) × Ratio (Equal)	-1.02 (.49)	-2.06**	.36	[.14, .94]
Age (Adults) × Ratio (Equal)	-14.12 (165.82)	-.08	< .001	
Ratio (Equal) × Superstition (Present)	-4.02 (.54)	-7.41**	.02	[.01, .05]

Note. OR = odds ratio; CI = confidence interval.

*
 $p < .05$

**
 $p < .01$