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Preschoolers' Understanding of Mental and Bodily Reactions to Contamination: What You Don't Know Can Hurt You, but Cannot Sadden You

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Evidence of the operation of a biological theory might be found in children's distinction between mental (emotional) and bodily (illness) reactions to contamination. Study 1 explored whether children see emotions as voluntary but illness as outside of intentional control. Three- and 5-year-olds judged that simple volitions were insufficient to alter either outcome. Study 2 suggested that children distinguish reactions mediated by representations from those mediated by physical interactions. Children indicated that knowlege determines mental reactions to contamination, but physical contact determines bodily reactions. Study 3 explored knowledge about particulars of emotional and illness reactions. Most preschoolers did not realize that illness takes time to develop. These data suggest that preschoolers do distinguish between physical and mental reactions to contamination but have a poor understanding of the actual bodily processes involved.

Recent research suggests that young children's cognition may be understood as organized around a set of framework theories that provide coherent accounts of causal relationships within particular domains (see Wellman & Gelman, 1992, for a review). Within this tradition, some consensus exists that children have at least two framework theories: a commonsense physics and a theory of mind (e.g., Carey & Spelke, 1994; Gopnik & Wellman, 1994). Debate continues regarding a third theory: a framework theory of biology. Some researchers find evidence that preschoolers hold such a theory (e.g., Hatano & Inagaki, 1994; Keil, 1992; Wellman & Gelman, 1992), whereas others argue that a distinct biological domain does not appear until children reach school age (e.g., Carey, 1985, 1995; Solomon, Johnson, Zaitchik, & Carey, 1996). Evidence for and against these assertions has come primarily from two sources: studies of children's understanding of morphological features of living things (including beliefs about inheritance) and studies of beliefs about illness causation (including contagion and contamination). This article contributes to this debate by extending research on young children's understanding of contamination. In particular, I focus on children's understanding of different types of reactions to contamination. Do preschoolers share the adult intuition that contamination has different effects on the mind and the body?

Young children have often been said to see illness in psychological or social terms (e.g., Hergenrather & Rabinowitz, 1991; Perrin & Gerrity, 1981). This position is consistent with Carey's (1985) claim that preschoolers have not differentiated biological from behavioral phenomena. Thus, one might expect that children see contamination as a social-psychological phenomenon. Yet, evidence suggests that preschoolers have a physical understanding of contamination. They know that contaminants may be invisible, physical particles (Au, Sidle, & Rollins, 1993; Rosen & Rozin, 1993) and that physical contact is necessary for a contaminant to render a food dangerous (although a substantial minority of preschoolers may miss this; Springer & Belk, 1994). Furthermore, they know that contamination causes illness through the actions of invisible entities (e.g., germs; Kalish, 1996), at least in some cases. Thus, contamination seems to be understood to be a physical process. However, these findings concern only the sources of contamination. Also crucial to a biological understanding of contamination are beliefs about how the contaminants affect the body. What seems to make contamination a biological process is that it affects living things; contaminants make people sick. In existing literature, researchers have not focused on this aspect of the problem. We know little about how children conceptualize different sorts of reactions to contamination.

Adults recognize two different kinds of reactions to invisible, physical contaminants: emotional reactions (e.g., sadness) and physiological reactions (e.g., illness). Although the two responses are similar in some respects, they can be seen as quite different. Emotions are psychological states mediated by mental processes; they are how contamination affects people's minds. Illness is a physiological state mediated by physical processes; it is how contamination affects people's bodies. The physical

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nature of the contaminant does not guarantee that a person's reaction is similarly physical. If one is interested in characterizing children's understanding of contamination as biological or not biological, it is crucial to know how they think about reactions to contamination. In particular, it is important to know whether children also make a distinction between mental and bodily responses.

Psychological states may be distinguished from physical states in that the former are intentional whereas the latter are not. There are two senses in which psychological states may be intentional. In the narrow sense, *intentional* means voluntary or under conscious control. Inagaki and Hatano (1993) have argued that children distinguish psychological and biological states because psychological states are recognized as consciously controllable (through purely mental means), whereas biological states are said to be alterable only through physical means. Study 1 of this article explored whether children use narrow intentionality to distinguish mental and bodily reactions to contamination. In the second, broad sense, *intentional* means representational or about something. Emotions may be intentional (one is disgusted about something, or sad that something occurred) whereas illness may not be. In more general terms, this distinction also refers to the fact that mental events are embedded in a network of causal relationships with other intentional states (Wellman, 1990). For example, children know that mental states are not physical things (one cannot see a desire for a cookie; a belief about fire is not hot; Wellman & Estes, 1986). Children also recognize that the representational content of mental states has causal force (e.g., people's actions are determined by what they think, not what actually is the case; Bartsch & Wellman, 1989). However, bodily states are embedded in a network of physical causal relationships. Physical interactions, rather than representations, have causal force. In Study 2, I explored whether children recognize that mental reactions to contamination are broadly intentional (dependent on representations) whereas bodily reactions are not.

Although mental and bodily processes may generally be distinguished by intentionality, more specific differences between emotional and illness reactions to contamination exist. In particular, emotional responses are typically immediate whereas illness takes time to develop. This is not always true of mental and bodily reactions (e.g., realization may dawn slowly, whereas reflexes are very fast). One expects different progressions because of one's understanding of the processes involved. Illness involves incubation of a disease agent and some bodily response. This develops over time. One tends to see the mental processes involved in emotion as rapid (and often contrast emotions with deliberate rational reactions). Thus, understanding the different types of processes occurring in response to contamination leads to expectations that mental responses will be quick, and bodily responses will be slow. In Study 3, I explored whether preschoolers understand enough about the particular processes involved to expect a difference in time course between mental and bodily responses to contamination.

The three studies reported in this article address young children's understanding of mental and bodily responses to contamination. Of the many potential bodily responses to contamination (e.g., pain, injury, or death), I focused on sickness in these studies. Two psychological reactions were explored in these studies: sadness and perceptions of "yuckiness."[1] Although thinking that something is "yucky" may not be a strictly emotional reaction, understanding that both reactions are mediated by representations rather than physical mechanisms is crucial. Because many changes in understanding the relationship between intentional and nonintentional processes occur between the ages of 3 and 4 years, these studies included both younger (3-year-olds) and older (4- to 5-year-olds) preschoolers. Debates about conceptions of biology also center on children of these ages—for example, whether children younger than 7 years see inheritance as biological (Solomon et al., 1996; Springer & Keil, 1991). Part of adults' commonsense theory of biology is understanding how contamination may lead to illness. Commonsense theory of mind accounts for the connection between contamination and emotional reactions. The different theories involved distinguish these two reactions. The studies reported in this article address the question of whether children have the requisite theories to make similar distinctions.

Study 1

Actions and processes that have psychological causes are often voluntary and consciously controllable, or intentional in the narrow sense. Biological events are involuntary, and physical intervention is required to alter them. For example, speaking is typically intentional in this sense; a person chooses what to say and when to stop talking. Heartbeats are typically nonintentional; decisions are not necessary to make hearts beat, and intentions are not sufficient to stop them. This distinction is not the same as changeable versus unchangeable (Bales & Sera, 1995)—one can stop one's heartbeat, it just requires some physical actions in addition to the intentions.

One way children may distinguish mental and bodily phenomena is to treat all (and only) psychological states as intentional in the narrow sense: as pure products of mental forces. On the basis of this rationale, Inagaki and Hatano (1993) asked children whether various traits could be changed and how. Four- and 5-year-olds often cited effort or psychological processes as effective in changing mental characteristics (e.g., a quick temper) but gave only physical means for changing bodily characteristics (e.g., eye color). Inagaki and Hatano argued that this distinction between (narrowly) intentional and unintentional states demonstrates that children do distinguish biology from psychology. Psychological states are intentional, biological are not, and children recognize both kinds. Thus, in asking whether children distinguish mental and bodily reactions to contamination, psychologists should assess children's views of intentional control. A psychological reaction, such as emotion, should be

[1] Perceptions of yuckiness were used as a rough surrogate for judgments of disgust. Disgust is a difficult concept to convey to children and has usually been assessed by participants' ratings of how much they would or would not like to touch some object (e.g., Rozin, Fallon, & Augustoni-Ziskind, 1985). This measure also seems only to partially capture the notion of disgust. A more valid measure of disgust might involve the use of characteristic facial expressions (Ekman, 1972). However, the concern of this article is not judgments of disgust per se but rather the contrast between emotional–psychological reactions and physiological reactions.

under voluntary control. A physical reaction, such as illness, should be involuntary.

One problem with the above formulation is that adults recognize psychological states that are not narrowly intentional. For example, people do not choose their perceptions; if someone waves a red flag in front of our eyes, then we see red. Emotions (such as sadness) are also not completely voluntary. For example, humans cannot choose when or whether to be sad. However, we do exhort people to control their emotions—as if they had a choice. Thus for adults, the voluntary–involuntary distinction does not map exactly to the mental–nonmental distinction. Researchers know little about children's beliefs about the intentionality of mental states. Some studies have explored children's identification of purposeful and accidental movements (Schult & Kalish, 1993; Schult & Wellman, in press; Shultz, 1980), but these studies have focused on behaviors rather than on mental states. Thus, psychologists do not know if children recognize involuntary mental states. For children, mental–nonmental may correspond to (narrowly) intentional–unintentional.

For adults, both emotions and illness are involuntary reactions to contamination. Although one is mental and the other bodily, both are seen to be outside one's conscious control. If children recognize the psychological nature of emotions such as sadness and the physical nature of illness, they may believe that the former is intentional whereas the latter is not. If children do not have a conception of biology that is separate from their theory of human behavior (Carey, 1985), they may treat both sadness and illness as intentionally controllable. Thus, three patterns are predictable: the adult pattern of judging neither sadness nor illness to be intentional, an overpsychologizing pattern of treating both as psychological and intentional, or a differentiated pattern, with emotions seen as intentional but illness not.

As an assessment of their intuitions about intentionality, children judged whether people could choose to stop being sad or sick "just by wanting to." Questions were asked about changes of state, rather than about avoiding illness or sadness (e.g., choosing not to be sad), because both illness and emotions are probabilistic and vary from individual to individual. It is not clear when someone will get sick or sad in the first place. This form of questioning also corresponds to the methods used by Inagaki and Hatano (1993). In addition to judging whether states were under volitional control, children were also asked to indicate how states could be changed (or why they could not be). Responses to open-ended questions were coded for mention of mental or physical processes. Thus, in this study I explored one way that children might distinguish mental and bodily reactions to contamination. I further tested whether children accept that a psychological reaction may be involuntary.

Method

Participants. Twenty children recruited from preschools in a mid-sized midwestern city participated in the study. Ten were included in an older group (M age = 4 years 7 months, range = 4 years 4 months to 5 years 3 months). Ten children were included in a younger group (M age = 3 years 4 months, range = 2 years 11 months to 3 years 8 months). Children were predominantly White and from middle-class backgrounds. Each group had an approximately equal number of boys and girls.

Design and procedure. Children were presented with six stories in which characters knowingly ate contaminated food. The experimenter explicitly told the child about the resulting reaction of the character. In some cases, characters were said to be sick; in other cases, they were said to be sad. The emotion sadness was used because it was thought to be familiar and easily conveyed verbally to children. In addition to the six contamination stories, three stories presented characters experiencing reactions that could be altered voluntarily (e.g., closing eyes to avoid a bright light). A complete list of stories is presented in the Appendix. Items were presented in random order. After hearing each story, children were asked how the character could change his or her state. The child was asked whether, "just by wanting, without doing anything else," the character could change state (e.g., stop being sad, stop being sick, or close her eyes). This yes-or-no question was followed by an open-ended request for justification: "How could they do it?" or "What would they have to do?" Children were informed that they could show the experimenter how to make the change rather than describe the action in words.

Coding. Justifications were coded independently by the author and by an assistant who was unaware of the hypotheses and the purposes of the study. Responses were coded into one of three categories: immediate justifications, which simply required the formation of the correct intention (demonstrations of movements were coded into this category); mediated justifications, which required some physical action in addition to the intention; and uncodable, which included injunctions (e.g., "He shouldn't do that") and null and irrelevant responses (e.g., "My mom is sick"). Justifications referring to effort or mental practice (e.g., "He has to try hard" or "He has to think of something nice"; see Inagaki & Hatano, 1993) were counted as immediate. No child produced this kind of response. Eighty-nine percent of responses were codable as either immediate or mediated justifications. Uncodable justifications were dropped from analyses, and results report proportion of codable responses (i.e., proportion mediated + proportion immediate = 1 for each child). Raters agreed on codings 90% of the time. Disputes were resolved in favor of the impartial rater.

Results

The mean proportions of responses indicating that a character could change state by changing his or her mind are presented in Figure 1. Also indicated are the proportion of immediate justifications—responses indicating that intermediate steps were not required for the change to occur.

Three-year-olds did not see changes as differently possible for the three types of states. They tended to say all characters could change state, but about one third of responses denied that each state could change. Four-year-olds judged that changes could happen more often for voluntary items than for emotion or illness items: voluntary versus emotion, $T(6) = 0.0$, $p < .05$; and voluntary versus illness, $T(7) = 0.0$, $p < .05$ (one-tailed Wilcoxon tests).[2] Children in both age groups justified their answers in different ways. Younger children gave more immediate justifications for voluntary than for emotion or illness items: voluntary versus emotion, $T(9) = 44$, $p < .01$; and voluntary versus illness, $T(9) = 44$, $p < .01$. Emotion and illness items both received mediated justifications and did not differ from each other, $T(5) = 10$, *n.s.* The same patterns characterized older children's explanations for how the changes could occur: voluntary versus emotion, $T(9) = 45$, $p = .005$; volun-

[2] All tests are one tailed unless otherwise indicated. Two-tailed tests were used when there were no a priori predictions about directions of effects.

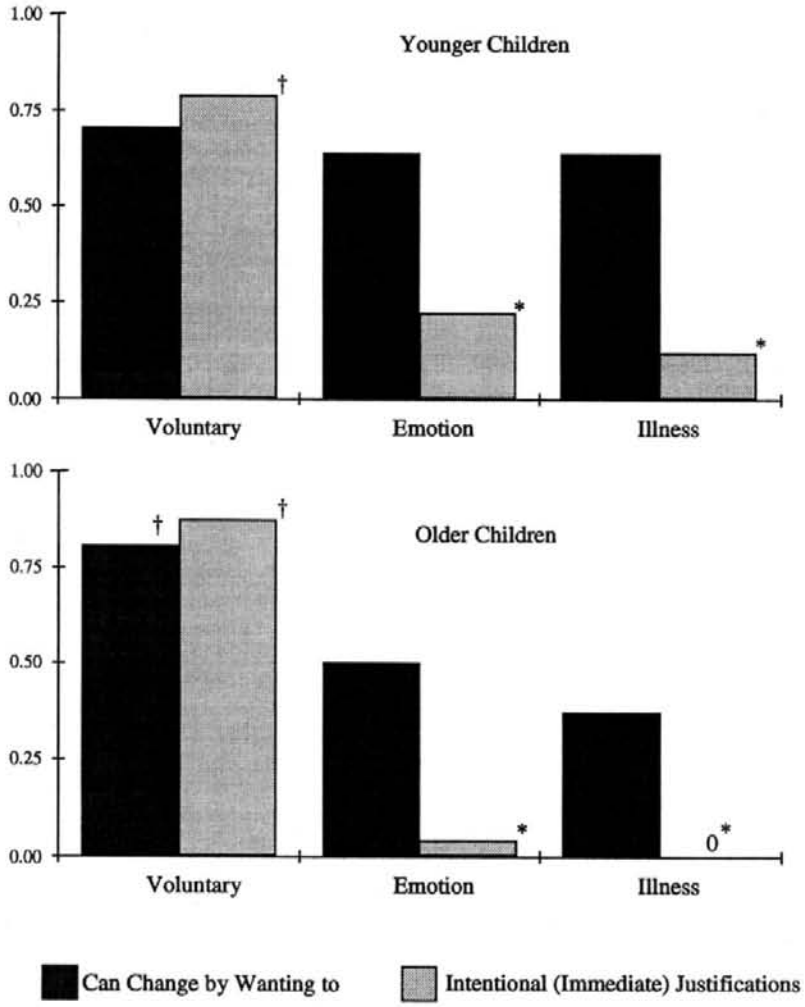

Figure 1. Results from Study 1. Bars indicate mean proportions of judgments that characters cannot change state just by wanting to and mean proportions of codable justifications that mentioned some intermediate steps between intentions and state changes. Cells in which performance differed from chance are indicated (*below chance, $p < .05$; †above chance, $p < .05$, Wilcoxon tests).

tary versus illness, $T(10) = 50$, $p < .005$; and emotion versus illness, $T(1) = 1$, *ns*.

Justifications for voluntary actions often (30% of total) involved the child demonstrating how to change the state. For example, a child would say "just do this" and would close his or her eyes to show how to avoid the bright light. An instance of a mediated justification was, "by turning off the lights." Justifications for emotion items usually involved substituting a new piece of food for the contaminated one. For example, a child would say the character could stop being sad by getting a new apple. An example of an immediate justification was, "He can just feel happy." Justifications for illness items typically involved going to the doctor or taking medicine. Other examples were "by washing the cookie," "by waiting until he stops being sick," and (an immediate justification) "just keep thinking about it."

A set of patterns can be defined to evaluate the consistency of individual participants' responses. Table 1 presents the number of children showing one of three possible patterns of responses. One pattern involves answering correctly for eight or nine of the nine items ($p = .02$, binomial theorem)—yes–immediate for voluntary items and no–mediated for emotion and illness items. A second pattern was defined as treating eight or nine changes as voluntary–immediate. Finally, a third pattern involved treating eight or nine changes as involuntary–mediated. Many children gave consistent justifications. Of these children, most showed the correct pattern. Fewer children gave constant responses to forced-choice questions. These pattern data are consistent with the group data reported above.

Discussion

Children recognized conditions that may be voluntarily altered through purely mental processes and conditions that require some physical action to mediate between an intention and a change. Responses to forced-choice questions ("Could he do

Table 1
Numbers of Children Showing Three Patterns of Responses: Study 1

Measure/children	Pattern		
	Correct[a]	Voluntary	Involuntary
Yes/no			
Older children	1	0	1
Younger children	1	3	0
Justifications			
Older children	9	0	0
Younger children	5	0	1

[a] Children were credited with showing a pattern if eight or nine (out of nine) responses were consistent ($p < .02$, binomial theorem, assuming P[correct] = .5).

it just by wanting to?") were generally uninformative. Children tended to answer the same way for all items, and few children showed clear patterns. They may have had difficulty understanding that the "just by wanting to" phrase was intended to focus specifically on mental causes (see also Schult & Kalish, 1993, for similar findings). Justification data, however, revealed clearer patterns. Both younger and older children indicated that simple actions (e.g., closing one's eyes) were direct products of intentions. However, children also judged that sadness and illness were unintentional. In both cases, children reported that physical means were necessary to effect changes in these states. In this way, mental and bodily reactions to contamination did not differ. Both were seen as beyond conscious mental control.

These results suggest that children do not use intentions (in the narrow sense) to distinguish between psychological and physical reactions to contamination. Both mental and bodily states may be involuntary. Although this result calls into question one means of demonstrating that children recognize nonpsychological reactions to contamination, it does not positively address the question. Study 2 explored another source of evidence for a distinction between the effects of contamination on the mind and the body.

Study 2

Both psychological and physical states may be unintentional in the narrow sense (of voluntary). However, in the broad sense of intentional (as involving representations), the two kinds of states are distinct. Mental and bodily phenomena are characterized by different sorts of causes. Effects on the body are mediated by physical interactions. For example, it is what one eats rather than what one desires that determines weight gain (Ingaki & Hatano, 1993; Johnson & Wellman, 1982). Psychological relationships, however, are mediated by representations; it is what one knows or thinks about a physical relationship that has psychological force. Thus, a biological reaction to contamination will involve physical interactions. For example, whether a person comes into contact with a contaminant will determine whether he or she gets sick. The person's mental state (e.g., what he or she knows or desires) will not affect this outcome. On the other hand, a psychological reaction is dependent on representations. Whether the person knows about a contaminant affects his or her emotional response. Physical contact is not necessary (e.g., one can be disgusted without actually ingesting anything; Rozin & Fallon, 1987). Whether it is representations or physical interactions that determine a particular state can indicate whether that state is mental or physical.

Study 2 presented children with a variety of stories involving characters who did or did not eat some contaminated food and who did or did not know about the contamination. Children were asked to predict who would get sick and who would be disgusted (operationalized as predicting whether a character would think a particular food is yucky or not, see Footnote 1). Of interest is whether illness and disgust are predicted from different features. In particular, if children see illness as a biological reaction to contamination, they should believe physical contact determines illness. If children overpsychologize, they may believe that characters' mental states determine whether they get sick.

Method

Participants. Twenty-five children recruited from preschools in a midsized midwestern city participated in the study. Twelve children were included in the younger group (M age = 3 years 8 months, range = 3 years 1 month to 4 years 3 months). Thirteen children were included in the older group (M age = 5 years 0 months, range = 4 years 7 months to 5 years 7 months). No child had participated in Study 1. Children were predominantly White and from middle-class backgrounds. Groups contained approximately equal numbers of boys and girls.

Design and procedure. Children were told eight stories involving characters and contaminated foods. Stories varied on two binary dimensions: whether the character in the story ate the food, and whether the character knew the food was contaminated. These dimensions were crossed, resulting in four story types (see Appendix for complete list of stimuli). Two instances of each type were used in the study. For each story, children were asked to make two judgments (in random order): whether the character in the story would get sick and whether the character thought the food was yummy or yucky. The belief (yummy or yucky) was used in place of sadness (from Study 1) to focus attention on the contaminated food. Asking whether the character was sad could too easily be interpreted as asking about the character's reaction to his or her illness (or lack of illness). The important feature is that this psychological reaction depends on knowledge rather than contact. Stories were presented in random order. Each story was accompanied by colored line drawings representing the action.

Results

The mean proportions of judgments predicting illness and disgust (yucky) are presented in Figure 2. Also included in Figure 2 is the "correct" pattern of responses that are based on treating disgust as dependent on knowledge and illness as dependent on contact. Cells that differed from chance (.5) in the predicted directions are indicated. Effects of each dimension were tested by comparing mean responses averaged across levels of the nontested dimension (e.g., the mean response when characters knew, computed across both levels of eating, was compared with the mean score when characters did not know, similarly averaged).

Younger children more often predicted disgust when characters knew about contamination than when they did not, $T(7) =$

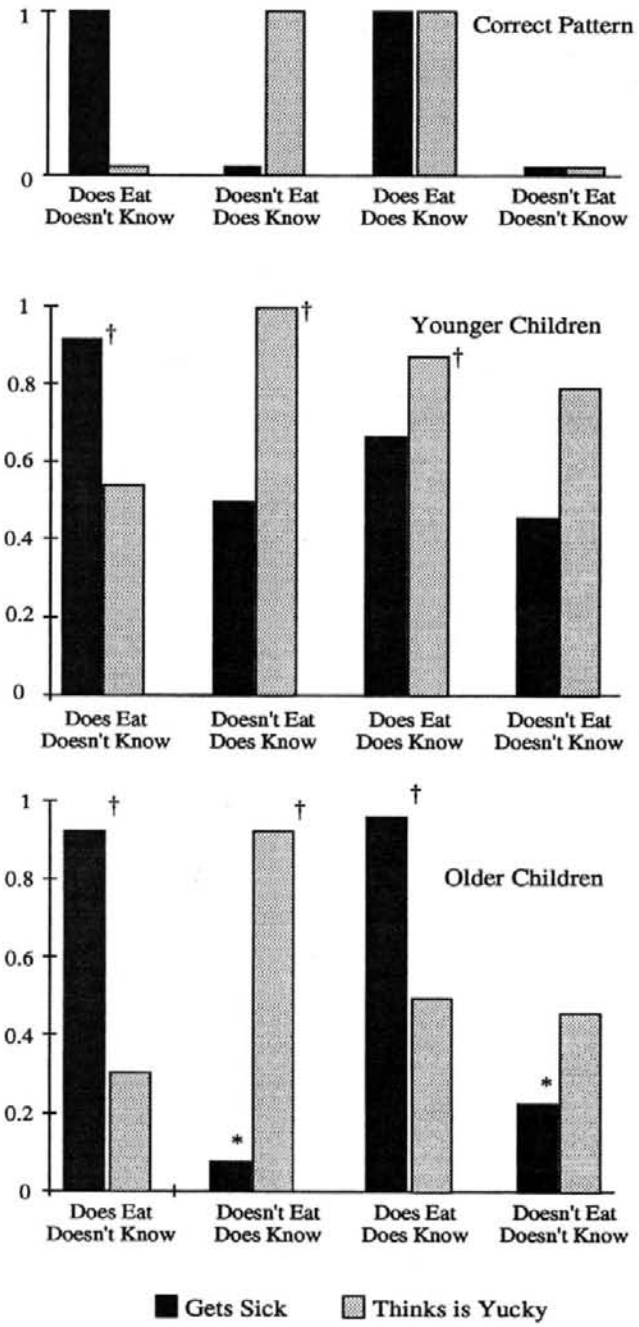

Figure 2. Predicted and observed patterns of judgments from Study 2. Bars indicate proportion of judgments that characters will get sick and proportion of judgments that characters think the food is yucky. Cells in which performance differed from chance are indicated (*below chance, $p < .05$; †above chance, $p < .05$, Wilcoxon tests).

24.5, $p < .05$ (one-tailed Wilcoxon rank test). The difference between characters who ate the food and those who did not was not significant, $T(5) = 0.0, p < .06$ (two-tailed). Older children not only showed the same effect of knowledge, $T(10) = 55$, $p < .01$, but also showed an effect of eating $T(13) = 15.5$, $p < .05$ (two-tailed). Characters who did not eat the food were judged to think the food was yucky. Illness judgments showed a different pattern. Both age groups thought eating led to illness more often than not eating: younger, $T(6) = 21$, $p < .05$; older, $T(10) = 55$, $p < .005$. Neither group thought that knowledge made a difference in whether characters would get sick: younger, $T(5) = 3.5$, *ns*; older, $T(4) = 3.0$, *ns*, two-tailed. The difference between predictions of illness for eating and noneating stories was greater for older than younger children, $T(12, 13) = 102.5$, $p < .005$ (Mann-Whitney test). Otherwise, the groups did not differ.

The different bases for judgments of disgust and illness are seen most clearly in responses for two types of items: Does Eat/Doesn't Know and Doesn't Eat/Does Know (see Figure 2). These items conform to typical expectations about the outcomes of stories (e.g., people who know food is dirty probably won't eat it). The other two items involve conflicting information. Poorer performance on Does Eat/Does Know and Doesn't Eat/Doesn't Know may have resulted from children's attempts to make sense of the incongruent stories. Five-year-olds' belief judgments seem to have been affected by characters' actions (whether they ate the food), usually a reasonable strategy. Three-year-olds seemed biased to say characters thought the food was yucky, except in cases in which both pieces of information pointed to the opposite inference: that is, the Eats/Doesn't Know stories; the mean proportion of yucky judgments for all other items was .89, greater than chance, $W(12) = 78$, $p < .005$, two-tailed.

Individual response patterns were also analyzed. Children made eight judgments of sickness and eight of disgust. Answering seven or eight of either type of question correctly differs from the proportion expected by chance ($p < .05$, assuming a .5 random chance of correct responding, binomial theorem). Two younger and 2 older children showed the correct pattern for disgust judgments. Two younger and 10 older children showed the correct pattern for illness judgments. Finally, 3 younger children judged that characters thought the food was yucky on seven or eight of the eight trials (also $p < .05$). These data are consistent with the group data. Older children did better on illness items. Younger children seemed biased to predict yucky responses.

Discussion

Children in both age groups predicted illness and disgust differently. Characters' knowledge of contamination did not influence predictions of illness. Knowledge of contamination did affect predictions of disgust (thinking the food is yucky). Predictions of illness were sensitive to contact; characters who ate the food were more likely to get sick than those who did not (whether or not they knew about contamination). Although children's predictions did deviate significantly from the correct pattern (see below), performance on the two canonical story types suggests that children were treating illness as physically mediated and disgust as intentionally mediated. When characters unknowingly ate contaminated food, they were predicted to get sick and to think the food was yummy. When characters avoided eating food known to be contaminated, they were predicted not to get sick and to think the food was yucky. Children did seem to distinguish mental from bodily reactions to contamination.

Children frequently gave incorrect responses. Younger children seemed generally biased to say that characters would think the food was yucky. This response is consistent with 3-year-olds' difficulties with false beliefs (Perner, Leekam, & Wimmer, 1987). In false-belief tasks, these children often predict beliefs according to the actual state of the world rather than according to what a character knows. Because all foods included in this task were actually yucky, this difficulty would lead to predictions that all foods were thought to be yucky. Younger children's predictions of illness were closer to correct patterns, although there seems to have been some bias to predict illness for all items. This response may be akin to the false-belief errors (e.g., all foods really would make people sick, so predict illness). Alternatively, both response biases may be due to conversational norms (e.g., because the experimenter is mentioning disgusting, unhealthy food, predict disgust and illness). Older children's responses more closely matched the predicted patterns, especially for illness judgments. Disgust judgments, however, were affected by whether the character ate the food as well as by knowledge. There is a relationship between eating and disgust; however, the direction of causality opposes that in the eating–illness relationship. Eating causes illness, whereas not eating is caused by disgust. Children may have perceived noncanonical stories (Eats/Knows and Doesn't Eat/Doesn't Know) as presenting conflicting information (e.g., if the person knew about contamination, why did he or she eat the food?). Disgust predictions were at chance levels for these stories. Only careful attention to the details of the stories would allow children to resolve the conflicting information. Illness judgments, however, did not show the effects of this conflict.

Contact with contaminated foods can cause emotional reaction through intentional processes and illness through physical processes. Children seem to have associated emotion and illness with the appropriate types of causality; emotion is part of the psychological world and illness part of the nonpsychological world. Do children, however, know more about the two responses than this? In particular, do they have some more specific knowledge about responses to contamination that might provide evidence for a naive theory of biology? From Study 1, it appears that children do know that the processes of illness are not under direct, voluntary control. In this way, though, illness does not differ from psychological reactions. However, there are other differences between emotions and illness. One difference is time course; emotional response is often an instantaneous reaction to contamination, whereas illness is a delayed reaction. Although time course does not always distinguish psychological from biological events, adults do see a speed difference between biological and psychological reactions to contamination. If children share adults' understanding of the biological processes involved in contamination, they may also see illness as a delayed effect.

Study 3

The mental events that result in emotional reactions happen very quickly. The biological events that result in illness, after contact with contamination, typically take some time. This is not a hard-and-fast distinction; physiological reactions to chemical contamination can be quick, and disgust or sadness can be a delayed reaction after one has pondered the implications of contamination. However, in the typical course of events, the speed of the two kinds of reactions differ. Although why people think emotions happen immediately is not clear, adults do have some commonsense understanding of the process of illness. At least in Western culture, people often understand contact with contaminated foods to transmit some agent (e.g., germs or poison), which begins a chain of events within the body. Illness results when the contaminant acts and the body responds. Although children need not share adults' understanding of germs and the immune system to have a biological understanding, they should recognize that there are some internal bodily processes that mediate between contact with a contaminant and the experience of illness. These bodily processes take some time. Thus, a biological understanding of the reaction to contamination should involve the belief that illness is a delayed result. In this way, the bodily reaction differs from the mental reaction. Study 3 asked children when (immediately or after some time) contact with contamination would result in bodily (illness) and mental (emotional) reactions.

Method

Participants. Twenty-two children recruited from preschools participated in the study. Eleven were included in an older group (M age = 5 years 1 month, range = 4 years 10 months to 5 years 6 months). Eleven children were included in a younger group (M age = 3 years 8 months, range = 3 years 5 months to 4 years 4 months). Children were predominantly White and from middle-class backgrounds. No child had participated in Study 1 or 2. An approximately equal number of boys and girls were in the two groups.

Design and procedure. Children listened to 12 stories. Each story described a character in the midst of some process. In 2 control stories, the outcome was an immediate product of the activity (e.g., a hand feeling hot when put on a stove). In 2 control stories, the outcome was delayed; some intervening time was required before the action produced a result (e.g., planting a seed to get a carrot). Eight stories (4 each) probed children's beliefs about the time course of emotional and biological reactions to contamination. A complete list of stimuli is presented in the Appendix. Before each story, children were first reminded of the connection between the action and the outcome (e.g., "To get a carrot you plant a seed" and "People get sad when their food gets dirty"). Stories then described the antecedent activity (planting a seed, food getting dirty). Children were asked when the character would experience the outcome (get a carrot, be sad). For example, "Right now, just when her food gets dirty, will Jenny be sad? Will Jenny be sad right now or not until later?" Stories were presented in random order, and order of alternative responses in questioning varied randomly.

Results

Figure 3 presents the mean proportion of judgments that outcomes would be delayed (not occur immediately). Younger children tended to judge that all outcomes would happen instantly. However, judgments for delayed controls were significantly different than judgments for other items, $T(10) = 1$, $p < .005$. Four-year-olds discriminated more and sharply differentiated immediate and delayed items, $T(9) = 45$, $p = .005$. Thus, children at both ages did distinguish between immediate and delayed outcomes, although older children did so more consistently.

The main questions of interest concern the emotion and illness items. Three-year-olds judged both sadness and illness to be

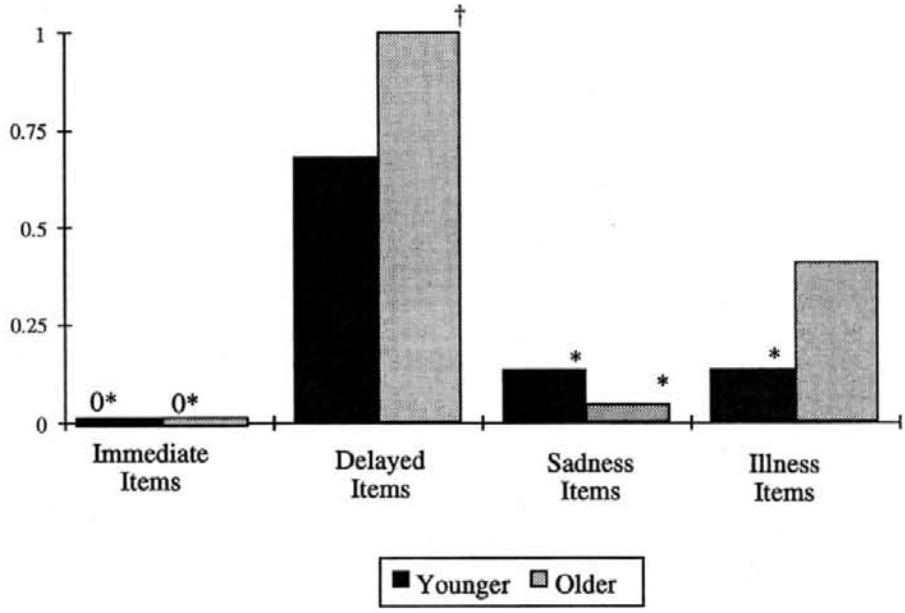

Figure 3. Results from Study 3. Bars indicate proportion of judgments that effects would be delayed. Cells in which performance differed from chance are indicatetl (*below chance, $p < .05$; †above chance, $p < .05$, Wilcoxon tests).

immediate consequences of contact with contaminated food. Judgments for both differed from delayed items, $T(9) = 45$, $p < .005$, and $T(10) = 53.5$, $p < .005$, respectively, and did not differ from each other, $T(5) = 6$, *ns*. Four-year-olds also judged sadness and illness to be immediate (e.g., vs. delayed items), $T(11) = 66$, $p < .005$, and $T(9) = 45.0$, $p < .005$, respectively. However, older children did see more delay for illness than for sadness, $T(7) = 0$, $p = .01$.

Most of the difference between older children's responses to emotional and illness items was due to a few children who performed perfectly on the task. A pattern of correct responding can be defined as answering seven or eight of the sadness and illness questions correctly (immediate and delayed, respectively, $p < .05$, binomial theorem). Three older children showed this pattern. Six older and 6 younger children showed a different pattern of consistently judging these items to be immediate consequences (also $p < .05$).

Discussion

Most children did not recognize that mental and bodily responses to contamination have different time courses. In general, both reactions were thought to occur immediately on contact. Younger children seemed biased to judge that all outcomes would be instantaneous. However, this bias cannot completely account for their responses; they did see significantly more lag for delayed controls than for other items. Older children performed slightly better. Although they also judged biological and psychological reactions to be more immediate than delayed controls, they did differentiate the two kinds of reactions. There were more delayed responses for illnesses than for emotions. However, only 3 of the older children consistently distinguished the reactions. These results suggest that many preschoolers may not understand the internal bodily processes that occur between contact with contaminants and the onset of illness. One feature of these internal bodily processes is that they take time to produce illness.

There are at least some cases in which children seem to see the onset of illness as removed from the cause. In the case of immanent justice (Kister & Patterson, 1980), a character is said to get sick because of some earlier misdeed. Springer and Ruckel (1992) argued that to the extent that they accepted immanent justice, children supplied a physical mechanism (e.g., a character who steals an apple gets sick because the apple had germs on it). Thus, a delay between misdeed and illness may be thought to occur because of internal, physical processes. However, in these studies, children have not been explicitly asked about the rapidity of illness. It may be that they believe illness occurs immediately on the transgression or immediately on discovery.

Conclusions

Preschoolers do seem to recognize a type of reaction to contamination that is part of the physical rather than mental world. They distinguish the causes of illness from the causes of emotional or other psychological reactions. Although both illness and emotions are thought to be involuntary and unalterable through purely mental processes, they are distinguished on other grounds. Illness depends on physical contact with contaminants; the mental state of the agent (whether they know about the contamination) does not affect this process. Disgust (beliefs about the yuckiness of food) depends on knowledge of contamination and, at least in stories in which the action was clear,

may be independent of physical contact. Illness is a product of physical events whereas disgust is a product of mental events.

This is not to say that preschoolers understand the particular bodily processes involved in illness. Children generally failed to recognize that illness was a delayed response to contact with contaminated food. Both illness and emotions were thought by all but a few older children to occur immediately. At least the adult understanding involves the belief that some relatively slow processes mediate between contact with contaminants and the onset of illness. Of course, children may know about these processes but just fail to recognize that they take time. However, results from the present studies suggest that knowing that the connection between contamination and illness is physical rather than mental precedes an understanding of the specific bodily processes involved in illness. Both younger and older preschoolers saw illness as a physical response, but only older children showed some signs of understanding more specifics.

Results of these three studies are consistent with other descriptions of children's knowledge of contamination. Recent studies have suggested that even young children understand the physical basis of contamination. Foods can become contaminated with invisible, physical particles of noxious substances (Au et al., 1993; Rosen & Rozin, 1993). Those particles are left as a result of physical contact between a contaminant and some food (Springer & Belk, 1994). At least in some cases (when the contaminants are described as germs), the particles are believed responsible for causing illness (Kalish, 1996). From the present studies, one learns that children also recognize that physical contact with the contaminated food is necessary to produce illness. It seems likely that they believe that the contaminants must somehow be transferred from the food to the person. Thus, children have a relatively coherent understanding of the physical basis of contamination. However, preschoolers' belief that illness follows immediately on contact may suggest that they have a poor understanding of what happens inside the body after contact with contaminants. Perhaps their knowledge of contamination is limited to the belief that contamination is the transfer of physical material. Yet, this conception does seem to involve more than a simple set of associations between contaminated food and the onset of illness.

In many studies, researchers have discovered that children understand biological phenomena at this level of generality; they know there are physical processes involving living things but do not know the details (Simons & Keil, 1995). For example, Gelman (1990) suggested that children have a skeletal "innards" principle, a fairly nonspecific belief that the movements of animals are accounted for by their internal makeup. They also know that regrowth (Backscheider, Shatz, & Gelman, 1993) and decomposition (Springer, Nguyen, & Samaniego, 1996) affect living things, without knowing the specifics of either process. Similarly, children see inheritance as involving bodily attributes (Springer & Keil, 1989) and see the process as physical rather than psychological (Springer & Keil, 1991).[3] Children's knowledge of contamination seems similar to their understanding of other biological relationships. Contagious illness is understood as a physical process (and is probably thought to be unique to living things). However, young children do not appear to understand the internal bodily reactions to contamination. Thus, preschoolers seem to have the same kind of knowledge about a wide range of biological phenomena. Given this uniformity, researchers are in a position to make some general claims regarding the nature of young children's understanding of biology.

In the first place, data support the contention that young children have at least some grasp of the mind–body distinction (Inagaki & Hatano, 1993). Contamination affects both the body (through physical processes) and the mind (through psychological processes). The bodily effects are physical because they are unintentional, both broadly and narrowly. Physical and psychological reactions may be alike in being unintentional in the narrow sense of involuntary or outside conscious control. Bodily effects of contamination are unintentional in the wider sense as well; the effects do not depend on representations or mental events; rather, they depend on physical interactions. It remains to be seen whether children hold the general view that all mental phenomena are mediated by representations, whereas no physical events are. For adults, the mind–body split is less clear-cut than that. For example, perceptions (on at least some accounts) are products of physical interactions and are independent of other mental states. Similarly, physical processes may be affected by intentional states. For example, many believe that mental states can contribute to susceptibility to illness. Less esoteric is that every time we act, a mental state is affecting a biological state. The problem is that (at least according to most current thinking) mental events are physical events; the mind–body distinction is a false one. Although it is often useful to distinguish mental and physical events, many feel it is impossible to reconcile the two, and one side must be abandoned (usually the intentional; e.g., Stitch, 1983). However, increasing evidence indicates that humans are innately disposed to distinguish the mental from the nonmental (see Wellman & Gelman, 1992). If one breaks the world into the mental and the physical, one should expect troubles distinguishing around the margins. Events involving the human body are exactly the margins in which the distinction runs into trouble. In fact, adults often use the word *sick* ambiguously—to refer to illness or disgust. If young children also believe in the mind–body split, will their distinction be sharper or fuzzier than adults'?

Although children seem to distinguish the mental from the nonmental, do they further recognize a unique realm of biological phenomena? There is considerable debate on this matter. Carey and her colleagues (Carey, 1985, 1995; Solomon et al., 1996) denied that preschoolers have a theory of biology, whereas Keil (1992; Simons & Keil, 1995), Gelman (Wellman & Gelman, 1992), and others argued that they do. In this debate, it seems possible that all participants could agree on the data—that something like the characterization of children's knowledge outlined above is accurate. For example, Carey credited young children with knowledge of input and output relationships involving animals and plants (e.g., if you eat dirt, you get sick). Furthermore, she believes children also seek explanations for these relationships. Initially, this may simply involve a mechanism placeholder (Ahn, Kalish, Medin, & Gelman, 1995); for

[3] To the extent that these studies and others (e.g., Springer, 1995) have described more detailed knowledge of the processes of inheritance, that knowledge has involved general physical mechanisms. For example, children are said to believe that inheritance takes place through material transfer.

example, believing that "there is something within the animals that is the source of growth and health" (Carey, 1995, p. 298) but not knowing more in detail. Carey has usually suggested that children see this something in psychological terms. However, she may accept that children assume that at least some underlying mechanisms are physical but maintain her denial that this constitutes a biological understanding. Thus, for example, all participants in the debate might agree that young children see illness as a physical reaction to contact with invisible contaminants but differ as to whether this demonstrates biological knowledge. Carey and her colleagues point to something that this explanation lacks; there is no specifically biological mechanism. Proponents of an early biology see positive features of this explanation; it identifies a domain of experience.

Understanding of contamination demonstrated by children in the studies reported in this article would not convince doubters that children have biological knowledge. Solomon and Cassimatis (1995) argued that children do not have a biological understanding of contagion because they do not see contagion as the result of a uniquely biological mechanism (see also Carey, 1995). In particular, children do not distinguish between germs and poisons as agents of contagion. Because poisons are physical but not biological, contagion is not purely biological. Ignoring differences between contamination and contagion (which seems to be contamination with a person as vector), do the present studies demonstrate a uniquely biological mechanism? According to the above logic, Studies 1 and 2 do not; they are concerned with demonstrating the physical nature of reactions to contamination rather than anything specifically biological. Beliefs about the internal action of contaminants, and the body's reaction, would be specifically biological (although whether the contaminant was a biological germ or a physical poison would not seem to matter). Study 3 seems to provide evidence against an understanding of biology. Children did not appear to understand the bodily processes that occur in response to contact with contaminants; they thought people would get sick instantly.[4] Therefore, nothing about Studies 1–3 would demonstrate uniquely biological knowledge.

What would a specifically biological mechanism be? Consider a number of possible explanations and understandings of contagion in Table 2. These explanations are nested, as each provides a mechanism for the preceding one (see Harre, 1961, 1988). An explanation of Type A may be merely an empirical association and involves no conception of mechanism (Gopnik & Wellman, 1994). An explanation of Type D (or a possible more specific Type E) involves general mechanisms (e.g., chemical reactions) that are not uniquely biological. The characterization of preschoolers' knowledge proposed above would credit them with knowledge involving Level B explanations. Carey's (1995) position seems to be that it is explanations akin to Level C that demonstrate biological understanding. Explanation C involves notions of the immune system and normal functioning that are said to be uniquely biological. However, it is also possible to characterize C as a more specific version of the mechanism assumed at B. That is, C is a particular account of how B operates (and is a higher order description of D). In this sense C is not unique—it is a kind of physical mechanism, part of a hierarchy. However, C might be characterized as a uniquely biological level of explanation (Beckner, 1959). What seems to characterize C is that it is a level more detailed than just some sort of physical mechanism and is less detailed than a specific chemical account. One may argue that it is the presence of this level of explanation that makes knowledge biological. Given this interpretation, the facts do seem to support the contention that biological knowledge does not emerge until school age; younger children do not give sufficiently detailed kinds of explanations for biological phenomena.

Table 2
Examples of Types of Explanations of Illness

Level	Explanation
A	Dirty food makes you sick
B	Invisible particles (e.g., germs) get on or in you, and this contact physically causes illness.
C	Foreign particles in the body are identified and attacked by our immune system. The action of these particles and our immune system disrupts our normal functioning and is the source of observable symptoms of illness.
D	Contaminants produce toxins that interfere with the ongoing chemical reactions in the body. Other particles (antibodies) may have a chemical structure such that they enter into reactions with the contaminant.

Those wishing to credit younger children with an understanding of biology have a different interpretation. Simons and Keil (1995) argued that children have an abstract notion of biology; they have general ideas about the types of mechanisms involved, but don't know specifics. According to this view, the level of explanation provided for a phenomenon is less important than that the phenomenon be characteristic of some domain of experience. It matters less how children explain inheritance, contagion, growth, and so on than that they recognize that these processes are related and all apply to a particular set of entities. Biology would be the subset of physical, causal processes that are unique to living things (Wellman & Gelman, 1992). Living things would, in turn, be defined as those entities that are subject to biological causes. This type of circularity is characteristic of theories (Wellman, 1990; see also Boyd's notion of homeostasis in Keil, 1989). Some minimum level of explanation is required; understanding the processes as involving physical causality seems necessary (e.g., to distinguish biological and psychological domains), but explanations of Level B would suffice. Thus, children may not understand any uniquely biological mechanisms in the sense of mechanisms at a particular level of specificity. Rather, their understanding of biology may be characterized as a framework that demarcates a domain of experience.

If there is, at least potentially, agreement regarding young children's understanding of biological phenomena (e.g., growth, inheritance, and contamination), then disagreements must turn on interpretations of what is implied by the label *biological.* Doubters argue that children do not understand biology because they do not have a biological level of explanation, or a level intermediate between general beliefs in some physical mecha-

[4] Solomon and Cassimatis (1995) argued that children younger than 7 years do not have a biological understanding of contagion. Some of the 5-year-olds tested in Study 3 did recognize that illness is a delayed response.

nism and detailed chemical–physical explanations. Proponents argue that children do understand biology because they recognize a biological domain, a subset of physical processes that go together and apply to a particular type of entities. Further reconciliation of these two views (e.g., settling the debate as to whether children have a "theory" of biology) would seem to depend as much on further semantic analysis as it would on new empirical findings.

At the most general level, the studies reported in this article explored children's understanding of the limits of intentionality. In the broad sense (as involving representations), mental reactions to contamination are intentional, whereas bodily reactions are not. In the narrow sense (as involving choice), both mental and bodily phenomena may be unintentional. Although children seemed to locate bodily reactions in the realm of physical events, most showed poor understanding of the internal bodily processes mediating between contact with contaminants and the onset of illness. Children tended to judge that both mental and bodily reactions would happen instantly. These studies suggest that children recognize unintentional, physical reactions to contamination. Whether this constitutes a biological understanding depends on one's interpretation of what is required for a body of knowledge to count as biological.

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Appendix

Stories Used in Studies 1–3

Study 1

Immediate

Here's Susie. She put her hand on a really hot plate. The hot plate makes her want to move her hand. Just by thinking about it, right now, can she move her hand away?

Here is Jack. Jack stepped on some sharp, pointy rocks. The pointy rocks make him want to move his foot away. Just by thinking about it, right now, can he move his foot away?

Here is Sarah. Someone shined a bright light in her eyes. The bright light makes her want to close her eyes. Just by thinking about it, right now, can she close her eyes?

Emotion

Joe's apple falls in the garbage. That makes Joe feel really sad. He wants to feel happy. Just by thinking about it, right now, can Joe feel happy?

A sick kid licked Johnny's cheese and got germs all over the cheese. That makes Johnny feel sad. He wants to feel happy. Just by thinking about it, right now, can Joe feel happy?

A sick kid sneezed on Sammy's cookie. The sick kid got germs all over the cookie. That makes Sammy feel sad. He wants to feel happy. Just by thinking about it, right now, can Sammy feel happy?

Illness

A bug got into Andrea's juice. She drank the juice. It makes her sick. Andrea wants to stop being sick. Just by thinking about it, right now, can Andrea stop being sick?

A fly got on George's bread. He ate the bread. That makes him sick. George wants to stop being sick. Just by thinking about it, right now, can George stop being sick?

Don ate some yucky dog food. The dog food makes him sick. Don wants to stop being sick. Just by thinking about it, right now, can Don stop being sick?

Study 2

Knows/Eats

Cathy found a bunch of food on the table. She ate it up. Then her mom told her that the food was really old and had germs all over it. Cathy ate the really old germy food by mistake.

Sam ate an apple he found on the table. After he ate the apple, his friend told him it was from the garbage. Same ate an apple from the garbage by mistake.

Knows/Doesn't Eat

Jenny dropped her carrot in the mud by mistake. It got all dirty. She took the carrot and threw it in the garbage. She didn't eat the carrot.

Marilyn was going to eat some bread for lunch. She saw a big fly on the bread. Marilyn threw the bread in the garbage and didn't eat it.

Doesn't Know/Eats

Jimmy was eating crackers. He didn't see the sick kid get germs all over the crackers. The sick kid got germs all over the crackers, but Jimmy didn't see. Jimmy ate the crackers.

Sally was eating some cheese. She didn't know it, but a sick kid sneezed on her cheese and got germs all over it. Sally didn't know and she ate the cheese.

Doesn't Know/Doesn't Eat

Thomas is working at the bread store. He doesn't know it, but a fly got germs on some bread. He didn't see the fly and he sold the bread to a lady. He sold the lady some germy bread by mistake.

Bobby left his sandwich under a tree and went to play. While he was playing, leaves and dirt fell on the sandwich. Later, Bobby looked for his sandwich but he forgot where he put it. He couldn't find the sandwich so he couldn't eat it.

Study 3

Immediate

Putting your hand on a hot plate can burn you. Here's Susie. She just put her hand on a really hot plate. Right now, just when she put her

hand on, would it feel hot? Will her hand feel hot right now or not until later?

Stepping on pointy rocks makes your feet hurt. Here is Jack. Jack just stepped on some sharp, pointy rocks. Right now, just when he stepped on the rock, would his foot hurt? Will his foot hurt now or not until later?

Delayed

Mixing the dough is the way to make cookies. Here is Sarah. She is making some cookies. She is just mixing up the cookie dough. Right now, just when she mixes it, will she have cookies? Will she have cookies now, or not until later?

Planting a seed is the way to grow a carrot. Here is Benny. He's planting a carrot seed. He just put the seed in the ground. Right now, just when he covers the seed with dirt, will he have a carrot? Will he have a carrot right now, or not until later?

Emotion

People get sad when their food gets dirty. Joe was going to eat his apple. All of a sudden his apple falls in the garbage. Right now, just when his apple falls in the garbage, will Joe be sad? Will he be sad right now, or not until later?

Getting germs on food makes people sad. A sick kid licked Johnny's cheese and got germs all over the cheese. Right now, just when the kid gets germs on the cheese, will Johnny be sad? Will he be sad right now or not until later?

People get sad when their food gets germs on it. Sally was going to eat her sandwich. All of a sudden someone sneezed germs all over her sandwich. Right now, just when her sandwich gets sneezed on will Sally be sad? Will she be sad right now, or not until later?

People get sad when bugs get in their food. Andrea is going to drink her juice. Just now a bug falls in the juice. Right now, just when the bug falls in the juice, will Andrea be sad? Will she be sad right now or not until later?

Illness

People get sick if they eat food with bugs on it. A fly gets on George's bread. George picks up the bread and eats it. Right now, just when he eats the bread, will George be sick? Will he be sick right now or not until later?

Eating dog food makes people sick. Don is eating some dog food. Right now, just when he eats the dog food, will Don be sick? Will he be sick right now or not until later?

Eating muddy food makes people sick. Kelly dropped her cookie into the mud. She picks up the cookie and eats it. Right now, just when she eats the cookie, will Kelly be sick? Will she be sick right now or not until later?

People can get sick if they share food with sick friends. Alice is eating with her sick friend Julie. Right now, just when they are sharing food, will Alice be sick? Will she be sick right now or not until later?

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