Action at an Attentional Distance: A Study of Children's Reasoning About Causes and Effects Involving Spatial and Attentional Discontinuity

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ABSTRACT

Spatial discontinuity between causes and effects is a feature of many scientific concepts, particularly those in the environmental and ecological sciences. Causes can be spatially separated from their effects by great distances. Action at a distance, the idea that causes and effects can be separated in physical space, is a well-studied concept in developmental psychology. However, the extant literature has focused largely on cases where causes and effects are separated in physical space but are contained within the same attentional space, for instance how magnets on a table interact or how a lamp projected against an object creates a shadow despite the spatial gap between the lamp, object, and shadow. This paper considers the understanding of causes and effects that are separated both in physical and attentional space—a concept referred to here as "action at an attentional distance." Findings from an in-depth study of second, fourth and sixth graders' (n = 10) reasoning about action at an attentional distance are presented. Children tended to reason locally, but when they did reason about action at an attentional distance, they relied upon mechanism information and prior knowledge. The findings are discussed in the context of the literature on causal explanation and the instructional implications are considered.

Keywords: causal reasoning, ecological science, spatial gaps

INTRODUCTION

Spatial discontinuity between causes and effects is a feature of many environmental and ecological issues. Carbon emissions in populated areas contribute to consequences for polar bears in the Arctic; heavy snow melt and rains in the Northern reaches of the tributaries leading into the Mississippi River result in flooding in New Orleans; volcanic eruptions in Iceland are presumed responsible for many deaths in Europe in the 1800s and eruptions in one location can disrupt air travel around the globe. How students learn to reason about spatially discontinuous causality, referred to as "action at a distance" in the developmental psychology literature (e.g. Spelke, Phillips, & Woodward, 1995), is an important question to consider in science education in preparing students to think as global citizens. "Action at an attentional distance" refers to instances of spatially discontinuous causes and effects in which the causes and effects reside in different attentional frames. It poses particular challenges in that it introduces not only questions of what is cognitively possible, but also of what is likely to occur in terms of human attention.

The seven cross-cutting concepts within the Next Generation Science Standards (Achieve, 2013) include "Cause and Effect." These cross-cutting concepts are intended to provide students with an organizational structure to understand the world and to connect core ideas across disciplines and grade bands. That spatial discontinuity can exist between causes and effects is a core structural idea in ecological and environmental science. This and related understandings can impact how students evaluate evidence, set parameters on inquiry-based investigations, and interpret research findings that they consume. Studying how students reason about such discontinuities at different grade levels offers greater context for instructional efforts.

Developmental Psychology: Physical Action at a Distance

The rules that we invoke to discern causality have garnered considerable interest over the decades with early work focused on whether humans rely on the rules set forth by Hume focused on temporal precedence of causes to effects and spatial contiguity between causes and effects (Bullock, Baillargeon, & Gelman, 1982). The concept of "action at a distance" has been studied largely with young children to test whether or not a physical connection between cause and effect is necessary for children to perceive a causal relationship. The findings have reliably shown that infants appear to expect causes and effects to physically touch one another. They recognize that objects act on one another only if they touch and that action is not enacted from a distance (e.g. Leslie & Keeble, 1987; Oakes, 1993; Van de Walle & Spelke, 1993). When shown a screen with a partially hidden block on the left side and another block moving behind the screen on the right side and then the half-hidden block moves to the left to come into full view, even six-month-olds appear to infer that the two objects that the block moving from the right side, came into physical contact with the half hidden block on the left to make it move (Van de Walle, et al., 1994). Spelke and colleagues (1995) found that infants extend the principles of no action at a distance to shadows. In one experiment, infants expected that a shadow of a ball would remain at rest when the ball moved, when in fact it does move thereby violating the principle of no action at a distance. Likewise, infants expected the shadow to move with the surface that it was reflected onto when the surface of the shadow was moved, when in fact it does not, thereby violating the principle of action on contact (Rubenstein, Van de Walle, & Spelke, as cited in Spelke et al., 1995).

However, even the knowledge of infants suggests malleability. Infants do appear to suspend these expectations for animate agents (Woodward, Phillips, & Spelke, 1993) and recognize that humans are capable of self-initiated movement (Gelman, 1990; Premack, 1990). Agency is a powerful, core aspect of human cognition (Carey, 2009). Even infants and preschoolers use agency to discern causal relationships and they focus their attention and learning on what they and others can do (Meltzoff, 2007; Sommerville, 2007).

By preschool, children demonstrate greater understanding of the contextual nuances of relying upon spatial cues to discern causal relationships. Bullock and Gelman (1979) introduced a study using a Jack-in the Box in which 3-5 year-olds were shown a simple mechanical event in which a ball dropped into an apparatus causing a Jack-in-the-Box to jump out. Children reacted with surprise when the apparent cause of the Jack jumping up occurred at a distance. Approximately half of the children predicted that the ball that was spatially separated from the Jack could no longer act as the cause of the movement with distance as the reason. When experimenters juxtaposed temporal and spatial cues, children tended to elevate temporal cues over spatial ones and selected the prior event as the cause despite the separation. This was so despite the fact that many of the children (50%, 81%, and 68% of 3-, 4-, and 5-year-olds, respectively) showed signs of surprise when temporal priority cues suggested that it was the cause.

Kushnir and Gopnik (2007) studied preschoolers' causal assumptions about spatial discontiguity between causes and effects in cases where the assumption interacted with information about the conditional probabilities of two events occurring together. Preschoolers saw a toy that lit up and played music according to different conditional probabilistic patterns when an object made physical contact with its surface presence or was held several inches away. Three to 4-year-olds were able to use the patterns in the probabilistic evidence to make accurate causal inferences, even in the face of conflicting prior beliefs about spatial contiguity.

Despite this ability, preschoolers are still less likely to pick a spatially remote event as a cause (e.g. Koslowski & Snipper, 1977; Lesser, 1977) and are more likely to choose inconsistent but spatially contiguous events over events that consistently co-vary but are not contiguous (Kushnir & Gopnik, 2007; Mendelson & Shultz, 1976). Even in contexts where children selected the prior event as the cause despite a spatial separation, they expressed some level of discomfort in choosing spatially discontiguous causes (Bullock & Gelman, 1979). This is especially the case for certain types of events, such as those that involve impact or hitting. Wilde and Coker (1978) found that while both 4- and 8-year-olds use temporal and spatial contiguity cues, 6- and 8-year-olds rely on covariation information when it contrasts with contiguity information. In Kushnir and Gopnik's study (2007) children were more likely to make correct inferences when causes were spatially contiguous, particularly when the evidence was ambiguous.

Sobel and Buchanan (2009) found that action at a distance made it more difficult for 4 and 5-year-olds to make inferences about an object's internal properties which relates to their ability to discern the mechanisms for how it behaves. When objects' internal and external causal properties conflicted with the perceptual appearance (Nazzi & Gopnik, 2000; Sobel, Yoachim, Gopnik, Meltzoff, & Blumenthal, 2007), preschoolers were still able to connect the internal properties of the object to the causal properties; but these cases involved physical contact. When contact causality was replaced by distance causality, 4- and 5-year-olds extended labels to objects with similar perceptual properties over objects with similar causal properties. Five-year-olds were more likely than 4- year-olds to make causal responses. When no perceptual conflict was present, 4-year-olds registered causal properties that acted at a distance and made inferences from them. These results support the hypothesis that children develop understandings of specific mechanisms that link causal relations when causes and effects are physically discontiguous.

Schlottman (1999) found that children increasingly rely on mechanism in instances over such perceptual information as their understanding of causality matures and their knowledge of types of causal mechanisms develops. She found a preference for spatially contiguous explanations across the ages she studied, as young as five years old through adult, prior to having experience with two mechanisms that implicated either a contiguous or a delayed, noncontiguous cause. However, once subjects learned about what mechanism was within a box, adults and 9- to 10-year-olds shifted their responses depending upon the mechanism, while younger children did not. She refers to this as the "mechanism principle" referring to the idea that "for two events to stand in a causal relation, we believe that there must be a mechanism by which the cause produces the effect—this distinguishes causation from correlation and coincidence" (p. 303). Increasing mechanism knowledge also correlates with the likelihood that one will discount magic as a cause (Subbotsky, 2001, 2004). Lesser (1977) used the magnets to try to train first through fourth graders to perceive causal action despite a physical separation. Prior to training, none of the children recognized action at a distance; afterwards, there was a significant increase in responses characterized by action at a distance in the older children. This suggests the possibility that children can learn to override the spatial separation with knowledge of mechanism.

Reasoning about Action at an Attentional Distance

The literature reviewed above on action at a physical distance offers a rich sense of how children's understanding develops when cause and effects are physically separated within the same space. However, what happens when the causes and effects exist within different attentional spaces? In the literature reviewed above, causes and effects are within one context; available to the subjects. Even when the necessary information was not visually available to the subjects, the cues were in the same attentional set. There have been some variations on this, where the cause was unseen, but signaled by an obvious effect, thus introducing the need to explain something. This compels explanation because research suggests that children do not allow for causeless effects (e.g. Bullock, Gelman, & Baillargeon, 1982; Schlottman, 1999) and typically will search for a non-obvious cause if an obvious one is not readily available or when faced with an obvious cause that behaves stochastically (Schulz & Sommerville, 2006). Further, young children invoke nonobvious causal mechanisms to explain biological processes and mechanisms (Gelman & Gottfried, 1996). Action at an attentional distance not only influences the types of explanations one can generate, it impacts the perception that explanation is needed.

In many complex environmental problems, causes and effects are separate not only in physical space, but in attentional space. From the perspective of the observer, attentional spatial distance can be categorized in at least three ways: 1) Situations where a cause and an effect are both accessible to the perceiver, though not perceptible in the same physical set due to spatial gaps and barriers. For example, a loud speaker goes off in a classroom, the students recognize the voice of the person who sits in the office, and may be compelled to imagine the mechanism that unites them. 2) Situations where an effect is present and one needs to explain it (not allowing for causeless effects) and in so doing, there is a need to invoke distal causes when local ones fail to explain the effect. For instance, trees in one's vicinity may be impacted by acid rain that generates at a distance from the trees. A difficulty in this case is that there are often competing local explanations that may be more obvious and may pull the explainers attention to them. 3) And situations where a cause is present, but the effect is not within the same attentional set. Thus the explainer does not necessarily perceive it as a cause because there is no effect to signal the need for explanation and the causal relationship may fail to gain attention at all. For instance, without some means to draw our attention to the relationship, it is very unlikely that we would connect our local use of greenhouse gases to effects on polar bears in the Arctic. With focused brainstorming or the persistence of scientific inquiry, one might detect the possible role of the cause, but in everyday reasoning, this may fall prey to factors of efficiency and our subsequent limited attention. In the developmental research, children depend upon seeing the relationship between events in a temporal and spatial sense to determine the possibility of a causal relationship between them. With action at an attentional distance, the available information may be limited to one set of events so discerning the relationship between them becomes problematic (Grotzer & Tutwiler, in review).

In general, split attention across gaps—spatial or temporal—makes the mental integration of the information much harder. Ginns (2006) reviewed research on the effects of split attention on novices attempting to learn spatially or temporally disparate information. A meta-analysis performed across 50 independent studies revealed instructional benefits of reducing split attention across time or space particular given the mediating variable of the complexity of the learning materials. The analyses indicate that, for complex learning materials in particular, the greater the spatial or temporal discontiguity of related elements of information the more difficult it is for students to learn them. When attentional gaps are inherent in causal relationships, this impacts the available causal information and therefore, the forms of causal induction that are possible, and shifts the cognitive terrain considerably.

In the science education literature, some findings exist to suggest that students struggle with concepts that embed action at an attentional distance and that students tend towards local explanations. For instance, students think that plants get their food directly from the soil rather than producing it through the process of photosynthesis using energy from the sun (e.g. Barker & Carr, 1989). Prior to receiving support, middle school students investigating a fish die-off in a virtual ecosystem limited their investigation to the local context (Grotzer, Tutwiler, Dede, Kamarainen & Metcalf, 2011) and on an inventory of environmental issues, sixth graders were twice as likely to consider it important to investigate near to the effect than distant to it (Gramling, Solis, Derbiszewska & Grotzer, 2014). Bar, Zinn and Rubin (1997) found that when reasoning about action at a distance, students looked for a medium to support certain actions such as forces and gravity but that they did not apply a consistent set of rules, instead their reasoning shifted with the perceived salient features of different situations.

RESEARCH QUESTIONS

From an empirical perspective, we sought to understand how students made sense of action at an attentional distance at different ages and what the implications might be for helping them learn to reason about it. Can students learn to be aware of the possibility of such causal relationships? Can they learn to be more likely to anticipate them? And the most challenging of all, can they learn to be more likely to attend to them in every day contexts? Given the lack of research on action at an attentional distance, we conducted a close study of the reasoning of ten students in grades two, four, and six and conducted grounded, emergent analysis to consider how they reasoned about problems that potentially invited action at an attentional distance reasoning. The study was designed to contrast particular types of questions involving action at an attentional distance to see what types of responses they elicited. We investigated the following questions:

1. How do students respond to open-ended questions that invite the opportunity to reason locally or distally about relationships between causes and effects?
2. If students do not offer distal explanations in response to open-ended questions, is it more likely due to a preference for spatially contiguous explanations or an inability to generate distal responses?
3. What variation existed in student responses and between students?
4. What reasoning patterns and problem features enabled reasoning about action at an attentional distance?

METHODS

To address these questions, we conducted in-depth interviews that closely considered students' reasoning in an attempt to find the affordances in what children think about in everyday contexts and with particular reasoning supports. The study was conducted across the school year with four students from each of three grade levels (second, fourth and sixth grades) from urban public schools in the Boston area (n = 12). The schools serve an ethnically diverse, economically disadvantaged population with approximately 45% of the students receiving free or reduced lunch and a high level of transience. Two students (one each in grades 4 and 6) moved during the year, resulting in a total of ten students (n = 10) for whom complete data was collected. In addition, additional students in fourth and sixth grade (n = 23) took a multiple choice inventory intended to discern student preferences for certain types of answers.

In four sessions throughout the school year, the students participated in clinical interviews in which they responded to scenarios that could be interpreted at varying levels of attentional distance. The questions were designed to explore students' intuitive interpretations of phenomena involving action at an attentional distance and assess their tendencies in framing problems where causes and effects do not reside in the same attentional space. Therefore, interviews were conducted open-endedly, with limited scaffolds, to allow students to bring their latent understanding to bear in their responses. Within each interview, experimenters asked follow up questions to clarify students' responses but did not attempt to aid students in moving toward a specific interpretation of the scenarios. The open-ended design in the initial interviews also sought to determine what information students brought to the problem space on their own in an attempt to assess how they might reason about such problems in the real world beyond school. Interviews took 40 minutes on average. Sessions were videotaped for later coding and analysis.

The design of the four sets of sessions used a Design-Based Research framing (Collins, Joseph, & Bielaczyc, 2004) in an attempt to develop tasks that best illuminated the potential in students' thinking and enabled the assessment of new questions that arose from each set of interviews. Towards that aim, after each set of sessions, initial analyses of the student responses were conducted to assess their thinking and design the appropriate follow-up tasks. These involved developing contrasts between alternative possible explanations for student responses, such as whether students understood responses including action at an attentional distance, but preferred local explanation; whether they would gravitate to one type of response or another if the two were controlled for content, length, and other variables that influence students' reasoning and so forth. Tasks that they might be familiar with, including social tasks, were included in an attempt to tap into students' concrete experiences and to consider whether these might be leveraged to help students learn about environmental issues (Rickinson, Lundholm, & Hopwood, 2010; Wyner, 2013). The details of how each session sought to illuminate aspects of student understanding building upon the previous set is explained below.

Task Design

Session One: The first session was designed to assess students' understanding of action at an attentional distance in the natural world and posed scenarios that could be explained at multiple levels. This first set of problems (and those in the following two sessions) was designed so that only the effect was in the student's attentional space (in contrast to problems where only a potential cause was in the student's attentional space). The extant research showing that even young children do not accept causeless effects and seek out explanations (e.g. Bullock et. al, 1982; Schlottman, 1999), suggested that this task framing might be less difficult as an initial starting point than the second type where students need to predict potential impacts in a more open-ended generative manner. The cognitive difficulty in this case was the presence of competing proximal (and often, obvious) explanations that could draw their attention away from more distant causes.

The question set contained some scenarios that had scientifically accepted answers (potentially more than one) that students might have learned about (the invasion of Asian Long Horn Beetles; impacts of acid rain on conifers, the decline of trees due to Dutch Elm Disease, etc.) and others for which there is a diversity of scientific opinion but not a clearly agreed upon answer (such as what creates certain cloud patterns). It included four scenarios that described an effect in the natural world observed by a protagonist in the story: dying trees in a two-mile area; water entering and leaving a salt marsh at regular intervals; patterns in a cloud formation; and the erosion of a carving in granite over time. In each scenario, the effects could be attributed to a local cause or drawn out to more distant causes. For instance the water in the marsh could be attributed to local waves along the shoreline; or to a distal explanation that included the role of the moon's gravitational pull on Earth which creates the tides that move the ocean water in a regular pattern.

Students were asked to take the perspective of the protagonist in the scenario and propose as many potential causes of the observed effect as they could think of. They were then asked to choose the two that they thought were the best explanations and to explain why. A student's ideas were read back to him or her before s/he answered this question to reduce the cognitive load of comparing the answers and the likelihood that they would otherwise choose one of their most recent ideas. As implied by the request to provide multiple causes, the focus was not on whether or not students could generate one answer that was deemed "correct." The interviewer encouraged students to keep proposing causes until they had given at least five responses or until the students indicated that they had no more ideas.

Session Two: After preliminary analysis of student responses from the first session, a set of scenarios to assess understanding in social contexts was developed based on extant findings that students can leverage knowledge of social relationships in understanding complex interactions in other domains (Grotzer, Duhaylongsod, & Tutwiler, 2011). Four scenarios described an effect experienced by the main character in the story that could be explained by multiple possible local or distal causes. Two scenarios included technology content to assess whether students would offer action at a distance responses if they were aware of a mechanism that they know has the potential to act at a distance (as computers do). Questions deliberately addressed content that students might be familiar with (such as one about a Nintendo DS game that many children are familiar with). The scenarios included: moving to a new school and finding out that students there already hold social information about the character; having someone know the character's physical location without being directly told by the protagonist; receiving a message via a virtual character through an electronic game; seeing a clue written in a foreign language (Mandarin) on an online notebook in a computer game (for fourth and sixth grade). Mandarin is taught to fourth and sixth graders at the schools so a local explanation would be feasible. Again, students were asked to generate as many responses as possible and were then asked to pick their top two responses. The second graders were given one less scenario (the computer game) because they generally took longer to respond than the older students.

Session Three: Initial data analysis from sessions one and two indicated that students generated primarily local explanations. Preliminary emergent analysis of students' responses suggested a working hypothesis that, due to efficiency or preference, students might offer parsimonious local responses in open-ended questions rather than draw extended connections to distal causes. Therefore, a set of "forced choice" questions were developed in an attempt to discern whether students' were expressing a preference for local explanation or would choose more distal responses if those were offered. The instrument also contrasted mechanisms that students would be more or less familiar with as follows below.

The instrument consisted of four multiple-choice questions; two focused on the natural world and two on social contexts. Four plausibly correct answer choices were given for each question; the responses were paired so that there were two with similar content formulated in local and distal framing. One set of two used scientifically accepted explanations that students may have learned, involving non-obvious mechanisms (e.g., acid in the rain) while the other used a plausible explanation that students might be more likely to generate on their own using obvious mechanisms (e.g., insect damage). The order of answer choices was counterbalanced across the questions. Students were asked to give their first and second choice for best answer. Asking for a second answer choice was intended to reveal whether there were systematic patterns in students' responses related to whether they chose distant variables or particular mechanisms. Students were asked to explain in writing why they chose particular answers as their first and second choice. All students in the class took this inventory. Students who were the focus of the study were interviewed about each of their responses. The ordering of session three and four was swapped for second grade due to a scheduling issue.

Session Four: The final session was designed to investigate students' ability to discern the possibility that a cause could have distant effects that fall beyond the attention of those precipitating the cause. In these "cause present/ effect distant" problems, students were asked to draw out the potential effects, thus they had to imagine the potential effects not present in their attentional set. This could prove difficult for students because there was nothing in the scenarios to signal that an event was causally linked to any particular effect. However, it was less complex than real world reasoning tasks in that they were cued to the existence of a possible cause. They were presented with four scenarios that included a cause and asked students to think of potential effects, including, putting fertilizer on the grass; leaving holiday lights on year-round; encouraging friends to recycle plastic bottles at a local supermarket; coughing into one's hand. Of particular interest was how far students would draw out possible effects. Again, students were asked to take the perspective of the protagonist in the scenario and consider as many effects as possible. Students initial responses were followed up with "can you tell me more about that?" or "where is this taking place?" questions to probe how far students could extend the effects they proposed.

Data Coding and Analysis

An emergent analysis was conducted according to grounded theory (Charmaz, 2006) in which two independent coders surfaced themes that they detected in the data. The overlapping categories identified independently by each coder were then refined and statements representing each reasoning type were coded. To protect against confirmation bias (e.g. Kuhn, Amsel, & O'Loughlin, 1988), coders sought disconfirming evidence and re-evaluated and refined any themes for which disconfirming evidence existed.

Following the emergent analysis, an etic-coding scheme was applied to the interview data to determine whether each response was characterized by local framing or action at an attentional distance. It was not scored for scientific accuracy, but for the spatial location. The initial process involved multiple rounds to refine the codes and related scoring scheme. Once the final coding scheme was developed, the following procedures were followed. One hundred percent of the student responses were scored by a primary coder. Twenty-five percent of the data were scored by a second coder for reliability purposes. Number of responses per question varied across children, but the overall numbers of responses for the different children were similar. A Cohen's kappa calculation was conducted to corroborate the strength of inter-rater reliability. Reliabilities were also conducted for individual children. The coding system was reliably applied with 91% agreement (.84 Cohen's Kappa, considered "Very Good"). Reliabilities were also conducted within each subject to ensure that coding reliability was high for each subject's data not just across the sample. The multiple choice assessments were scored for the answer types that they represented and for corroboration between written explanations and the forced choice responses.

FINDINGS

Overall Findings: What Patterns Between Local and Distal Responses Were Evident?

Students tended to give local responses. Students in all three grades tended to give local explanations. This persisted across domains and when reasoning from effect to cause or cause to effect. The only departure from the pattern occurred when students responded to multiple choice questions juxtaposing distal and local responses, as explained further below.

Table 1. Number of Local vs. Distal Responses

Grade	Session One: Natural Science		Session Two: Social		Session Three: Multiple Choice*		Session Four: Cause to Effect**		Total	
Second:	Local	Distal	Local	Distal	Local	Distal	Local	Distal	Local	Distal
Brianna	35	1	12	7	4	4	24	2	75	14
Stella	18	3	17	0	2	6	16	4	53	13
Darnel	19	1	11	0	4	4	14	9	48	14
Jaden	22	0	19	1	4	4	23	0	68	5
Fourth:										
James	18	5	12	6	4	4	7	12	41	27
Marala	36	2	22	6	4	4	9	4	71	16
Sudhir	17	1	12	2	5	3	9	6	43	12

Sixth:										
Reshon	11	1	6	8	4	4	9	4	30	17
Ihno	17	1	8	4	5	3	12	1	42	9
Sahil	16	3	10	7	4	4	14	2	44	16

*Session 4 for Grade 2
**Session 3 for Grade 2

All students tended to give responses that put the cause and effect in the same attentional space and, even, in direct contact (local responses). The quantitative coding of response types corroborated this emergent observation (See Table 1). For example, in Session 1 (natural science), students gave mostly local causes that involved physical contact between causes and effects. So in explaining how words on a granite stone were no longer legible when the story protagonist returns after many years, typical responses included words being covered by mud or sand or having been scraped off by animals or other rocks falling on them. Explanations for why trees in a certain area were dying included direct actions by animals, insects, or people. Less obvious explanations included the trees not having enough rain or the right soil. For patterns appearing in the clouds, answers suggesting physical contact from planes, rockets, or even birds. Even causes such as the wind that are not visibly obvious involved physical contact.

Ihno, a sixth grader, for example, had the following to say about the patterns in the clouds:
I: Probably because an airplane.
E: Okay. Airplane. What about the airplane, just…
I: It probably went through it.
E: Went through it. Okay.
I: Probably some birds, probably the wind was really fast.
E: Wind was very fast. Could you say a little bit more about that?
I: It probably…the wind was blowing real hard. It probably went through it.

The prevalence of local responses persisted across biological, social, and technological scenarios. As evidenced by the outcomes in Table 1, similar patterns were observed in subsequent sessions despite the focus on the social and technological domains (i.e. computers and electronic games). For instance, in the second session, when responding to a scenario in which a clue on an online notebook appeared in Mandarin, Marala, a fourth grader, attributed it to someone acting on the computer or that the cause existed in the game itself. She said, "Maybe there was something on the screen and it seemed to be like a bug, so somebody pounded the screen and it just changed the thing around and then it started doing a different language."

In explaining how the writing on granite might become hard to read over time, she said, "And, then, the bird could have accidentally dropped some mud balls, on top of the granite piece of rock and then it could have, like…a piece of granite rock could have, like, had, like, a layer harden". Her explanation of how fertilizer would impact the growth of grass also involved local and direct application, "and then they put the fertilizer in that area of the park and grass will start growing more because the fertilizer has more nutrition in it than normal dirt." She also explained the transfer of social information as direct and local, "I think that maybe Keisha might be talking to the teacher and the other girl might be walking around and listening to the teacher about what Keisha is saying."

Examples of contagion also involved direct and local transmission of germs. Second grader Stella said, "My friends might get sick if I shake their hand at school. And my friends might say what's wrong and then she says I keep sneezing and they might give them soup and then he might say thank you and sneeze on them again."

The prevalence of local responses occurred both in reasoning from effect to cause and from cause to effect. Despite the different cognitive demands of reasoning from an effect to its corresponding cause or from something that could be deemed a potential cause to possible effects, students typically generated local responses to both types of interview tasks. In Session 4, when students were asked to think of effects of different events, they continued to formulate mostly local answers. For instance, when asked what would happen if he sneezed into his hand, Sudhir, a fourth grader, said,

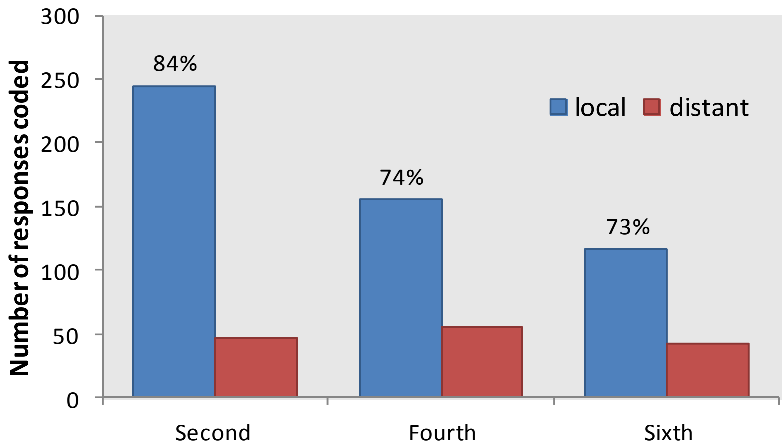
> "You could get a little more sick, 'cause if you shake hands with somebody, maybe you had a flu and they had a fever. And then they were probably coughing, they coughed in their mouth a few minutes before you guys met, and you kind of sneezed or coughed. So then, you shake hands, and kind of passes that fever to you and then you pass the flu to them. And then the effect will be sitting in bed, like, sleeping in bed, trying some soup."

Darnel, a second grader discussed that others would get the cold, but also included local conceptions of what might happen, "If you touch other people they get the coldness. Um, and then if you keep on touching yourself with the hand that got germs on it you…the cold is never going to leave you alone…."

The prevalence of local responses persisted across the developmental range of the study. As evidenced by the various local responses above, the pattern of local to distal responses was consistent across the three grade levels studied. (See Figure 1.) As discussed below, knowledge of particular mechanisms and contexts contributed to variation in what enabled students to construct distal responses. Not surprisingly, in the course of the interviews the fourth and sixth graders expressed more mechanism and content knowledge than those in the second grade. In this way, development and learning may contribute to students' ability to reason about action at a distance. In instances when students gave responses characterized by action at an attentional distance, they often reported that they learned the examples in school. However, their explanations may be still be typically characterized by efficiency that results in constraining the parameters of the problem space (as opposed to efficiency in terms of how much information they shared in the interview; many students had a great deal to say that was focused on local causes.) The multiple choice questions, discussed below, offer insight into this possibility.

Despite the similarity in tendency towards local responses, there were some differences between grade levels in how students supported their reasoning. Second graders anthropomorphized phenomena more often than the older students. Second and fourth graders referred more explicitly to anecdotes and personal experiences than sixth graders in their responses (although all grades employed prior knowledge). Fourth graders more readily offered that the source of their information was testimony from trusted others (Harris, 2012). Whether prompted or not to reveal the source of their knowledge, they repeatedly referred to the confidence they had in what they learned from parents, teachers, books, and other media. For instance, James consistently referred to what he learned from his mother. He prefaced many of his explanations with, "My mom told me…" When asked how he knew about the behavior of the tides and their relationship to the moon, he replied. "I don't know. My mom was just telling me once, about how the…like the water follows the moon. And it goes sometimes…the high tide and low tide. And I'm not sure how that works. I'll have to ask when I get home tonight." There are many possible reasons why this may be so ranging from being at an age when one spends more time with parents, perhaps is more comfortable talking about parents, to differences due to the small sample size.

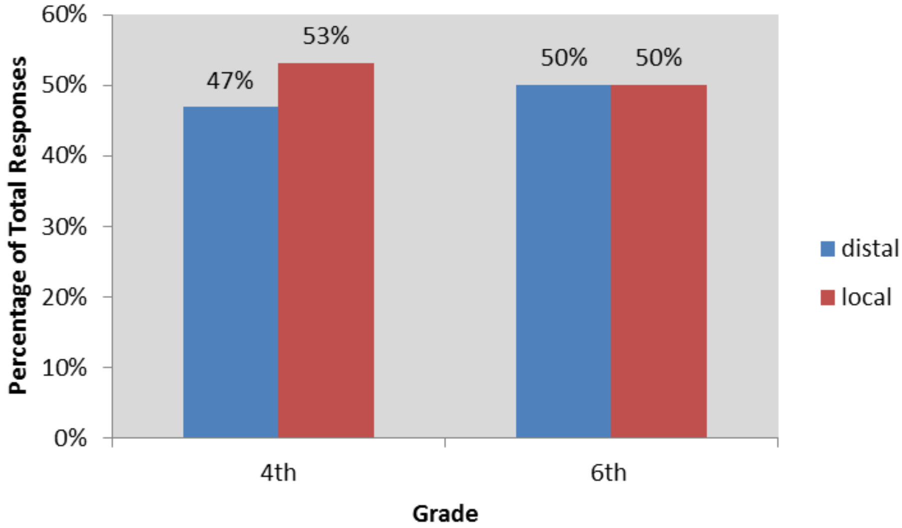
Figure 1. Number of Local vs. Distal Responses by Grade



Students chose explanations characterized by action at an attentional distance more that they generated them. The third session was an assessment of preference where students were asked to choose between local and distal responses that were framed with scientifically accepted information as well as with obvious and nonobvious causes. Students chose distal explanations at the same rate as local ones. These findings, in contrast to those of the open-ended questions, raise the possibility that students are just less likely to generate distal explanations. When cued to candidate explanations that involve action at an attentional distance, students find them feasible as possible explanations, expressing no preference one way or the other.

To consider the possibility that the students may be more accepting of distal explanations as a result of their interview experiences, we administered the multiple choice inventories to broader group of fourth and sixth graders. (n = 23). The results were the same (See Figure 2.). Students did not demonstrate a clear preference for local over distal explanations. While the assessments revealed no clear preference for local/distal responses (even when separated by first and second choice), some nuanced patterns did arise in relation to the types of causes students gravitated towards. There was also no clear preference for obvious/non-obvious when all responses were tabulated, but taking into account first and second responses, fourth and sixth graders had more non-obvious causes as their first choices (4th grade: 33 vs. 15; 6th grade: 28 vs. 15). This suggests that the non-obviousness of the candidate causes did not interact with students' selection when students were cued to them.

Figure 2. Percentage of Local vs. Distal Explanations Selected on Multiple Choice Inventory



What Variation Existed in Student Responses and Between Students?

Offering Local and Distal Responses. Although students were inclined to give more local responses, they demonstrated an ability to imagine a host of distal possibilities. Given that interviewers encouraged more than one response per question, students had the opportunity to offer both local and distal responses for the same scenario. James offered a varied set of answers when discussing why a girl might know information about another girl, Keisha, whom she had never met before. Interestingly, James's first response provided a distal explanation.

J: Maybe she read about Keisha.
E: Where? Where did she read?
J: Like, maybe she read about Keisha online.
E: How? How did she read about Keisha online?
J: Like, there's, like, ways you can go look up people's files about people. And maybe she went up online and looked up files about Keisha. 'Cause she heard that this new girl named Keisha was coming to her school the next day.

When asked to provide other answers, he followed up with two local responses in which the information is directly share by" 1) an old friend who moved, "Or maybe it's one of Keisha's old friends from somewhere else… …who knows about Keisha, like an old friend that moved and she met that friend again and she doesn't tell 'til like later. Or 2) by a teacher, "Maybe the teacher told them about Keisha. "Cause they never said what day of school it is. It could be, like, the middle of the school year, and you get a new classmate. It's happened to me before."

Some Students More Readily Gave Distal Responses. The number of distal responses also varied across students. For example, while Sudhir consistently gave local answers across all four sessions, James seemed less committed to a local stance and gave distal responses throughout the interviews. Furthermore, whether students gave local or distal responses seemed to be mediated by several factors, including students' familiarity with the context, prior knowledge and experience as it related to the scenarios, and use of particular cognitive strategies. What was clear from the emergent patterns was that students were more sensitive to potential causes and effects that resided in the same attentional space but, given certain conditions, were also able to invoke distal causality.

What Enabled Action at an Attentional Distance Reasoning?

What were some of the affordances or problem features that mediated students’ ability to offer distal responses? There were a number of identifiable aspects to students’ reasoning that appeared to impact their ability to offer responses characterized by action at an attentional distance. These included accessing prior knowledge; relying upon mechanism knowledge, and creating narratives to link between proximal and distal causes and effects.

Prior knowledge and experience in general. Students were more likely to give distal responses if they were knowledgeable about the domains in which they were being tested. Students drew upon prior knowledge in contexts that involved games, technology, social interactions, and scientific concepts learned in school. They drew from compelling life experiences and their understanding of scientific and social phenomena in order to generate possible causes and effects. Students actively sought to leverage their knowledge to fill in missing information in the scenarios and, at times, explicitly referred to their reliance on the things they knew and had experienced. For instance, in Session 3 (multiple choice instrument), after realizing that he was being asked about the Nintendo DS scenario again—a scenario also given in Session 2—James expressed his confidence in his ability to respond to the question, now that he had personal experience with a DS game, “Well, now I have my own Nintendo DS because I got one for my birthday…So I may have a few things [to say].” Although, James picked a local response as his first choice, he went on to pick a distal response as the second best answer and explained his reasoning based on his knowledge of the game, “Because if he has a DSi, you can use Internet on it so he can be playing, like, this Internet game where he’s talking with all his friends and one of his friends asks him, “Are you excited about your fieldtrip?,” because he’s on this Internet thing.”

Marala explained, “Yes, it’s possible [for two people to communicate at a distance] as you have wireless connection across the world in phones and computers, too, so it has to be the same for the Nintendo DS, because it’s made out of the same thing that computers are made out of.”

By contrast, the fertilizer question in Session 4 proved to be difficult to students across grades. In that scenario, students were asked to give possible effects of putting fertilizer on the grass. Though students were able to deduce that fertilizer helps plants grow, they also demonstrated a limited understanding of what it really is and how it works. When asked about this scenario, Sudhir said the following.

S: Well, I think, well, the grass could kind of grow, maybe a little faster but not that much.
E: Okay. Tell me a little bit more about that.
a: Because, wait, fertilizer. Oh, because…wait, I have a question. I’m not really good at gardening, but, is fertilizer the soil?
E: What do you think?
S: Oh well, because some fertilizers kind of help plants grow but, like, some fertilizers maybe just…don’t really help the plant at all. Or it could actually kind of die.

E: Okay. Tell me more about that.
S: Because I think some fertilizers have chemicals that can actually hurt the plant.

Only Sahil was able to construct distal responses for the fertilizer scenario. He said, "It may also be that the fertilizer somehow gets into the water in Fresh Pond and that somehow harms, like, 'cause the water you drink comes from Fresh Pond. And they…yeah, but that…yeah, so maybe somehow it gets through the sanitizing machines and it harms you."

Students also referred to memorable life experiences in informing and validating their reasoning. Interview transcripts were peppered with students' references to things they had seen, heard, or felt that provided insights into the causal intricacies of scenarios or provided support for a proposed cause or effect. This pattern seemed particularly prevalent in the fourth grade. However, these experiences did not consistently support responses characterized by action at an attentional distance and could just as easily result in local responses. For instance, in Session 1, Marala talked about her experience at the Boston Museum of Science to support her idea that words carved in a granite stone could be covered by animal waste that hardened over the years.
M: Have you ever been to the Museum of Science?
E: Yeah.
M: In the dinosaur section?
E: Uh-huh
M: The dinosaur section has this place where it says dinosaur waste. And, it has a piece of dinosaur waste, and it looks like rock or granite or something like that. And, then, it's all hardened up. So, I was thinking that, if animal waste went on top of the rock and it splattered and it got really thin and then it just hardened over ten years or something like that, it could have covered it up and stuck onto the granite rock.

Prior knowledge of science concepts. Students relied heavily on basic knowledge of scientific phenomena, such as the water cycle and decay, but many also demonstrated quite nuanced and sophisticated understanding of complex phenomena like global warming, fossilization, and tides. Students even drew from science concepts to respond to social questions. Whether they simply interjected scientific terminology in their answers or actually expounded on the mechanisms involved in various science concepts, it was clear that science—learned in school, from parents, and through popular media—played an important role in students' explanations scenarios. Sudhir shared scientific knowledge throughout the study. He had the following to say as he explained that rain could be causing trees to die.
E: Oh, okay. So what other reasons for why the trees died?
S: Maybe, the area where the trees are, like, are near water, so maybe some people are dumping chemicals. So maybe it went, and that could, the water could become acid rain. Maybe the acid rain fell on the trees.
E: So is acid rain different than real—than normal rain?
S: Yeah, 'cause normal rain usually just has water, but…it's not really pure and then, like, acid rain has, like, chemicals and water with it, mixed in with it. Sometimes it can kill animals.

Limited prior knowledge hindered students' ability to think distally, but emergent patterns showed that students were often able to utilize their prior knowledge if they had a working understanding of concepts. That is, it was not necessary for students to have a completely worked out causal model of phenomena, in order to draw from information they possessed. The marsh scenario posed a serious challenge for students, because the tangible presence of the waves close to the marsh was a compelling cause for the pattern of the water coming in and out. However, all several students had an idea of the moon's role in causing tides and utilized this knowledge to formulate distal responses. Sudhir, a fourth grader said,

S: And, uh, at different points of the day there's a high tide and a low tide, which is controlled by the moon.
E: That is controlled by the moon, you said?
S: Yeah, the moon…when the moon is angled the waves are low or high.
S: 'Cause I say, I know that the moon's pull on Earth can control the tides, like high tide and low tide. So I thought I should explain that a little more.

James, a fourth grader responded, "That happens in water areas. There's usually high tide, because of the moon. 'Cause the water usually follows the moon and the way the moon goes. So, it makes high tide and low tide." In a later session, he elaborated, "I heard that the water travels, follows, the moon, so where the moon is, so if the moon's gone it goes low tide but if the moon's starting to come up and it's getting darker, the water starts going high tide. So in the morning the moon's still barely up and at the night the moon's up." Sahil, a sixth grader said, "Because tides, I think, tides are…I think I read it somewhere, but I'm not sure. I think the tides are because the moon's gravity pulls the water towards it." The more developed their understanding of the relation between the moon and the tides, the more sophisticated their causal model was. It seems, then, that even partial understanding of some concepts can serve as a first step toward a distal conception of phenomena, because it helps to direct students' focus away from the immediate attentional space.

Reshon, a sixth grader, had prior knowledge about the spread of germs and this seemed to allow them to imagine effects that are not directly connected to the cause, "If I shake a hand to any person I know, like my friends, they would get…they would have the cold. And that's not really good." And then later he continued: "Anyone I know would get sick and if that person I know knows anyone, shake their hand or anything or sneeze on them, they would get sick and pass it on and pass it on, without them knowing."

Prior science knowledge did not consistently result in distal responses. Marala utilized her knowledge of water particles to respond to a scenario that asked students to give possible causes for the appearance of a pattern of holes in the clouds that are local in character.

M: Maybe the wind could have blown the holes, because clouds are made up of water particles and the wind could have separated the water particles easily.
E: Okay. So how do you think that the wind does that? How does it separate water particles?
M: Well the water particles are like H2O, you know? Hydro…what's it called again?
E: Hydrogen?
M: Hydrogen and oxygen are going together to make water particles and then they stick together…they're making water particles. And when the wind could come through, it could part them and separate them. So, there would be holes in the clouds, because the hydrogen and the oxygen in the clouds are being separated.

Prior mechanism knowledge in particular. While prior knowledge was generally important, prior knowledge of mechanisms was particularly powerful. For example, in Session 1, when responding to a scenario about the salt marsh, Sahil clearly knew about tides and it was clearly the explanation that he preferred:

S: Could be because of the tide… …like there is water and the moon is right here, so the water attracts to the gravity of the moon and like, it's like, like the Atlantic Ocean. So it's like a little bit, if the moon is over like right here so it'll go right…so the water will go right here because it will attract to the gravity of the moon. So isn't that tide? Isn't that called tide?

E: So of the two ideas you said the tide and maybe the schedule of the ships. If you had to pick one that you thought that…like if you were Deon you would want to check out which one would you want to check out?

S: [Almost instantly] Tide.

Students' reliance on prior mechanism knowledge was particularly evident on their choices and explanations of the multiple-choice survey. Regardless of their preference for local or distal causes, students tended to make their choices based on the general topic of answers. Once students detected a type of mechanism they were familiar with, they typically chose the two answers that discussed that same mechanism. In Session 1, Sudhir demonstrated his knowledge of tides. In Session 3, when it came to choose the best two answers for a question in which the protagonist observed a pattern where, twice a day, water came in and out of a marsh, Sudhir's choices resembled what he knew about tides and waves. He explained,

> "I picked D as the correct answer because I just know watching science channels where they show the moon kind of…the moon's pull on the Earth is kind of controlling the tides. And that's why we pretty much have, like, low tide and high tide. And so, if the moon kind of turns a little, while it's orbiting around the Earth, some places could have high tide and some places could have low tide."

Ihno, a sixth grader, referred to his broader knowledge of technology and how it works, in one of his explanations when asked about someone communicating with him over his DS.

I: No, but he can communicate with him with the DS.

E: Yeah? How do you know that? Like, like, what tells you that?

I: It tells me it because electronics, like a phone, how you can use like, call. Or like a computer how you can just get in touch with your friends and stuff. Like that you can talk to your friends.

Prior mechanism knowledge was perhaps the most evident factor mediating variability between students. Students' knowledge repertoire gave each a unique set of causal dispositions which drove their reasoning. For example, fourth graders, Sudhir and James had a very complex understanding of global warming and greenhouse gases, and they referred to this knowledge several times during the study to make the case for distal causes and effects. In Session 4, James's first thought regarding the possible effects of using holiday lights year-round was global warming:

J: Global warming.
E: Okay. Tell me about that.
J: 'Cause if you put up the lights all year round, then the lights will be on a lot because that's why you put them up and it will just make more global warming because of how much electricity we're using.
E: Okay. So what's going on there?
J: Already we're starting to have a lot of global warming 'cause of how much electricity we use. So with the electricity, the more electricity I'm using, I'm making global warming worst.
E: Can you explain that? As much as you can.
J: Yeah. With the electricity coming out nowadays what we do is we send, in order to get the electricity, we send out greenhouse gases and so when the sun's rays come by and comes to Earth every day, the greenhouse gases trap the sunlight in, making the Earth hotter for people. And the hotness of it is, like, burning plants and giving people sunburns and stuff. So I'm just reasoning that global warming and greenhouse gases.

Sudhir explained aspects of the mechanisms connecting electricity to global warming. "Uh…you know how electricity lets out, I think, carbon dioxide? No, I think it's carbon, but then when it goes into the air its carbon dioxide. Well, they're using that much electricity, maybe a whole year will be a little over, maybe, a ton of carbon dioxide because you're using so much electricity that's added to the greenhouse effect."

Second graders also revealed the use of mechanism knowledge to construct distal responses. For instance, Jaden talked about germs and possible dire consequences in his explanation, "Then you would spread germs, like when you give a high five or shake hands or give a hug. Um, you'll be spreading the germs and then that person will get a cough and then that person touches someone, that person gets a cough. And that person and that person…and it goes all over. And what might happen if all these people get, spread germs? The dogs, cats, all the animals will get it and they will die." Darnel realized that "You might make the whole world sick."

Prior mechanism knowledge did not refer only to students' understanding of mechanisms in science. Students also relied on psychological and social mechanisms. These findings resonate with research on "Theory of Mind" (e.g. Astington & Hughes, 2013) demonstrating that by preschool, and certainly by fourth grade, children have a very sophisticated grasp of others' desires and goals. They can quickly identify and act according to the mores, rules, and consequences in different social contexts. Fourth and sixth graders in this study tapped into their knowledge of social contexts and human interactions to reason about the causal qualities of social and non-social interview questions. They took what they knew about causes and effects in social contexts to supplement the causal details provided in the vignettes. For instance, Sudhir utilized examples of negative human actions and motives, like bragging, cheating, and being deceitful. In Session 3, when he explained why it was possible that a girl could have gained information about Keisha before meeting her by overhearing a conversation between Keisha and the teacher. "Some kids could be bragging about their grades, even to teachers to get their attention a little. And to be, like, to be noticed as the teacher's pet and then saying, 'Oh, the teacher said I'm her favorite.' So she's just trying to show her, like, 'Oh, I have good grades' and then trying to get her to have a teacher's pet. But today, like, everybody's just equal, even in their education."

Certain scenarios were much more likely to compel reasoning about the mechanisms involved in action at an attentional distance than others. The scenarios focused on germs and bottles had the most distal responses. These were closely followed by scenarios focused on DS games, having someone find know how to find the protagonist without direct communication, and the salt march. The granite rock, cloud formations, and fertilizer scenarios had the fewest and only one student expressed the scientific knowledge that might have enabled a distal response. These appear to have interacted with students' knowledge. Students expressed the most mechanism knowledge in response to those for which they gave the most distal responses. It is possible that for other scenarios, students found that they were adequately resolved by more local responses, such as the patterns in the clouds and the granite rock, and so these were less likely to compel more distal responses.

Connecting causes and effects through narratives that linked mechanisms. Narratives tended to aid students' creation of distal responses as they constructed explanations based on their prior knowledge and personal experience. Thinking through a narrative also functioned as a medium through which students imagined the mechanisms that connected the two. Although not all narratives contained a mechanism, students were more likely to discuss one within the context of a narrative. Jaden, a second grader, offered a long extended narrative for how germs could have distant effects:

> "Then you would spread germs, like when you give a high five or shake hands or give a hug. Um, you'll be spreading the germs and then that person will get a cough and then that person touches someone, that person gets a cough. And that person and that person…and it goes all over. And what might happen if all these people get, spread germs? The dogs, cats, all the animals will get it and they will die. ….Nobody would be able to do their job. Um, that's interesting. People would die. There would be nobody helping the world. Like protecting the world. There would be no reason to protect the world because even the bad guys would die. Construction workers, they couldn't build because they were all sick. And more people they couldn't get new houses. So they would have to live with what they have. All the stores would be closed… You couldn't watch, like, the Celtics play, football games, baseball games, any kind of games or whatever you want to watch you couldn't watch it because there will be nobody to like make it [Athletes would be affected too?] Yeah, um, the world would be quiet, so quiet, um, lots of people would go to sleep. And that's all."

DISCUSSION

The etic and emergent patterns create a textured picture of students' inclinations when interpreting phenomena in which the cause and effect do not reside in the same attentional space. We observed that students found these tasks challenging and that they tended to respond with local causes and effects. However, students also demonstrated an ability to formulate distal responses, especially when aided by their prior knowledge and experience, familiarity with the context, and creation of narratives. It seems that the broader students' knowledge and experiential repertoire, the more likely they to focus on potential causes and effects beyond their immediate attentional space.

The finding that students chose responses characterized by action at an attentional distance on the multiple choice inventory raises the question of whether students find it difficult to generate distal explanations or tend towards efficiency such that they do not to invest the extended effort to generate them. Ultimately, whether or not people reason about extended impacts involving action at an attentional distance is consequential for the ecological systems with which we interact. However, the answer to the question of whether this is due to tendency or ability has important instructional implications. Ability can be viewed in terms of building a repertoire of causal instances that involve action at an attentional distance. These findings suggest that students believe that it is possible, and even feasible, for causes and effects to exist across spatial discontinuity in separate attentional frames.

Mechanism and prior knowledge also played a strong role in students' reasoning about action at an attentional distance. This follows is consonant with the extant research on action at a distance within the same attentional frame. In many respects, it makes sense that mechanism plays such an important role when the causes and effects are in two separate attentional frames. The co-variation relationship between causes and effects is obscured in action at an attentional distance (Grotzer & Tutwiler, in review). As co-variation is difficult to discern, students would need to rely upon other models of causal induction, primarily knowledge of mechanisms and how they work and prior knowledge of causal connections as a means to connect possible causes and effects.

The prior knowledge that students drew upon often came in the form of information that they had learned from other sources. This resonates with the arguments that Harris (2012) has made about the importance of testimony in children's learning about information that is beyond their perceptual reach. The simple, yet significant, conclusion gained from his work is that children depend on the knowledge, or testimony, of other individuals in order to learn about phenomena they cannot observe for themselves. Many facts and concepts in history, religion, and certainly, science require that children trust in what others tell them to be true. The concept of trust in testimony has not been explicitly studied in the context of science education, but it is not surprising that students invoked the knowledge gained from others when they reasoned about action at an attentional distance when either the cause or effect was intangible to the observer.

Narratives that connected mechanisms from proximal to distal are particularly interesting in terms of attentional frames. In a sense, these narratives function to bring causes and effects into the same attentional frame. It can be argued that the plausibility for action at an attentional distance might be furthered by causal entities that in some ways bridge or broach attentional frames. For instance, the moon is not always visible in the sky when the tides are acting, but it moves in and out of the same attentional frame as the tides, perhaps setting up a plausible case for its role in the movement of water. Similarly, the sun can enter our attention frame as it warms our skin even though it is very far away. This might set up the plausibility of the sun as a possible cause of sun burn or skin cancer over longer time frames when cause and effect are not in the same frame. Connections such as these may well have attentional advantages over those that do not broach the same frame such as carbon and resulting climate change.

The findings of this study suggest that instruction can leverage knowledge of mechanisms and powerful narratives to help children connect distant causes and effects. Drawing upon a distinction made by Pazzani (1991) between theories of causation and theories of causality, powerful narratives enable knowledge of particular instances of causation. With high-order reflection upon these instances, instruction may be able to help students to build theories of causality that include action at an attentional distance as a potential defining feature. We are currently testing curriculum that employs such techniques as a next step in figuring out ways to help students develop an understanding of action at an attentional distance.

Even given this promise, the challenges of helping students to actually recognize action at an attentional distance in the real world are humbling with a number of difficult challenges to surmount. For instance, it is likely that instances with local effects and distant causes would be easier to detect because they involve an attentional trigger but not all phenomena involving action at an attentional distance involve such triggers. When causes are local (as when connected to our own actions) and the impacts are distant, there is little to draw our attention to them. Further, as action at an attentional distance is compounded with other complex causal features, such as non-obvious mechanisms; outcomes that involve time delays and other accumulation features, the challenges become exponentially greater. However, not recognizing action at an attentional distance can have high environmental costs, so further study of how children learn to understand and recognize it can have important consequences for the next generation.

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