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RIVERSIDE

Maternal Contributions to the Development of Contamination Sensitivity

A Dissertation submitted in partial satisfaction  
of the requirements for the degree of

Doctor of Philosophy

in

Psychology

by

Heidi Dawn Beebe

March 2013

Dissertation Committee:

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The Dissertation of Heidi Dawn Beebe is approved:

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Committee Chairperson

University of California, Riverside

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## ABSTRACT OF THE DISSERTATION

Maternal Contributions to the Development of Contamination Sensitivity

by

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Doctor of Philosophy, Graduate Program in Psychology  
University of California, Riverside, March 2013  
Dr. Mary Gauvain, Chairperson

Knowing whether food and water is safe to consume, referred to as contamination sensitivity, is vital to the sustainability of our species. Children 3 years of age may have rudimentary understanding of contamination, which develops until the age of 10-12 years. Contamination sensitivity is related to biological concepts because contamination involves biological entities, such as bacteria. Sociocultural theory suggests that children learn about important concepts through social interactions and joint discussions with more experienced social partners. Biological concepts and contamination knowledge may be learned from other people, but research has not explored social contributions to the development of biological knowledge pertaining to contamination. Research suggests children learn about biological concepts through psychological concepts, such as explaining biological phenomenon (illness) using social constructs (misbehaving). This study examines whether mothers spontaneously discuss contamination concepts with their children during an interaction involving picture books, if these discussions differ by child age, and whether these interactions improve children's contamination sensitivity.



Seventy-eight mother-child dyads were divided into two child age groups, 5-year-olds and 8-year-olds. A child-only pretest and posttest involving 13 images depicting contaminated or uncontaminated food and water were presented. Children were asked if each item was safe to consume and to explain why. Three short vignettes using two dolls were used to test for the use of immanent justice. The mother-child interaction consisted of seven stories about events involving contamination (or not) based on previous research. A sociomoral story was included to examine whether mothers use immanent justice to explain potential illness when a person is misbehaving. Mother and child looked at each story separately and discussed the events of each story.

Overall, results revealed that during these interactions, mothers provide contamination related information to their children, such as making specific reference of contamination and decontamination. Mothers made very few references to immanent justice. Child age-related differences were found. Mothers demonstrated higher level biological concepts with 8-year-olds and were more encouraging of 5-year-olds. These discussions improved children's biological concepts, specifically for contaminated items. References to immanent justice and the absence of contamination were found specifically to predict children's increase in biological concepts.

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## **Chapter 1: Introduction**

Knowing whether food or water is consumable is vital to the sustainability of our species yet little research has been conducted looking at how children learn about food and water contamination. Understanding whether something is suitable for consumption is referred to as contamination sensitivity (Siegal & Share, 1990). Contamination concepts lie within the broader framework of biological concepts because contamination involves biological mechanisms such as germs. Some researchers suggest that we are predisposed to pay attention to certain biological elements in our environment contributing to a naïve theory of biology (Inagaki & Hatano, 2002; Keil, 2007; Medin & Atran, 2004; Springer, 1999). Naïve theories, such as naïve biology, are considered universal frameworks that help define a specific domain for non-expert adults and children (e.g., biology), enable a child to provide logical predictions and explanations within the domain, and can be built upon to inform or become more precise theories (Carey, 1985; Inagaki & Hatano, 2002; Wellman & Gelman, 1992). Research investigating biological concept development often examines the child as an isolated organism within whom concepts develop via internal cognitive mechanisms (e.g., Carey, 1985; Erickson, Keil, & Lockhart, 2010; Morris, Taplin, & Gelman, 2000). As a result, external factors, such as social interactions, are often ignored as potential influences to the development of biological concepts.

Some researchers have examined social factors that influence the development of biological concepts such as broader cultural differences (Medin & Atran, 2004) or specific experiences such as caring for animals (Inagaki, 1990). Sociocultural theory

contends that interactions with more experienced social members help form early concepts important for social interactions and everyday activities (Hedegaard, 2007; Vygotsky, 1934/1986). Some researchers assert that Vygotsky's (1934/1986) ideas regarding concept formation of early (spontaneous) and later (scientific) concepts also applies to children's developing contamination sensitivity (Gauvain & Beebe, 2011). However, studies have not looked at what kind of information children over the age of 4 years learn from their caregivers through everyday interactions regarding contamination.

The proposed study will look at the information mothers talk to their children about in regards to contamination appearing in common situations such as going to the grocery store or playing with other children. Investigating the nature of social interactions during early concept formation of contamination sensitivity will provide a basis for the kind of contamination information social partners expose children to from the age of 5 years through 8 years old. This is a critical period in the development of contamination understanding because, according to the literature, children shift from a rudimentary understanding of contamination to a more adult-like understanding of contamination (Bibace & Walsh, 1980; Carey, 1985; Rozin, Fallon, & Augustoni-Ziskind, 1985). In addition, these ages represent a shift in children's conservation abilities and causal reasoning skills, which are thought to be important to understanding contamination and illness (Au, Sidle, & Rollins, 1993; Bibace & Walsh, 1980; Boruchovitch & Mednick, 2000). Such a foundation will also inform research interested in how children learn about biological concepts generally from social partners because little research has investigated the social processes involved in biological concept



formation. This research will also contribute to the contamination sensitivity literature by helping to describe the concepts children are learning from mothers and how discussions and interactions with mothers about contamination influence children's subsequent knowledge of contamination.

This study will begin by discussing research that explores the various ways in which children understand biological phenomenon including through psychological perspectives, immanent justice, and naïve biology. Following this discussion, contamination sensitivity is addressed as a subcategory of biological knowledge. A discussion of innate and social mechanisms that contribute to the development of contamination sensitivity will follow. This discussion will include addressing disgust as both an innate and social mechanism for learning about contamination and the role social interactions have in learning about biological concepts. The aims of the study will conclude the introduction.

### **Children's Understanding of Biological Phenomenon**

The idea of naïve theories has emerged from the debate over whether cognitive development occurs generally, as in cognitive processes develop similarly, or occurs specifically, as in conceptual abilities developing for specific types of content. These developmental perspectives are referred to as domain-general development and domain-specific development. Naïve theories provide frameworks thought to aid children in rapidly acquiring specific bodies of knowledge which then inform later conceptual acquisitions (Gelman & Legare, 2011; Murphy & Medin, 1985; Wellman & Gelman, 1992). Naïve theories are considered "naïve" because they are based on knowledge that

is not informed by formal education and may be innate (Murphy & Medin, 1985; Wellman & Gelman, 1992). When one's knowledge or framework is "naïve" it allows one to acquire new concepts without having to first have a learned understanding of that theory. The major naïve theories include naïve physics, naïve psychology, and naïve biology (Wellman & Gelman, 1992). Naïve physics is a theoretical framework about how physical objects exist in space, have weight and mass, interact with each other, and that they exist even if a person is not present (Gelman & Legare, 2011; Wellman & Gelman, 1992). Naïve psychology is the ability to explain behaviors through thoughts, wants, beliefs, and ideas (Carey, 1985; Wellman & Gelman, 1992). Naïve biology is described as the everyday knowledge of biological aspects of the world. This includes animal functions, such as eating and sleeping; biological outcomes, such as illness and death; organic growth; inheritance; and reproduction (Inagaki & Hatano, 2002; Wellman & Gelman, 1992). These theories may overlap one another. For example, some biological entities, such as animals, also possess physical properties, such as having mass. In the case of naïve psychology and naïve biology, humans, who have both psychological and biological processes, may create confusion on the part of the developing child who uses the human as primary example for both theories (Atran, Medin, & Ross, 2004; Medin & Atran, 2004). Such overlap has resulted in debate about the development of these theories, specifically, for the purposes of this study, in regards naïve biology.

Some researchers suggest naïve biology as emerging from naïve psychology around 8 to 10 years old (Carey 1985; Solomon & Cassimatis, 1999), while others suggest naïve biology is exhibited in the preschool years and separate from naïve

psychology (Inagaki & Hatano, 2002; Kalish, 1996). This section will discuss perspectives on the development of the understanding of biological phenomenon and how reasoning based on immanent justice has been used to explain children's understanding of biological phenomenon. First, the perspective of naïve biology emerging from naïve psychology is discussed, followed by a look at how reasoning using immanent justice has been employed to help explain children's developing biological knowledge. Finally, the perspective that naïve biology begins in early childhood is addressed.

**Naïve biology emerging from naïve psychology.** Psychologists have been interested in how children conceive of the biological world since the early 19<sup>th</sup> century (Piaget, 1929). However, Carey (1985) sparked specific interest in the development of biological concepts with her research on children's biological knowledge and explanations between the ages of 4 years and 10 years old. Carey asserts that young children's biological knowledge is informed by their understanding of human behaviors and social conventions. In her work she found that until about the age of 10 years children explain biological phenomenon by using individual motivation and psychological intention. For example, she suggests that children explain that we eat because we are hungry or because it is dinner time rather than needing the energy from the food for sustenance. For Carey, these explanations are not considered biological because they involve the actions, thoughts, and feelings of people rather than the biological processes that take place at the physical level (e.g., stomach lining absorbs nutrients from the food and distributes it through the body). Therefore, she suggests that a theory of biology emerges from a naïve theory of psychology. She states that though

children before age 10 may be able to distinguish physical (biological) and social phenomena, they are not able to provide a biological basis for the distinction, thus the biological theory is not autonomous, or distinct, from a psychological theory. She asserts that children do not have specifically biological concepts due to the child's association of social conventions and psychological explanations with biological phenomenon until around the age of 10 years old.

Solomon, Johnson, Zaitchik, and Carey (1996) conducted further research based on Carey's (1985) assertion that children do not acquire an intuitive or autonomous theory of biology before the age of 10 years. The focus of their research was on potential biological family traits such as skin color and included preschoolers, 6-year-olds, 7-year-olds, and adults. Participants were told a story about a boy born to a king but adopted by a shepherd (or vice versa). Biological and adoptive parents had differing features (e.g., skin color, or beliefs such as skunks seeing in the dark or not) and participants were asked which of the features the child in the story would have. The researchers found that children 7 years of age and adults correctly attributed biological parents with physical traits, such as skin color, and adoptive parents with beliefs. Children 6 years and younger were not as likely to make this attribution nor were they able to make appropriately biological explanations for their choices (e.g., an appropriate biological explanation would be "His skin is darker because his real father is the king who has darker skin than the shepherd"). The investigators see their results as evidence that children under 7 years of age do not possess a naïve theory of biology. They suggest that though some basic biological concepts, such as babies coming from their mother, may be known at a young

age, biological mechanisms explaining their conceptual understanding did not exist before this age. The investigators suggest that social conventions, such as family members looking alike, may be what are guiding young children in making incorrect attributions about biological properties such as skin color in their study.

Other research found similar age patterns for biological understanding when considering germs and contagion (Solomon & Cassimatis, 1999). They found that children under the age of 7 years were not likely to differentiate between the contagiousness of symptoms caused by germs and symptoms caused by poisons. The researchers recognized that young children were familiar with germs but, according to the researchers, did not understand the biological mechanisms of germs. According to Carey (1985) and her colleagues (Solomon & Cassimatis, 1999; Solomon, Johnson, Zaitchik, & Carey, 1996) for children to possess an autonomous biological theory it is essential that the child is able to separate psychological from biological phenomenon, in other words, to know the difference between what is a psychological and a biological phenomenon.

A notable concern regarding the above discussed research is that while these studies all remark that children make mention of biological properties, the researchers assert that because children's explanation did not differentiate between psychological and biological properties or biological and non-biological contagion, it cannot be considered a biological explanation. However, children's reasoning and explanations still include biological elements or processes. For example, because humans are biological, children (in the United States, as is the case in the above research) may be using humans as the primary source of comparison for other biological kinds. Naïve psychology is based on

thoughts and intentions of humans, thus humans also serve as the primary source of comparison for psychological phenomenon. An overlap in using humans as the primary source of comparison between the two theories may cause children to incorporate some psychological elements in their biological explanations. However, this does not preclude the fact that children may still possess a naïve theory of biology, as they are using biological properties in their reasoning and explanation of biological phenomenon. Other researchers (e.g., Keil 2007) agree with this assertion and these viewpoints are discussed further below.

**Immanent justice.** Some social conventions involve adhering to acceptable moral behaviors, such as not stealing from others. The idea that one can be rendered ill due to immoral behavior occurs in folkbiology (Legare, Evans, Rosengren, & Harris, 2012) and has been described by researchers in relation to Piaget's (1948) idea of immanent justice. Immanent justice is the notion that consequences of actions can be brought on by an omnipotent power that deems the action inappropriate or immoral. Piaget theorized that children under the age of 7 years were likely to attribute tragic or undesirable outcomes as punishments for misdeeds. For instance, a bridge that collapses beneath a thief does so because of his misdeeds. In line with this thought process, a person who gets very ill does so because of his or her moral transgressions, not because a virus or germ has caused them to become ill. According to Piaget (1948), after the age of 7 years the application of immanent justice begins to disappear. He suggests that the use of immanent justice as an explanation for undesirable outcomes is stronger the younger

the child is and does not suddenly disappear but rather coexists for a time (perhaps the rest of the life) with logical or scientific explanations (Piaget, 1948).

The application of immanent justice as an explanation for undesirable outcomes is particularly interesting when considering the development of biological concepts from Carey's point of view. She suggests that children under the age of 10 attribute psychological characteristics to biological entities or events (Carey, 1985). Immanent justice involves an omnipotent power making decisions about who will be punished and why. Because immanent justice involves psychological phenomenon (e.g., making decisions) it stands as an example of how children may not separate biological from psychological phenomenon.

Research has found that children will attribute causes of illness, specifically contagious diseases, to improper social or moral behaviors rather than to biological reasons, such as germs, until about 2<sup>nd</sup> grade (Kister & Patterson, 1980). Kister and Patterson's (1980) research supports Piaget's claim that children under the age of 7 years may attribute contracting an illness to immanent justice. Other research has found that both children and adults show some indication of using immanent justice as an explanation of illness but are more inclined to use biological or folkloric explanations (e.g., you'll get sick if you go out in the cold without a hat on) for illness (Raman & Winer, 2002). Rather than suggesting that children use either an immanent justice or biological explanation for illness, Raman and Winer contend that children hold a "coexistence model" in which children may pull from a variety of explanations, using the one they feel best suits the context. This coincides with Piaget's (1948) claim that

immanent justice does not suddenly disappear as the child gets older and, in fact, may never disappear for a small number of adults. He recognized that some adults show evidence of immanent justice, though he attributes this to adults “who can never learn from facts” (p. 261). For instance, he describes adults who, despite factual evidence for some cause, insist on attributing immanent justice to others’ or their own misfortune.

In other research Raman and Winer (2004) found that college students used immanent justice as explanations for illness more frequently than children. According to Raman and Winer, adults are both more capable of multi-focused thinking (e.g., the ability to consider multiple explanations for a phenomenon) and more embedded in cultural norms having had more experience with values important to their culture. This interpretation, however, is somewhat in opposition to Piaget’s (1948) developmental theory regarding immanent justice. Raman and Winer (2004) suggest that immanent justice may be a product of culturally important learned explanations and the need to see the world as predictable. Thus, immanent justice explanations are used more frequently with age and experience in situations requiring such explanations (e.g., situations where the adult is trying to make a moral point or does not know the cause). As stated above, Piaget recognizes that, for some adults, the use of immanent justice remains due to a lack of desire to learn from one’s factual experiences. However, he contends that the belief in immanent justice is decidedly more prevalent with younger children than with adults and that for most adults the use of immanent justice disappears completely (though may be retained by some adults) (Piaget, 1948).



**Naïve biology as separate from naïve psychology.** Other researchers have found that young children may understand biological entities and processes as separate from social (or moral) processes (Inagaki & Hatano, 2006; Medin & Atran, 2004; Springer, 1999). These researchers have developed theories to explain how and why naïve biology is acquired from a very young age (Inagaki & Hatano, 2006; Keil, 1992b; Medin & Atran, 2004; Springer, 1999).

Springer (1999) asserts that a naïve theory of biology is acquired by 4 or 5 years old. He explains that naïve biology is informed by innate predispositions constraining the type of input to which children attend. By innate predispositions, he is referring to genetic constraints that provide structure for objects or concepts found in the world, such as a constraint toward understanding biological entities as fitting within their own group or concept. However, Springer suggests that naïve biology is primarily driven by knowledge the child acquires from her surroundings from which she is able to make inferences. In other words, innate predispositions help to focus children's attention to specific aspects of the biological world. However, the knowledge the child uses to make assumptions or conclusions about their biological world comes from experiences with their surroundings and social partners.

Inagaki and Hatano (2002; 2006) hold a similar view and claim that children as young as 4 or 5 years old may be developing a naïve theory of biology. They suggest there are innate (potentially neurological) bases for naïve biology while emphasizing that sociocultural constraints guide the developing child in the construction of the concepts of naïve biology. As compared with Springer (1999), Inagaki and Hatano place somewhat

more emphasis on innate bases that contribute to a naïve theory of biology, yet agree that the child's social environment provides specific and relevant information that provides specialization to the child's knowledge. For instance, being raised with a pet in the home provides an opportunity for the child to interact with and care for the animal which provides concrete examples about living things for the child (Inagaki, 1990).

Other researchers agree that young children may be acquiring a naïve theory of biology between the ages of 4 and 5 years and that children will use invisible biological entities, such as germs, to explain illness or contamination rather than nonbiological elements such as poison (e.g., Kalish, 1996; Toyama, 2011). Ericson, Kiel, and Lockhart (2010) found that kindergarteners were able to understand that biological processes involve causal mechanisms and accurately categorized biological behaviors as separate from psychological behaviors. Gelman and Wellman (1991) found that preschoolers demonstrate an understanding of animal insides, essences, and innate potentials, and that preschoolers believe that babies or seeds have inherent properties, though they know very little about babies or seeds specifically. Gelman and Wellman suggest their findings provide evidence for a cognitive predisposition for biological concepts, such as insides or innate potentials. They also suggest that knowledge based on such predispositions develops and is built upon through everyday experiences. For example, they show that young children believe that people's insides are important, though young children know little about insides. The predisposition to insides being important is then reinforced through experiences or education such as learning that eating certain foods may make your stomach feel sick.

In a series of studies involving kindergarteners and preschoolers, Keil (1992a) provides additional evidence for the appearance of naïve biology at a young age. He demonstrated that kindergarteners, and perhaps preschoolers, will use systematic properties and concepts to explain natural kinds (i.e., entities that possess natural properties and are not man-made), specifically animals. For example, Keil investigated what properties children primarily use to identify animals and found that kindergarteners primarily used external and internal properties and not behavioral properties, while 4<sup>th</sup> graders began incorporating behavioral properties in identification. He speculated this may be evidence against children's early biological concepts being based on behaviors or psychological reasoning. In addition, kindergarteners and 4<sup>th</sup> graders were able to accurately sort unfamiliar natural kinds and man-made artifacts. Keil (2007) suggests that biological entities can be considered as part of more than one framework. For instance, properties of an animal can be considered as psychological if framed in such a way, likewise, the same properties, if framed differently, could be considered as biological. Keil suggests that considering properties differently depending on how questions are framed may be a reason research is conflicting when trying to parse apart whether naïve biology or naïve psychology is driving children's concept formation.

Researchers interested in folkbiology (Medin & Atran, 2004) hold similar views as Kiel (1992a; 2007) but highlight the universal aspects of a naïve biology beginning at a young age through cross-cultural research. They suggest that children from a young age recognize the notion of a biological essence and that this recognition is universal and separate from naïve psychology (Medin & Atran, 2004). Cross-cultural research has

found that children ages 4-5 years in communities such as urban Brazil (Sousa, Atran, & Medin, 2002) and Yukatek Maya (Atran, Medin, & Ross, 2004) are able to make correct inferences regarding birth parents for biological kinds such as animals. The cross-cultural nature of this research helps supports the suggestion that naïve biology may be an innate mechanism aiding children in the development of biological concepts.

It is not to say, however, that biological theories are resistant to cultural processes. Medin and Atran (2004) point out that although young children in different cultures appear to be able to reason about biological entities in biological terms (e.g., animals and people need to eat, inherit physical properties, etc.), differences also appear between cultures, such as using humans or other animals as a prototype for other biological kinds. They attribute these differences to experiential differences and that these differences can exist both between and within cultures. For example, experience with nature has been found to improve biological reasoning within culture through raising animals (Inagaki, 1990) and between cultures based on a stronger emphasis for agriculture, hunting, and gathering forest products in some cultures (Atran et al., 2004).

What children use as a primary model for naïve theories may be influenced by one's cultural as well. Carey (1985) suggested that children's naïve biology develops from a naïve psychology because young children use people as the primary source for comparison for other biological entities. However, research has suggested that young children in agricultural cultures or cultures that involve knowledge of clan animals (animals that symbolize a group of people or explain a clan's beginnings) may not use humans as the prototypical model for biological phenomenon and are less likely to use

psychological explanations for animals or other non-human biological entities (Medin & Atran, 2004). Similar to Keil (1992a; 2007), Medin and Atran (2004) see a lack of naïve biology based on Carey's (1985) standards as reflecting a lack of experience with biological kinds (e.g., plant and animals) that children in urban American cultures may obtain. They suggest that despite urban American children's lack of experience with biological kinds, they still possess a folkbiology, but it is simply not as developed as compared to children who have more experience with biological kinds. To clarify this assertion, Medin and Atran note that they see folkbiology (naïve biology) as innate, in that it is an innate predisposition that helps canalize learning about biological kinds but still requires cultural input to further learning in various directions. In other words, children are born with a predisposition to recognize biological kinds as separate from nonbiological kinds and this predisposition canalizes, or focuses, how children sort or group these kinds. More or less experience with various biological and nonbiological kinds helps refine the understanding the child has about different kinds and how they might group these kinds. In this way culture helps to define biological theories the child already possess. This view is also similar to Springer's (1999) and Inagaki and Hatano (2002; 2006).

The above research helps support the previous discussion that children may possess a naïve theory of biology while still expressing aspects of other theories, such as naïve psychology. Research suggesting that a theory of biology is not obtained until it can be distinguished from other theories like naïve psychology (e.g., Carey, 1985) when coupled with views of Keil (2007) and Medin and Atran (2004) may be reflecting a

development process of concept development. Research showing that young children recognize biological essences (e.g., Gelman & Wellman, 1991; Medin & Atran, 2004) may reflect the beginning of the development of biological concepts. In addition, research showing that children confuse biological and psychological concepts until later in childhood (e.g., Carey, 1985) may reflect a later point in the development of biological concepts.

In sum, the above discussion on biological concepts highlights two basic views on children's abilities to understand biological concepts before the age of 8 years. On the one hand, researchers suggest that children's concepts about biology develop from a naïve psychology and that young children may apply human characteristics to animals and plants as a result. In addition, immanent justice provides an example of how children attribute biological occurrences (e.g., illness) to psychological phenomenon (e.g., disobeying). On the other hand, researchers suggest children have a predisposition for biological kinds (naïve biology) from 4-5 years of age, or younger, but that specific explanations for biological kinds at very young ages may be influenced by cultural or social experiences. Research on naïve biology and folkbiology helps to inform researchers interested in learning about the development of contamination sensitivity because contamination involves biological processes.

### **Contamination Sensitivity**

Contamination sensitivity is the ability to distinguish when an acceptable food or water has been rendered inedible due to contact or association with an outside substance considered soiled or impure (Fallon, Rozin, & Pliner, 1984). Contamination sensitivity

lies within the broader framework of naïve biology because contamination involves biological processes such as the transfer of living microorganisms that can cause illness. On a practical level it may be important for even young children to have an understanding of what is appropriate to consume since consuming contaminated food can directly affect their health and longevity. In this case, children must know the rules surrounding appropriate behaviors that are associated with contamination. However, understanding contamination is not merely about understanding rules that keep one from getting ill. When children are able to use their conceptual knowledge about biological entities, it may aid them in appropriately applying a learned rule regarding contamination. Having a naïve biology may assist children in learning rules associated with contamination faster than rules that are not associated with a naïve theory (e.g., taking turns when opening Christmas presents, or making sure both socks you wear are matching). In other words, not only does the presence of naïve biology at a young age help children understand biological concepts (e.g., Medin & Atran, 2004), but it may help children in learning behaviors associated with biological entities, such as rules about eating moldy food.

Contamination sensitivity is specifically interesting for developmental psychologists because it requires that children understand processes involving invisible entities (e.g., germs) such as how those entities move from one location to another, to what degree those entities are harmful, and what the outcome may be when those entities are transferred from one location to another (Au, Sidle, & Rollins, 1993). For example, research has found that children as young as 3 years old exhibit an understanding that

food and drink can be rendered contaminated when in contact with certain biological items, such as a cockroach (Siegal & Share, 1990). Additional research has found that children as young as 3 years of age understand that invisible agents, such as germs, can cause illness (Kalish, 1996; Siegal, 1988).

The extent of contamination knowledge as young as 3 years of age, however, has been debated. Some researchers propose that though young children's knowledge seems rudimentary, children still provide explanations for contamination using invisible mechanisms, generally germs, and these explanations are typically correct in how children describe the invisible mechanism in terms of basic biological properties and how they apply their understanding of contamination (Kalish, 1996; Siegal, 1988). This research suggests that at the age of 3 years children are ready to learn about and understand invisible biological mechanisms for explaining illness. Other researchers argue that preschoolers and kindergarteners are more likely to use immanent justice rather than contagion as an explanation of illness than second and fourth graders and that younger children are more likely to overextend their use of contagion (i.e., apply contagion as a cause for illness in non-contagious circumstances such as the ingestion of poison) (Kister & Patterson, 1980). Regardless of age, this research found an inverse relationship between using immanent justice as a way to explain illness and an understanding of contagion suggesting that as an understanding of contagion increased, use of immanent justice decreased. Together, the research above suggests that the extent to which children understand contamination as a biological process is debated and further research may be needed to better understand children's contamination concepts.



Contamination sensitivity has shown other age-related patterns. In research, 5- and 6-year-olds display better contamination rejection than preschoolers (Siegal, 1988; Toyama, 2011) and 8-year-olds show better rejection of contaminated substances than both 4- and 6-year-olds (Hejmadi, Rozin, & Siegal, 2004; Siegal, 1988). By 10 to 12 years of age children are approaching adult-like understanding of contamination (Fallon et al., 1984; Stevenson et al., 2010). This pattern follows similar age-related patterns for biological concepts (Anggoro, Waxman, & Medin, 2008; Gimenez & Harris, 2002; Hatano & Inagaki, 1999).

Understanding of illness caused by contamination was examined cross-sectionally from 1<sup>st</sup> grade through adulthood (Raman & Winer, 2002). It was found that children gave more biological than non-biological reasons for illness as they got older. The researchers suggest that cognitive capabilities improve, which allows for more than one explanation to be understood for the same phenomenon (biological versus folk-based or immanent justice). Raman and Winer propose that as a child has more experience with the social environment, social conventions (e.g., going outside without a coat in the cold could make you sick) are learned and incorporated in everyday use (Raman & Winer, 2002). According to the researchers, learning social conventions through social interactions may result in older children's and adults' use of social conventions to explain illness.

While research has been conducted examining what children know about contamination, very little research has investigated how children learn about contamination and if and how more experienced social partners may contribute to this

learning process. Results from previous research suggest that adults may exhibit more immanent justice and folk-based explanations than 6<sup>th</sup> grade children for contaminated related illness (Raman & Winer, 2002, 2004). If adults are expressing more non-biological (e.g., immanent justice or folk-based) reasons for illness, it may be the case that parents are discussing contamination issues with their children in terms of these non-biological explanations as well as biological explanations. However, this question has not been addressed in the literature with children older than 4 years of age.

### **Innate and Social Mechanisms Contributing to Contamination Sensitivity**

The theoretical views discussed above regarding naïve biology (Inagaki & Hatano, 2002; Keil, 2007; Medin & Atran, 2004; Springer, 1999) emphasize contributions from both innate mechanisms and social environments to the acquisition and development of biological concepts which may contribute to the development of contamination sensitivity. Below, disgust and social interactions are discussed in regards to the development of contamination sensitivity.

**Disgust.** Disgust is an innate mechanism believed to contribute to the understanding of contamination. Disgust is considered a primary emotion that involves distinct facial expressions, specific neurological activity in the right frontal cortex, and specific body actions thought to be adaptive mechanisms for humans to communicate potentially harmful situations (Oaten, Stevenson, & Case, 2009; Rozin, Haidt, & McCauley, 2008). Researchers consider the use of disgust facial expressions to be specifically related to disease (Oaten, Stevenson, & Case, 2009). Research has found that children as young as 2-1/2 years will exhibit avoidant behaviors and disgust facial

expressions in response to odors from bodily waste and a dirty white sock (Stevenson et al., 2010). The expression of disgust is believed to be innate because babies exhibit disgust facial expressions early on and the same expressions are found around the world and recognized cross-culturally (Rozin, Haidt, & McCauley, 2008). The innate processes of disgust may be evolutionarily beneficial as the expressions involved are related to expelling food from the body, specifically food that may cause illness (Rozin, Haidt, & McCauley, 2008). Rozin and Fallon's (1987) definition of disgust involves the universal revulsion of consuming or coming into contact with offensive items, including food items rendered unacceptable when in contact with offensive items. Furthermore, they specify that offensive items are considered contaminants. Thus, disgust expressions are connected with contamination.

In addition to the connection between disgust and contamination, disgust has been shown to be associated with moral offenses, e.g., incest (Rozin, Haidt, & Fincher, 2009; Rozin, Haidt, & McCauley, 2008). Furthermore, it was noted above that some research has suggested that young children may confuse contracting an illness with moral behavior rather than through contamination or contagion (Kister & Peterson, 1980). Given the relationship between disgust and contamination (Rozin & Fallon, 1987), disgust and moral behaviors (Rozin, Haidt, & Fincher, 2009), and contamination and moral behaviors (Kister & Peterson, 1980) there may be a triadic relationship between all three elements: disgust, contamination, and moral behavior. This triadic relationship may account for inconclusive findings in research that children attribute sociomoral behavior to contracted illnesses that would otherwise be due to contamination (e.g., Kalish, 1996; Kister &

Peters on, 1980). Research has shown that adults will exhibit disgust expressions for immoral acts as well as contaminated substances (Stevenson et al., 2010). Given the connections between disgust, contamination, and moral behaviors, it may be confusing for young children if disgust expressions are used for a moral transgression as well as contact with contamination. Examining *how* children are taught about contamination rather than *what* children know may provide insight into the basis for their knowledge and seemingly conflicting explanations.

The disgust reaction that acts as protection against contaminants may be innate, while at the same time play an important social function. The disgust reaction transmits concern about contamination between people (Rozin, Haidt, & McCauley, 2008). Disgust reactions occur during social contact between the developing child and others in their social surrounding that may facilitate the child's understanding of contamination. Research examining the exhibition of disgust between mothers and children ages 2 1/2 – 14 years old has found that mothers exhibit more disgust-avoidant behaviors and expressions with younger children (Stevenson et al., 2010). As children approach the age of 7 years parents begin to exhibit disgust behaviors at adult-like levels. An example of children learning about contaminated substances through interaction involving disgust behaviors suggests that children's choices of potentially contaminated substances were predicted by mothers' disgust responses (Stevenson et al., 2010). While disgust can be used as social mechanism to teach about contamination, the innate nature of disgust means that caregivers may be inadvertently teaching children about contaminants through the automatic expression of disgust in everyday contexts. Children learn important

information for becoming a competent member of society through observations of more experienced members (Rogoff, 1998). Thus, when children see others responding with disgust to specific behaviors or items, they have learned information regarding that item or behavior. For example, a child may see his mother make a disgust face when she cleans up dog feces or takes out the garbage. Though the mother was not attempting to directly teach her child the disgusting and potentially contaminating nature of garbage or feces, the child has learned this information the innate behaviors of the mother. In sum, disgust has been found in research to be closely connected with the development of contamination sensitivity and may be pivotal in social interactions that aim to communicate potential contamination.

**Social interactions.** Exhibiting and observing disgust behaviors alone, however, may not communicate all necessary information about the invisible mechanisms involved with contamination such as how germs transfer from one location to another. For instance, a child may understand something to be inedible because her mother has exhibited disgust behaviors toward it. However, in order to make future inferences from that inedible item to other inedible items the child must learn what properties make that substance inedible. In many cases the reason may not be visibly apparent. After a child sneezes on her hand, then reaches for a cookie to eat, a mother may make a disgust face then follow up with instructions for the child to wash her hands as the germs from her sneeze could now get on the cookie. In this way, interactions in everyday settings may teach children both how to interact with potential contaminants and specific information that can be used to further inform their concepts about contamination.

Very little research has been conducted investigating how children learn about contamination (see Au et al., 2008). Researchers examining contamination sensitivity have suggested that children are learning about what is safe and unsafe to eat through constant interaction with various substances and observations of others' behaviors with these substances (Au, Sidle, & Rollins, 1993). Researchers who study social influences on children's learning suggest that children learn important behaviors through observing others in their social environment, both family members and community members (Paradise & Rogoff, 2009). For example, a child might learn how to make a common family meal while watching others in the home prepare the meal. This pattern of learning can also be applied to learning about how to interact with potential contaminants.

Yet, observation of these behaviors alone may not be enough for a young child to learn about events or objects around them, especially when what is being learned is not readily perceptible and requires inference. As some researchers suggest, learning about biological mechanisms and entities requires social input and may be influenced by variable social factors, such as raising animals or growing plants at home, or a child being exposed to specific kin relationships such as adoption which emphasizes biological properties such as hair and skin color (Inagaki & Hatano, 2002; Keil, 1992a; Springer, 1999). Research suggests that social factors, such as being adopted, may increase children's coherence of their biological theory, especially between the ages of 4 and 5 years old (Springer, 1999). However, Springer emphasizes that it is unknown what exactly children are learning from their parents about these biological concepts. In addition, specific types of interactions with other social members and one's environment

may also direct the child's learning about biological concepts that are specific for that child's development into a competent member of their community (Gauvain, 2001; Rogoff, 2003). This may be especially important when considering contamination because though some contaminants are universal, such as animal feces, some contaminants are environmentally specific such as specific plants causing illness. Participation in everyday activities provides opportunity for children to observe other's behaviors with contaminants as well as

Though research has not explored what social factors may inform contamination sensitivity learning, research outside of contamination and naïve biology literature has investigated the benefits of joint discussions and interaction in remembering subsequent information (Gauvain, 2001). This research suggests that when children have joint discussions with others, such as a teacher or a parent, of events in the present or past they are more likely to remember those events later (Haden, Ornstein, Eckerman, & Didow, 2001; McCabe & Peterson, 2000). For example, 2 1/2 – 3 1/2-year-olds remembered up to three weeks later more of the events that were jointly discussed with a mother than events that were either talked about only by the mother or not talked about at all (Haden et al., 2001). Research has looked at parent-child spontaneous discussions at a museum and how this type of exchange contributes to the development of a child's scientific reasoning (Crowley et al., 2001). When parents and children 4-8 years old were observed figuring out how to use a zoetrope, parents helped focus children's attention on relevant aspects of the device and provided explanations about how it worked. This provided

greater opportunity for learning compared to children who interacted with peers or worked alone with the zoetrope.

These findings support sociocultural theory, which asserts that children learn about important everyday knowledge through social interactions and joint discussions with more experienced social partners (Gauvain, 2001; Rogoff, 1998). In accordance with Vygotsky's (1978) zone of proximal development (ZPD), parents provide the level of information regarding concepts that they believe the child is capable of understanding. As a more expert social partner presents new knowledge, the novice, or child, applies the new knowledge to previous knowledge (Wood, Bruner, & Ross, 1976). For example, a parent may believe that their young child is not able to understand the concept of germs because of its invisible nature, thus she may explain that food is inedible because it has fallen to the ground and is dirty (dirt being a visible contaminant). Later, the child may learn about germs in school, such as the ability for germs to move from one place to another, that they are invisible, and that they cause illness. The child then may begin to incorporate germs as an explanation of why food is inedible when it falls to the ground. Over time and with the help of scaffolding from social partners such as parents and teachers, the developing child's knowledge builds on itself and forms more thorough concepts (Wood et al., 1976).

In applying sociocultural theory to learning biological concepts, researchers (e.g., Inagaki & Hatano, 2002; Keil, 2007; Medin & Atran, 2004; Springer, 1999), suggest that sociocultural contexts contribute to the growth of biological concepts, which include contamination sensitivity. In their frameworks, sociocultural contexts provide situations



in which children can learn knowledge from others, especially through discussion of examples from everyday occurrences. Very little research, however, has directly examined the social contributions to contamination sensitivity development. In a recent study Kalyva and colleagues (2010) attempt to understand the importance of social interaction in contamination sensitivity by examining autistic, Down syndrome, and typically developing children in their ability to identify contaminated substances. They hypothesized that autistic children would be less likely to make contamination distinctions because they are less responsive to social signals and communicative messages. The research confirmed that autistic children around the age of 9 years had significantly lower contamination sensitivity than both Down syndrome and typically developing children of the same age. In addition, these children had significantly lower contamination sensitivity than typically developing 3-4-year-olds from other research. Though social interactions were not directly studied, the authors attribute the low level of contamination sensitivity to severely delayed abilities in autistic children to pick up and process social cues. The researchers suggest this lack of contamination sensitivity may also result in higher levels of gastrointestinal illnesses seen in autistic children.

Other research has looked more directly at input from social partners regarding contamination. One study conducted in Japan examined teachers' discussions with preschool children during mealtime (Toyama, 2011). The researcher found that preschool teachers talked more about proper hygienic behaviors than eating behaviors or manners during mealtime. Explanations from teachers, however, did not generally contain a lot of biological detail but rather involved basic level explanations such as "It's

dirty.” Similar findings were suggested in a study that observed mothers’ explanations to 1- 4-year-olds during mealtime about food that had been dropped on the floor (Toyama, 2000). Basic explanations such as “It’s dirty” were most frequent, with mention of germs or illness as second most frequent. These basic explanations could be due to the age of the children, though further research investigating discussions regarding hygienic and contaminated concepts has yet to be done with children over 5 years old. Nevertheless, these discussions draw children’s attention to specific aspects (hygiene) of a daily activity (meal time) and teach children both important aspects about the concept of hygiene, such as when food is safe to eat, and that hygiene is important more generally. The above research suggests that social interactions are beneficial for learning and that biological concepts are informed by social input, however, research has not investigated the kinds of social interactions that take place when children are learning about contamination.

### **Aims of Proposed Research**

The aims of the proposed research are to examine the kinds of information mothers provide for children about contamination of food and water, how these interactions may facilitate children’s learning about contamination, and whether there are age-related differences in the way mothers talk to their children in regards to contamination. Three research questions address these aims .

**Research question 1: What do mothers convey to young children during social interactions involving information about contaminated substances?** Three hypotheses are derived from this research question.

***Hypothesis 1.1.*** Mothers will provide information to their children regarding contaminated situations that teach their children the harmful nature of various contaminants and that this information will be biological. Research with children younger than 4 years suggests that mothers and teachers provide some knowledge about what is safe to consume, yet they provide only basic information as to why it is unsafe, such as not eating food that has fallen on the floor because it is bad for you (Toyama, 2000, 2011). Other research examining children's knowledge of contamination has suggested that children at 3 years of age have some understanding about contamination and that these young children can provide biologically based answers as to why the substance is contaminated (Siegal & Share, 1990). According to the investigators, these findings may be suggestive of information they are learning with social partners. This hypothesis is also based on sociocultural theory which suggests that discussions and explanations from more expert social partners is necessary for developing into a competent member of the community (Gauvain, 1995). Given the health ramifications of ingesting contaminated food or water, caregivers have strong incentive to teach their children about food and water safety.

***Hypothesis 1.2.*** In conjunction with biological explanations, mothers will use disgust facial expressions when discussing contamination related scenarios. This hypothesis is based on the disgust literature, which has found that mothers use disgust facial expressions with their children when presented with contaminated items (Stevenson et al., 2010).

***Hypothesis 1.3.*** Mothers will provide more biological explanations regarding contamination than immanent justice explanations when discussing contamination related scenarios. Some research suggests that children provide immanent justice explanations for illness caused by contamination (Kister & Peterson, 1980). It may be the case that mothers are providing immanent justice rather than biological explanations to their children in regards to contamination and illness. Mother's use of immanent justice as an explanation for illness has not been found in the literature, though more recent literature investigating children's use of immanent justice as explanation for illness suggests that children are more likely to use biological explanations than immanent justice explanations (Raman & Winer, 2002).

**Research question 2: Do discussions with mothers about contamination improve a child's understanding of contamination?** Two hypotheses are derived from this research question.

***Hypothesis 2.1.*** Social participation in discussion with mothers about contamination will support children's learning about contamination. This hypothesis is rooted in sociocultural theory, which has shown that cognitive processes are impacted by information and interactions provided by a more experienced social partner (Gauvain, 2001). In the area of contamination sensitivity, research conducted by Stevenson and his colleagues (2010) found that disgust responses elicited by mothers predicted children's subsequent choices of potentially contaminated substances. These findings support the hypothesis for this study that discussions involving both verbal and nonverbal

communication about contamination with mothers and children will improve knowledge about contamination by children.

Specifically, it is hypothesized that the level of a child's conceptual knowledge about contamination will increase, while knowing whether something is contaminated or not will remain the same. In other words, children's explanations about *why* something is contaminated are expected to be conceptually more biological after discussions with their mothers about contamination than simply knowing *if* something is contaminated. This conceptual knowledge is expected to present itself through biological concepts.

Researchers who suggest that children under the age of 7 or 8 years old do not possess naïve biology partially attribute it to a lack of biological mechanisms in their explanations for biological phenomenon (e.g., Carey, 1985; Solomon et al., 1996).

However, other research maintains that children can still possess naïve biology without having to use biological mechanisms specifically in explanations because the framework for understanding biological kinds is still present (Keil, 1992a; Medin & Atran, 2004).

Studies interested in contamination have not investigated the level of biological concepts used to explain contamination. Given that contamination is a biological phenomenon, assessing biological concepts provided by the mother may be one way of gauging contamination concept learning in the child. Again, this is based on sociocultural theory which asserts that interactions with more experienced social partners not only improves knowledge but helps to build on concepts the child already has (Vygotsky, 1934/1986).

***Hypothesis 2.2.*** Children's use of immanent justice to explain consequences of behaviors that involve potential contamination will not change after discussions with

mothers involving potentially contaminated scenarios. It is expected that mothers will provide biological explanations over immanent justice explanations (see Hypothesis 1.3). Thus it is not expected that children's use of immanent justice will change from the pretest to the posttest. This is also based on evidence that children are not likely to use immanent justice as an explanation for illness (Raman & Winer, 2002).

**Research question 3: Do mothers provide different kinds of information about contamination to their children based on the child's age during interactions involving contaminated situations?** Three hypotheses are the basis of study of this research question.

*Hypothesis 3.1.* Mothers will adjust the kind of information they provide for their children based on the age of the child. This hypothesis is based on Vygotsky's (1978) idea of the zone of proximal development (ZPD), which asserts that experienced social partners will draw attention to information believed by the experienced social partner to be important to the child and befitting to the child's competence level. At 3 and 4 years old children may hold basic conceptions about contamination (e.g., that a cockroach will contaminate juice) (Siegal & Share, 1990), but they may not understand mechanisms involved in the contamination, e.g. how the cockroach has contaminated the juice (Kalish, 1996). Based on Vygotsky's (1934/1986) theory, as children develop and learn new information, their contamination concepts are expected to adjust to newly learned information both in school and in the home, providing a new dynamic to the social interactions they may have with a parent regarding contamination. In essence, this bidirectional relationship between the knowledge the child brings to the discussion and

the information the mother provides should allow the child's concept of contamination to develop from having a less biological foundation (e.g., cockroaches make juice bad to drink) to a more biologically-based foundation (e.g., cockroaches have germs that get into the juice and make one ill when ingested).

**Hypothesis 3.2.** Explanations from the mother to the youngest children are hypothesized to be less biological in nature (e.g., because it will make you sick) or include mainly visible contaminants (e.g., it has dirt on it). This outcome is predicted due to the expectation that mothers will alter their explanations based on the amount of knowledge their child already possesses. Based on the theoretical view of Vygotsky's (1978) ZPD, mothers are expected to adjust to their child's growing knowledge of biology and include more biological explanations to their 8-year-olds than their 5-year-olds regarding contamination. Previous research has found that preschool teachers and parents use less concrete terms such as "bad" while talking to children around age 4 years in Japan about food that has fallen to the ground (Toyama, 2000, 2011).

**Hypothesis 3.3.** More disgust facial expressions by mother will occur with 5-year-olds than 8-year-olds. This is based on the research finding that parents use more disgust facial expressions with younger children (Stevenson et al., 2010). In accordance with sociocultural theory, as children gain more biological knowledge, mothers are expected to provide more biological explanations about the mechanisms of germs or bacteria (e.g., germs or bacteria are alive and can live on you or be killed through washing our hands). As biological explanations increase, the mother is expected to reduce her nonverbal communication of contamination through disgust expressions.

To summarize, this study will examine whether mothers provide information regarding contamination and biological concepts with their children, whether this information improves children's understanding of contamination, and if mothers vary the information they give their children based on the child's age. In addition, this study will examine behaviors between mothers and children during discussions about contamination. The goal of this research is to advance our understanding of social contributions to the development of contamination sensitivity. In the next section, the piloting conducted to create the pretest, posttest, and interactive story materials and procedure is described.



## **Chapter 2: Piloting the Pretest, Posttest, and Interactive Story Materials**

Two types of pilot data were collected. The first, referred to as Pilot Phase I, focused on the images to be used as stimuli and involved a small set of children and some young adults. The second, referred to as Pilot Phase II, focused on the procedure and included a small set of mothers and children. Development of the materials and procedures resulted from these two piloting efforts.

### **Pilot Phase I**

Phase I piloted the images to be presented to the children individually during the pretest and the posttest and the stories for the interaction activity. The piloting participants, materials, procedures, and results for both of these examinations are described more below.

#### **Part 1: Piloting Pre- and Posttest Images**

**Participants.** To pilot the pre- and posttest images, three children, a 4-year-old boy, a 5-year-old girl, and an 8-year-old girl, were recruited from family and friends of the primary investigator. The children's ages represent the ages of children that were included in the final study.

**Materials.** The stimuli that were piloted for the pre- and posttest were photographed pictorial images. The content and presentation of these images were based on prior research on contamination sensitivity conducted with Western (Siegal, 1988; Siegal & Share, 1990) and non-Western (Gauvain & Beebe, 2011) samples. All the images included in the pilot test were color photographs printed on 5" x 5" (12.7cm x

12.7 cm) white paper. Photographic images were chosen over illustrated (drawn) images because the former allows for more detail to be depicted, which is important for the study. For instance, children were asked to differentiate and make judgments about distinct types of contamination (e.g., moldy or rotten or dirty food). Although most of the images were photographs that were downloaded directly from the web (Google images), some images were created for the study by merging two or more photographs, (e.g., an image of a man coughing on food or an image of food in some contaminated state) or staged and photographed by the primary investigator.

In total, 37 different photographs were shown in random order to the three pilot children. The photographs depicted familiar fruits and vegetables, common household items, and other familiar images or objects (e.g., apples, tomatoes, a lake, and people sneezing). The images varied as to whether they depicted a contaminated scene or not. In this study *moldy* refers to the growth of a fungus on the food, *dirty* refers to ground soil appearing on the food, *rotten* refers to the decomposing of food caused by natural enzymes in the food and does not include microorganisms such as mold, and *untainted* refers to an item that is unsoiled or apparently free of infection. The piloted items, identified as contaminated (C) or not contaminated (UC), are listed in Table 1.

Table 1

*Stimuli piloted for possible inclusion as pre- or posttest items.*

Stimuli Type	Stimuli Reference #	Stimuli	Presentation	Contamination Status
Food	1*	Tomato	untainted	UC
	2	Tomato	dirty	C
	3	Tomato	moldy	C
	4	Potato	untainted	UC
	5	Potato	dirty	C
	6	Potato	rotten	C
	7	Cucumber	untainted	UC
	8	Cucumber	dirty	C
	9	Cucumber	moldy	C
	10	Orange	untainted	UC
	11	Orange	dirty (on ground)	C
	12	Orange	moldy	C
	13	Apple	untainted (in tree)	UC
	14	Apple	dirty (on ground)	C
	15	Apple	moldy	C
	16	Strawberries	moldy	C
	17	Bread	moldy	C
	18	Bread	untainted	UC
	19	Cheese	moldy	C
	20	Candy bar	sealed and wrapped in commercial packaging	UC
Drink	21	Water	still and clean and contained in a Britta pitcher	UC
	22	Water	clear and flowing from a garden elbow-joint spigot	UC
	23	Water	clear and flowing from a kitchen sink faucet	UC
	24	Water	clear and boiling in a glass pot	UC

	25	Water	clear and flowing from a drinking fountain	UC
	26	Water	murky in a metal pail	C
	27	Water	clear and still in a lake in a forest in the mountains	C
	28	Water	clear in a swift, small river running through a forest in the mountains	C
	29	Water	clear in a clean toilet	C
	30	Juice	cockroach in a glass of orange juice	C
Animal/ Human Action	31	Animal	dog drinking juice from a glass	C
	32	Animal	cat eating pancakes from a plate	C
	33	Animal	parrot eating spaghetti from a plate	C
	34	Human	boy hugging a woman who is sneezing	C
	35	Human	man coughing over a table of food	C
	36	Human	in cupped hands with man drinking the water from his hands	C
	37	Insect	cockroaches crawling on sandwich	C

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*Note.* \*Reference numbers are used to identify the items so they can be tracked through the piloting phase and understood in relation to the information in Table 2.

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**Procedure.** Each of the three child participants was interviewed separately and asked to examine each of the 34 photographic images one at a time in random order. The major issue of concern in this pilot was the clarity and familiarity of the images. Thus, to

probe for clarity and familiarity, when each image was shown, the interviewee was asked by the experimenter (the primary investigator) what was depicted in the picture.

**Results.** The children's responses to the questions about what was depicted in each picture indicated that all three children could identify the photographic images accurately and that they were able to discern the important features in the images, e.g., that the bread or fruit was moldy or that the water appeared clean. This information suggests that the images are appropriate to use in the study with children between 4 and 8 years of age.

After obtaining verification from the pilot participants about the identification of the images, the set was reduced from 37 to 28 photographs. Previous research using similar protocol suggests that 28 images was an adequate number of stimuli (Gauvain & Beebe, 2011). This number provided sufficient variability of item type and representations of contamination (or not), but was not so large, based on prior research in Uganda, to be fatiguing or cause children to lose interest in the task. To reduce the item set, items were identified in relation to the five categories of representation used in previous research in Uganda (Gauvain & Beebe, 2011), specifically:

1. items that were naturally contaminated due to spoiling (e.g., moldy cheese)
2. items that were contaminated due to condition (e.g., exposed water)
3. items that were contaminated by an outside organic source, either human (e.g., sneezing on food) or animal (e.g., cat licking food or an insect in a drink)
4. items that were not contaminated (e.g., an untainted potato)
5. items in the process of being decontaminated (e.g., boiling water)

After the items were identified in relation to these categories, items were chosen that represented each category, with at least 2 items per category. The final 28 images selected for piloting with mothers and children in Phase II appear in Table 2.

Table 2  
*Stimuli selected for the pre- and posttest for Piloting Phase II.*

Category	Stimuli			Contamination Status
	Reference #	Stimuli	Presentation	
Natural Food Contamination	3*	Tomato	moldy	C
	5	Potato	dirty	C
	9	Cucumber	moldy	C
	11	Orange	dirty (on the ground)	C
	14	Apple	dirty (on the ground)	C
	16	Strawberries	moldy	C
	17	Bread	moldy	C
Natural Water Contamination	23	Water	clear and flowing from a kitchen sink faucet	UC
	25	Water	clear and flowing from a drinking fountain	UC
	26	Water	murky in a metal pail	C
	27	Water	clear and still in a lake in a forest in the mountains	C
Human/animal Contamination	36	Water	in cupped hands with man drinking the water from his hands	C
	30	Juice	cockroach in a glass of orange juice	C
	29	Water	clear in a clean toilet	C
	31	Animal	dog drinking juice from a glass	C
	32	Animal	cat eating pancakes from a plate	C

	34	Human	boy hugging a woman who is sneezing	C
	35	Human	man coughing over a table of food	C
	37	Insect	cockroaches crawling on sandwich	C
Decontamination	21	Water	still and clean and contained in a Britta pitcher	UC
	24	Water	clear and boiling in a glass pot	UC
Untaminated	1	Tomato	untainted	UC
	4	Potato	untainted	UC
	10	Orange	untainted	UC
	13	Apple	untainted (in tree)	UC
	18	Bread	untainted	UC
	20	Candy bar	sealed and wrapped in commercial packaging	UC
	**	Juice	untainted (orange juice)	UC

*Notes.* \* Reference numbers are for tracking purposes only and refer to the enumeration of the items in Table 1.

\*\* This stimuli item was used in previous research (Gauvain & Beebe, 2011) and not tested on children in Part 1 of Piloting Phase 1.

## **Part 2: Piloting the Stories for the Mother-Child Interaction**

In the second part of the first phase of piloting, the stories being considered for use in the mother-child interaction were examined.

**Participants.** Three undergraduate students, two females, were recruited to participate in this part of the piloting. These students were invited individually to the laboratory where they were presented with a set of six stories and then asked several probe questions about each of the stories.

**Materials.** The six interaction stories were based on stimuli used in prior research on contamination sensitivity in Tanzania (Gauvain & Beebe, 2011). The stimuli in the previous research were modeled after research conducted by Hejmadi et al., (2004), Siegal and Share (1990), and Stevenson et al., (2010). For this study, the stories were adapted for a Western setting.

Six stories that probe understanding and interaction of contamination were designed for the current study. Each story includes three to four drawings that show a situation in which something becomes contaminated or not. The stories were based on types of contamination understanding and disgust responses that have been examined in other research (Au et al., 2008; Gauvain & Beebe, 2011; Hejmadi, et al., 2004; Siegal & Share, 1990; Stevenson, et al., 2010). The six stories are as follows:

1. Boy eating apple – 3 drawings/scenes
  - Scene 1 - boy sees apples in tree
  - Scene 2 - boy reaches for apple on ground
  - Scene 3 - boy eats apple he picks up from the ground
2. Children playing – 3 drawings/scenes
  - Scene 1 - children playing outside with a dog
  - Scene 2 - mother carries a baby outside
  - Scene 3 - children touch the baby
3. Tea party – 4 drawings/scenes
  - Scene 1 - two girls having a tea party
  - Scene 2 - smaller girl gets water from the toilet
  - Scene 3 - smaller girl pours toilet water into the other girl's teacup
  - Scene 4 - other girl drinks water from the teacup
4. Boy drinking milk – 3 pictures
  - Scene 1 - boy has a glass of milk and sees a fly in the milk
  - Scene 2 - he removes the fly from the milk
  - Scene 3 - he drinks the milk
5. Washing carrots – 4 pictures
  - Scene 1 - mother and child are at grocery getting carrots



Scene 2 - they come home and wash the carrots in the sink

Scene 3 - mother cuts the carrots for a snack

Scene 4 - the child eats the carrots

6. Hand slapping game – 4 images

Scene 1 - two girls are playing a hand slapping game

Scene 2 - one girl coughs on her hands

Scene 3 - they continue their hand game

Scene 4 - mother comes out with a plate of cookies and both girls take a cookie

Story #2 above was later removed to reduce redundancy with Story #4 above in the type of contamination represented. Another story (Story #4 above) was changed to describe a clearer and more plausible situation. The glass of milk used in Story #4 was removed because it is important that the contaminant in the liquid is visible and the opaque nature of the milk may make it difficult to see the bug in the liquid. To alter the milk story, a boy eating a bowl of soup was created to provide a substance that is clearer than milk and thus easier to see a bug. Two new stories were added, one story depicted people in the process of decontaminating water and the other story had a sociomoral dimension. The story involving decontamination (boiling water during a camping trip) is as follows:

Family camping – 4 drawings/scenes

Scene 1 - family camping in the forest

Scene 2 - mother gets water from a lake

Scene 3 - mother boils the water at the camp site

Scene 4 - mother drinks the boiled water

The sociomoral story was added to examine whether mothers discuss any connection between illness and moral transgressions, as some investigators have found (Kister & Peterson, 1980). The new story, which involved a thief getting ill, is as follows:

Thief story – 4 drawings/scenes

Scene 1 - a thief breaks into a house at night

Scene 2 - the thief sees a glass of milk on the kitchen counter

Scene 3 - the thief drinks the milk

Scene 4 - the thief has a stomach ache

After these changes were made, the final set of seven stories piloted in Phase I was as follows:

1. Boy eating apple–3 pictures
  - Scene 1 - boy sees apples in tree
  - Scene 2 - boy reaches for apple on ground
  - Scene 3 - boy eats apple
2. Family camping – 4 pictures
  - Scene 1 - a family is in the forest camping
  - Scene 2 - mother goes and gets water from a lake
  - Scene 3 - mother boils the water at their camp site
  - Scene 4 - mother drinks the water
3. Tea party – 4 drawings/scenes
  - Scene 1 - two girls having a tea party
  - Scene 2 - smaller girl gets water from the toilet
  - Scene 3 - smaller girl pours toilet water into the other girl's teacup
  - Scene 4 - other girl drinks water from the teacup
4. Insect in soup – 3 pictures
  - Scene 1 - boy has a bowl of soup and sees a cockroach in it
  - Scene 2 - he removes the cockroach from the soup
  - Scene 3 - he eats the soup
5. Washing carrots–4 pictures
  - Scene 1 - mother and child are at grocery store getting carrots
  - Scene 2 - they come home and wash the carrots in the sink
  - Scene 3 - mother cuts the carrots for a snack
  - Scene 4 - the child eats the carrots
6. Hand slapping game – 4 images
  - Scene 1 - two girls are playing a hand slapping game
  - Scene 2 - one girl coughs on her hands
  - Scene 3 - they continue their hand game
  - Scene 4 - mother comes out with a plate of cookies and both girls take a cookie

7. Thief story – 4 drawings/scenes

Scene 1 - a thief breaks into a house at night

Scene 2 - the thief sees a glass of milk on the kitchen counter

Scene 3 - the thief drinks the milk

Scene 4 - the thief has a stomach ache

These seven stories represent a range of contamination knowledge and disgust responses.

Table 3 lists these stories and identifies the types of contamination or disgust addressed in each story along with references and relevant age related information regarding the contamination scenario. The stories are listed in the order they will be presented in the dissertation study. Following the table, there is discussion of the overall rationale for including this set of stories in the dissertation.

**Table 3**  
*Types of contamination knowledge and disgust responses in the stories in the mother-child interaction session\*.*

Story order	Story	Scene #	Depiction	Contam Status†	Description and Rationale	Age-related issues
1	Insect in soup	1	boy sees an insect (cockroach) in his bowl of soup	C	Contamination due to an action on the part of an outside animal source	3-year-olds recognize this scenario as contaminated
		2	boy removes insect from soup			
		3	boy eats the soup			
2	Washing carrots	1	mother and child select carrots at grocery store	D	Washing vegetables is a familiar activity for children in the US. The purpose of washing is tested here (washing helps kills germs left by other people).	
		2	mother and child wash carrots in sink at home			
		3	mother cuts carrots			
		4	child eats the carrots			
3	Thief story	1	thief breaks into a house at night	C	Either the moral transgression (thief breaking into a home) or the potential natural contamination (milk left out at night) or both can be discussed as a cause for the thief's illness.	Children as young as 5 years were found to use immanent justice as an explanation for illness
		2	he sees a glass of milk on the counter			
		3	he drinks the milk			
		4	he then has a stomach ache			

4	Tea party	1 two girls are playing tea party 2 younger girl gets water from the toilet 3 younger girl pours water from the toilet into the older girl's teacup 4 older girl drinks the water from the teacup	C	Toilets elicit strong disgust responses from both mothers and young children and are a form of human contamination.	4.5 year old children recognize toilets as contaminated
5	Boy eating apple	1 boy sees apples in tree 2 boy picks up apple from ground 3 boy eats the apple from the ground	C	Story addresses a visible type of contamination, dirt on food, which can also be easily removed through washing. This provides opportunity to discuss decontamination.	5 years and older understand this type of contamination
6	Family camping	1 family is camping in the forest 2 mother gets water from a lake 3 mother boils the lake water at their camp site 4 mother drinks the water	D	Decontamination may be harder for children to understand as it involves knowledge of the contamination as well as how it can be removed. Boiling water to kill germs is less familiar to children in the US and requires biological understanding of germs.	
7	Hand slapping game	1 two girls are playing a hand slapping game 2 one girl coughs on her hands 3 they continue their hand game 4 mother enters with a plate of cookies and both girls take a cookie	C	The story emphasizes human contamination which illustrates the spread of germs from person to person.	

*Notes.* \*The order of stories listed is the order in which they were presented in the final study. Pilot Phase II indicated there may be response effects when the thief story is at the end. To account for this the order of stories was revised into this final order.

†C = contamination; D = decontamination

Once the stories and their sequences were determined, the stories were printed in color on two white 8.5” x 11” (21.6 cm x 27.9 cm) pieces of paper with two illustrations per page. The stories were illustrated and bound which provides a familiar storybook-like experience for the mother and child, mimicking an event they may do together at home. Illustrations also allow for continuity between the images that tell the story. For instance, by illustrating a sequence of events, different characters can be drawn from story to story, a task found to be difficult with photographic images. By keeping the characters different from story to story it reduces confusion on the part of the mother or child that the stories may in some way be connected. A storybook-like procedure was used, similar to Hejmadi, et al. (2004).

**Procedure.** All stories were piloted with three undergraduate students. Participants were interviewed separately in the laboratory. For each story, the participant was asked to identify and describe the events depicted in the illustrations.

**Results.** Results revealed that all participants were able to identify the storyline for each story sequence and to explain the events depicted in each illustration accurately. Minor changes were made based on feedback from the students to enhance the clarity of each story, such as repositioning the boy’s eyes in the apple story so it was more apparent he was looking up or down.

In preparation for the piloting conducted in Phase II, the stories were made into a final format as they will appear when presented to the mother and child. This included editing the illustrations as needed (e.g., adjusting the boy’s eyes in the apple story),

printing the stories on white 8.5" x 11" (21.6 cm x 27.9 cm) card stock paper (one illustration per page), laminating all the pages, and binding them into individual booklets.

### **Pilot Phase II**

Piloting involving the entire dissertation procedure was conducted in order to test both the materials and the procedure with mothers and children. Phase II piloting involved conducting the procedure in the same manner as expected for the final study.

### **Participants**

Four children, two 5-year-olds (2 males) and two 8-year-olds (1 male) were recruited using a posting on Craigs list. Mothers were compensated \$20 for their time and transportation.

### **Pretest**

Mother and child were brought to the laboratory into the observation room where the mother filled out a consent form, a brief overview of the three activities were explained, and initial questions were answered. The researcher gave a brief overview of the procedure (e.g., that there would be three parts, and during the first and last part the mother would be in the other room). The mother was then brought to a nearby room where she filled out a demographic questionnaire. The child and the researcher remained in the observation room and proceeded with the pretest.

**Materials.** Table 4 (following page) displays the 13 images used for the pretest in the order they were presented.

Table 4  
*Items presented in the pretest in the order of presentation.*

Order of Presentation	Category	Stimuli Reference #*	Stimuli	Presentation	Contamination Status
1	Uncontaminated	18	Bread	Untainted	UC
2	Natural Food Contamination	17	Bread	Moldy	C
3	Uncontaminated	**	Juice	Untainted (orange juice)	UC
4	Human/animal Contamination	30	Juice	Cockroach in a glass of orange juice	C
5	Natural Water Contamination	21	Water	Still and clean and contained in a Britta pitcher	UC
6	Natural Water Contamination	32	Animal	Cat eating pancakes from a plate	C
7	Natural Water Contamination	35	Human	Man coughing over table of food	C
8	Uncontaminated	10	Orange	Untainted	UC
9	Natural Food Contamination	9	Cucumber	Moldy	C
10	Natural Water Contamination	26	Water	Murky in a metal pail	C
11	Human/animal Contamination	35	Human	Man coughing over a table of food	C
12	Natural Food Contamination	11	Orange	Dirty (on ground)	C
13	Natural Water Contamination	25	Water	Clear and flowing from a drinking fountain	UC

*Notes.* \* Numbers refer to the reference numbers from Table 1.

\*\* This item was not tested in Phase I piloting as it was used in previous research

**Procedure.** The procedure for the pretest was carried out as planned for the proposed dissertation study. The researcher began by showing the items to the child one at a time and by asking the child what was in the picture to ensure that the child could identify the item. Then the researcher asked if it was OK or not OK to do (or eat or drink) what was in the picture. Following the child's response, the researcher asked why it was OK (or not OK). If a child gave a vague or incomplete response, such as "it has things on it," the researcher probed further and asked why those things are OK (or not OK depending on the response).

**Results.** The two 5-year-olds and two 8-year-olds were able to identify all items accurately, however, one 8-year-old boy had trouble with a single image, that of a moldy cucumber. Because this image was redundant with pictures of other moldy foods, it was removed from the set. The first two children (a 5- and 8-year-old boy) were asked probe questions for only four items as per previous research using a similar protocol. The pretest, including the four probe items, took about 7 minutes. It was later decided to include probe questions for each item in order to increase the opportunity to examine children's conceptual knowledge. Probe questions were then included for all items with the remaining two children (a 5-year-old boy and an 8-year-old girl). The addition of probe questions for each item extended the pretest to about 10 minutes.

### **Mother-Child Interaction**

Following the pretest, the mother was brought back into the observation room for the interaction stories.



**Materials.** The seven story booklets created after Phase I of piloting were used in the interaction. The stories and their order of presentation was as follows:

1. Boy eating apple
2. Family camping
3. Tea party
4. Insect in soup
5. Washing carrots
6. Hand slapping
7. Thief story

A training story was included in the set of illustrated stories used in the mother-child interaction. The training story was not tested in Phase I since it was a story that had been used in previous research (Gauvain & Beebe, 2011). The training story was found in previous research to be useful in explaining a procedure that used a sequence of images. It is used in the proposal to explain the layout and use of the booklets made for the mother and child. The training story is as follows:

Boy in garden – 3 pictures

Scene 1 - boy is digging in his garden

Scene 2 - there is a drooping corn plant seen in the garden

Scene 3 – boy pours water on the plant

**Procedure.** The training story was used to explain the task to the mother and child. The mother and child were shown the booklet that contained the training story and explained that this story was similar to the other stories the mother and child would look at together. The mother and child were then told that they should talk about the story as represented in the pictures. The experimenter talked through the garden story with the participants and explained what was depicted in each picture (e.g., for scene 1, “In this picture the boy is working in his garden”). The mother and child were then told that they

should talk about the events that happen in the story. An example from the training story provided by saying it was good that the boy watered the plant since plants need water to grow. The mother and child were then asked to look at each story and talk about them, proceeding through all seven stories in the order they were numbered. The mother and child were then asked if they had any questions. After answering questions, the experimenter left the room and the mother and child looked at the stories on their own. The entire interaction was videotaped.

**Results.** The materials and procedure were successful. All participants understood that task. All of the mothers, as instructed, discussed what was happening in the story, they discussed the story as intended, and they directed the children's attention to different forms of contamination that were displayed. Some of the mothers also pointed out why something was contaminated and, for some of the items, how one could decontaminate the item. Two of the mothers directed their children's attention to how activities shown in the story were similar to routines and practices they do at home. The entire interaction lasted between 10 and 15 minutes.

There were small adjustments made to the Thief Story as a result of information obtained during the piloting. In piloting, one mother asked aloud why the thief would break in just to drink milk. While piloting the Thief Story it became apparent that the immoral behavior may not have been salient enough. After considering previous research (Kister & Peterson, 1980; Solomon & Cassimatis, 1999) the immoral transgression was changed to a more obvious moral transgression (money on the table the thief puts in his pockets in addition to breaking in to the house) for clarity purposes.

## **Posttest**

Following the interaction, the child remained in the observation room while the mother was asked to move into the seating area, where she then completed a survey on illness and germs. The experimenter then conducted the child-only posttest which included the remaining contaminated/uncontaminated items developed for the study as well as two additional items used to test immanent justice responses.

**Materials.** The 15 items used in the posttest were presented in the order listed in Table 5. Items 14 and 15 were the items used for the sociomoral questions.

**Procedure.** The posttest was administered using the same procedure as the pretest. During piloting, two sociomoral items, a wrapped candy bar and moldy strawberries, were used only in the posttest. Two figurines were used to tell a story about each item individually. One figure stole the food item from the other figure and ate the food. Participants were asked if the behavior was OK or not OK and if anything would happen to the figure who stole the food. Participants were asked to explain their answer.

**Table 5**  
*Items used in the posttest as they were presented.*

Order of Presentation	Category	Stimuli Reference #*	Stimuli	Presentation	Contamination Status
1	Uncontaminated	1	Tomato	untainted	UC
2	Natural Food Contamination	3	Tomato	moldy	C
3	Human/animal Contamination	29	Water	clear in a clean toilet	C
4	Human/animal Contamination	37	Insect	cockroaches crawling on sandwich	C
5	Natural Food Contamination	5	Potato	dirty	C
6	Decontamination	24	Water	clear and boiling in a glass pot	UC
7	Human/animal Contamination	31	Animal	dog drinking juice from a glass	C
8	Uncontaminated	13	Apple	untainted (in tree)	UC
9	Natural Water Contamination	27	Water	clear and still in a lake in a forest in the mountains	C
10	Natural Food Contamination	5	Potato	dirty	C
11	Human/animal Contamination	34	Human	boy hugging a woman who is sneezing	C
12	Natural Food Contamination	14	Apple	dirty (on the ground)	C
13	Natural Water Contamination	23	Water	clear and flowing from a kitchen sink faucet	UC
14	Uncontaminated	20	Candy bar	sealed and wrapped in commercial packaging	UC
15	Natural Food Contamination	16	Strawberries	moldy	C

*Note.* \* Numbers refer to the reference numbers from Table 1.

**Results.** Results using the posttest items indicated that the procedure was successful in eliciting children's explanations about contamination. Children were also found to repeat phrases and explanations their mothers used in the interaction. Piloting with the first two children (a 5- and an 8-year-old boy) revealed that the unhealthy aspect of the candy bar could cause the child to reject it as something that should not be eaten. For the remaining participants (a 5-year-old boy and an 8-year-old girl) a bowl of untainted blueberries was used and the candy bar item was removed. Both the 5-year-old boy and 8-year-old girl accepted the blueberries as edible and rejected the strawberries as inedible. The posttest took about 12 minutes.

After the posttest test was finished and the mother completed the survey, the mother was compensated \$20 for her time and transportation. The parent survey took 3-5 minutes longer than the child's posttest. It was decided to adjust the questions in the parent survey. Items involving how much the mother worried about germs and all water questions in the parent survey were removed as they did not seem relevant to the current study's questions. Items regarding stomach illness were then added to replace items asking about water contamination. Stomach illness questions were more appropriate for the nature of the study. The final number of items was reduced in the survey to adjust the timing of the child and parent during the posttest session and to make for a more concise survey.

### **General Discussion and Further Changes**

Following Phase II of the piloting the items in the pre- and posttest were further changed to create a more incisive and balanced set of items and to refine the types of

contamination tested. Specifically, it was decided to test dirty, rotten, and untainted forms of food in both the pre- and posttest as these are different types of contamination with different consequences, e.g., unlike soiled food, rotten food cannot be decontaminated and has a higher likelihood than soiled food to cause illness. Some items were removed to reduce the final list to include 13 contaminated/uncontaminated items and 2 sociomoral items. The removed items were deemed redundant and included water in a metal pail, untainted bread, and untainted orange juice. A few items were shifted from the pretest to posttest or vice versa to balance the contamination types for each test. The final set of items chosen for the dissertation reflects these changes and is listed in Table 6. In the table, the starred items are the new or adjusted items in the final set of 32 items and items that are crossed out have been removed from the list.

Adjustments to the sociomoral questions asked at the end of the posttest (and now added to the pretest) were adjusted to match other immanent justice stories used in research (Kister & Peterson, 1980; Solomon & Cassimatis, 1999). The moral transgression was increased to include one figure hitting the other then stealing the item. Sociomoral items were added to the pretest and a neutral non-food item, such as a toy, was added to the sociomoral items. The same sequence between the figures will transpire and questions regarding the food items will be applied to the toy. The neutral item is included to test for immanent justice beliefs that may not appear with food items. Research suggests that children may vary their application of immanent justice depending on the situation in question (Springer & Ruckel, 1992). Adding a neutral non food item allows for comparing immanent justice beliefs between food and nonfood items.

Category	Pretest	Posttest
Natural	Moldy bread	Moldy cheese*
Contamination	Dirty orange (on ground)	Dirty apples (on ground)
	Rotten potato**	Rotten tomato
	Dirty potatoes **	Dirty tomato
	<del>Moldy cucumber</del>	
Exposed water	Flowing river*	Clear lake
	Water fountain with flowing water	Water from kitchen sink
	<del>Water in metal pail</del>	
Human/animal Contamination	Cat eating pancakes on plate	Dog drinking juice from glass
	Cockroach in juice	Cockroaches on sandwich
	Boy hugging sneezing woman**	Person on coughing over table of food**
	Drinking water from hands	Clean toilet with water in it
Decontamination	Water in Brita pitcher	Water boiling
Untaminated	Untainted orange	Untainted apple
	Untainted potatoes*	Untainted tomato*
	<del>Clean bread</del>	
	<del>Clean orange juice</del>	
Sociomoral items	Untainted cucumber	Untainted blueberries
	Rotten corn	Rotten strawberries
	Ball	Teddy bear

*Notes.* \* New items added to the final list  
\*\* Items moved from pre- to posttest or post- to pretest

Explanations of the interaction to the mother and child on the part of the experimenter will be adjusted to exclude prompts regarding discussions of what the mother and child think about the images they look at. Instead, mother and child will be shown how the stories can be used, moving page by page, using the training story. This will conclude the training session for the interaction. This change is made due to

research that suggests that mothers will adjust their prompts and behaviors with their children depending on what the mother believes the goals of the activity are (Gauvain, 1995). By keeping the prompt for the interaction more neutral it will allow for an interaction between mothers and children that will be less influenced by the experimenter.



## Chapter 3: Methods

### Participants

Participants were recruited from the community surrounding Riverside, California ( $N = 76$ ; 38 females). Mothers and their children were recruited using postings on Craigslist and through a child care center on the University of California, Riverside campus. Ages of the children ranged from 4 years 6 months to 8 years 11 months ( $M = 6$  years 7 months). Children were from a variety of ethnic backgrounds that included White (28%), Latino/Hispanic (26%), African American (12%), Asian (3%), and other/mixed ethnicity (31%). The distribution of household income is as follows: \$0-\$19,999 (12%), \$20,000-\$39,999 (34%), \$40,000-\$74,999 (37%), \$75,000-\$99,999 (5%), and over \$100,000 (8%). The majority of mothers had at least some college education (47%) or a bachelor's degree or higher degree (34%). All mothers had at least some high school education.

Children were divided into two age groups, 5-year-olds ( $n = 38$ ; 17 females) and 8-year-olds ( $n = 38$ ; 21 females). The 5-year-old age group ranged in age from 4 years 6 months to 5 years 11 months ( $M = 5$  years 2 months) and the 8-year-old age group ranged from 7 years 4 months to 8 years 11 months ( $M = 8$  years 0 months). For the 5-year-olds, 26% had no schooling, 58% were in or had completed preschool and 16% were in or had completed kindergarten. For the 8-year-olds, 8% were in or had completed kindergarten, 21% were in or had completed first grade, 63% were in or had completed second grade, and 8% were in third grade. Some of the data were collected in the summer after the school year was completed, thus some of the children's grades were recently completed.

## **Design and Materials**

This study includes two age groups involved in a child-only pre- and posttest design with a mother-child interactive story activity following the pretest. In addition, mothers provided demographic information and took a survey with questions about stomach illness and germs.

**Pre- and posttest.** The pre- and posttest were based on previous research that tested contamination sensitivity in Ugandan children ages 4-12 years using pictures (Gauvain & Beebe, 2011) and research that has shown testing health knowledge in 3-5-year-olds with pictures to be effective (Mobley, 1996). The method for the current study involved 13 laminated 5” x 5” photographic pictures for the pre-test and 13 laminated 5” x 5” photographic pictures for the posttest. Images were of contaminated, uncontaminated, or in the process of being decontaminated items or situations in which the child was asked if it is OK, not OK, or if they are unsure to eat, drink, or do what was represented in the picture. The child was then asked to explain her answer. Following the contamination images three additional images were used to probe children’s belief in immanent justice.

The items used in the pre- and posttest were familiar to American children and fit into one of five categories: natural contamination (includes dirty or rotten food), natural water sources (such as a lake), human or animal contamination (including vectors or drinking water from hands), decontamination (boiling water), uncontaminated (clean fruit and vegetables), and items used during the sociomoral questions (see Table 7). The sociomoral questions involved three items used to tell a sociomoral story. Two of the

items were food items, one of which was clearly rotten and inedible. The food items were used to test whether children focus on the contamination aspect of the food or the sociomoral aspects of the question. The third item was a non-food item used as a control. Figurines were used to tell a short story about these three items in which one figure hits the other and takes the item from the other figure either eating it or playing with it. Both a male and a female figure were used and the figure that performed the hitting was counterbalanced to control for gender bias. Probe questions followed asking whether it was OK to take and eat or play with the item and what would happen to the figure who took it. To test whether the gender of the doll hitting the other doll had an effect on the pre- and posttest sociomoral responses two  $3$  (contaminated food, uncontaminated food, toy)  $\times$   $2$  (doll gender) MANOVAs were conducted. Results indicated the gender of the doll who carried out the hitting did not have an effect on the child accepting items as OK to eat or play with in the pretest,  $F(3,64) = .95, p = .42, \eta_p^2 = .04$ , or the posttest,  $F(3,64) = .57, p = .64, \eta_p^2 = .03$ . Thus, sociomoral responses will be collapsed by doll gender.

Table 7

*Pretest and posttest items listed in the order they are presented to children, contamination category and a description of their presentation.*

	Stimuli	Contamination Category	Presentation
Pretest	Potato	Uncontaminated	untainted
	Bread	Natural contamination	moldy
	River*	Exposed Water	clear and flowing in a forest
	Juice	Human/animal	cockroach in a glass of orange juice
	Water	Decontaminated	still and clean and contained in a Britta pitcher
	Animal	Human/animal	cat eating pancakes from a plate
	Potato	Natural contamination	rotted
	Orange	Uncontaminated	untainted
	Water*	Human/animal	in cupped hands with man drinking the water from his hands
	Potato*	Natural contamination	dirty (in a pile on the ground)
	Human	Human/animal	woman hugging a man who is sneezing
	Orange*	Natural contamination	dirty (on the ground)
	Water	Uncontaminated	clear and flowing from a drinking fountain
Pretest Sociomoral	Cucumber	Uncontaminated	untainted
	Corn	Natural contamination	moldy
	Teddy Bear	Control	untainted
Posttest	Tomato	Uncontaminated	untainted
	Cheese*	Natural contamination	moldy
	Water *	Exposed Water	clear and still in a lake in a forest in the mountains
	Insect	Human/animal	cockroaches crawling on sandwich
	Water	Decontaminated	clear and boiling in a glass pot
	Animal	Human/animal	dog drinking juice from a glass
	Tomato	Natural contamination	moldy
	Apple	Uncontaminated	untainted (in tree)
	Water *	Human/animal	clear in a clean toilet
	Tomato*	Natural contamination	dirty (on the ground)
	Human	Human/animal	man coughing over a plate of cookies
	Apple*	Natural contamination	dirty (on the ground)
	Water	Uncontaminated	clear and flowing from a kitchen sink faucet
Posttest Sociomoral	Blueberries	Uncontaminated	untainted
	Strawberries	Natural contamination	moldy
	Ball	Control	untainted

*Note.* \* Indicates *difficult items*.

Table 7 displays the list of the items for both the pre- and posttest in each contamination category types. The items in the posttest corresponded with items from the pretest. For instance, a potato was used in the pretest, and another vegetable with edible skin was used in the posttest, such as a tomato. No items were repeated from pre- to posttest. Stimuli items in the pretest did not appear in the story activity. Some of the items addressed in the story activity (e.g., toilet water, dirty apple, or vegetables in a grocery store) were included in the posttest to test whether children apply contamination explanations from the same items discussed during the story activity with their mothers with those depicted in the posttest. Items in the pre- and posttest were tested in piloting and all children were found to be familiar with the items. Items in the pre- and posttest were in a fixed order and contaminated and uncontaminated items and water and food items were distributed evenly in their presentation so that many items of one type (e.g., contaminated food) were not grouped together.

In order to avoid ceiling effects for the older children, items varied in the difficulty of the biological concepts needed to understand the contamination. These items are referred to as *difficult items* (see Table 7). For instance, cheese with some mold on it can be eaten if the mold is cut off. Mold has been found in other studies (Siegal & Share, 1990) to signify contamination understanding in young children and 8-year-old children may not know that removing cheese mold can render the cheese edible. Furthermore, contaminated items that can be decontaminated require a child understands multiple pieces of knowledge in order for the decontamination process to be effective. For example, a child may know that mold renders a food item contaminated, however,

some mold can be removed allowing the food to remain edible. Whereas, for items such as a glass of water, if a contaminant comes in contact with one part of the water (the top of water in a glass) the rest of the water is considered unconsumable. Research suggests that young children may have a more difficult time than older children and adults using more than one criterion in making decisions about whether an item is contaminated or not (Raman & Winer, 2004). In addition, children were tested not only on their acceptance of the item as safe to consume or do, but also the depth of their knowledge regarding the food or activity by coding for the depth of biological explanations. It is the explanations of their OK/not OK answers that should keep the test from having a ceiling effect. For instance, a child might say a food item with dirt on it can be eaten if the dirt is washed off during the pretest, but during the posttest may say another food is safe to consume when the dirt is washed off because dirt has bacteria and washing it keeps the bacteria from getting inside you. This would indicate an increase in conceptual knowledge regarding biological properties involved with decontaminating the food item.

**Interactive story activity.** The interactive story activity is presented after the pretest. It is based on methods used in previous research conducted by Gauvain and Beebe (2011) in Tanzania with children age 4-9 years old, other research that has used stories to test contamination sensitivity (Hejmadi, et al., 2004), and research examining parent-child discussions of biological concepts (Jipson & Callanan, 2003).

The interactive story activity used a series of illustrations to create short stories that depicted everyday scenarios in which some kind of contamination may or may not be avoided. There were 3 – 4 illustrations per story and a total of eight stories including a

training story. The training story was a neutral story not containing contaminated items of a child planting a plant in a garden, watering it, and watching it grow. Appendix A depicts all story images. The seven test stories were as follows: (1) a boy has a bowl of soup with a cockroach in it, he removes the cockroach, then continues eating the soup (contamination story); (2) mother and child are at the grocery store, they bring home vegetables, then wash them, cut them, and have them for a snack (decontamination story); (3) a thief enters a house at night, he sees milk and money on the table, he takes the money and drinks the milk, he then gets sick to his stomach (sociomoral story); (4) two little girls are playing tea party, the littlest girl dips the teapot into the toilet, then pours the water from the teapot into the other girls teacup, and the older girl begins to drink from the teacup (contamination story); (5) a child is standing near an apple tree, sees apples within reach in the tree and on the ground, picks one from the ground and begins to eat the apple (contamination story); (6) a family is camping in the woods, mother gathers water from a lake, she boils the water, then cools it and drinks (decontamination story); (7) two children are playing a hand slapping game, one of the m sneezes into her hand, they continue with their hand game, then mother brings in a plate of cookies that the girls pick-up to eat (contamination story).

Piloting the interactive story activity found that all mothers and children, both 5 and 8 years old, talked about what was happening in the stories, including the contaminated aspects of the story. Some mothers probed their children with questions regarding the stories and children would sometimes offer spontaneous comments about what they saw happening in the stories. Also, some mothers would elaborate on the story

to include steps the story characters could decontaminate already contaminated items. For instance, in the story where a boy eats an apple from the ground some mothers would comment that if the boy had washed the apple then it might be OK to eat. Piloting, therefore, indicated the stories elicited conversation between mother and child that was appropriate for this study. All the stories used in this study were piloted.

The illustrations for each story were combined into a story book format. Illustrations were presented one at a time so that as the pages were turned the next illustration in the story appeared. Each previous picture remained on the page so that by the end of the story all illustrations for each story were visible on the two open pages. Each story had its own booklet. The booklets were given neutral names, e.g., A Family, Danny, and At Night, and placed in the order mothers were to look at them with their child. The order of the stories was chosen to keep food and water or contaminated and decontaminating stories separated. The thief story was included as a sociomoral item and included early on so other food/water contamination stories would not prime the mother.

**Parent survey and demographics.** A survey was given to mothers to test their knowledge about illness, germs and contamination, and what their child knows about germs. This survey is based on previous research assessing similar topics with adults (Schonfeld, Johnson, Perrin, O'Hare, & Cicchetti, 1993; Lagare & Gelman, 2009) (see Appendix B for survey). The survey was used to assess the mother's knowledge as a comparison for what she may talk to her child about, as well as discover what she believes her child knows about illness and germs. Sociocultural theory suggests that caregivers will adjust the information they provide the developing child based on the



child's abilities and knowledge (Gauvain, 2001). In doing so, mothers may discuss contamination concepts at a lower biological level than what they would express with other adults. Collecting survey information regarding mothers' knowledge about germs and illness helps provide a general biological concept score for mothers.

The survey was divided into two sets of knowledge, illness knowledge and germ knowledge. Questions were open-ended, and questions with a yes or no response followed with why or why not probe questions. For illness knowledge, 10 questions were asked. These questions focused on how stomach illness is contracted, treated, and prevented. Examples of stomach illness questions included the following:

1. How does someone get stomach illness?
2. Can someone get a stomach illness from someone else who has a stomach illness?
3. Are there treatments or cures for stomach illness?
4. What do you do so you don't get stomach illnesses?

Twelve questions comprised the germ questions. These questions asked what germs were, about the vitality of germs (live, die, or move), consequences of germs getting in or on you, and how to treat and prevent germs from getting in or on you. Examples of germ questions included the following:

1. Briefly describe what germs are.
2. Are germs alive?
3. Can germs die?
4. How do you know if something has germs on or in it?

5. What would you do if germs get on or in you?

Demographic information was also collected using a written questionnaire. The demographic information included ethnicity of child and parents, marital status of parents, primary language spoken at home, zip code where child resides, mother's and father's employment and education information, and household income. Appendix C displays the demographic questionnaire.

### **Procedure**

Recruitment materials informed mothers that the researchers were interested in how mothers and children talk about everyday items and activities while looking at story books. Two separate rooms were used to conduct the study; the main room was used for the pretest, interactive story activity, and posttest. All activity in the main room was video recorded. The second room was used to keep the mother separate from the child during the pre- and posttest. Mothers completed the demographic questionnaire and survey in the second room. Mothers and children came to the laboratory on a single occasion. Upon arrival mother and child were brought to the main room used for the study and mothers filled out a consent form while the child was asked to give verbal assent. The mother was brought to the second room to fill out the demographic questionnaire while the child was given the pretest. For the pre-test, the child was shown each item individually and asked if it is OK to eat/drink/do what was depicted in the picture. Each item was probed about why something may or may not be OK to eat/drink/do. If a child answered that an item is not consumable she was asked if there is any way to make the item OK to consume. Following the main pretest items the three

sociomoral images were shown using two figurines. Each item was shown and the child was told “This (item) is Suzy’s but Tommy wants it. Tommy hits Suzy and takes (eats) the (item). Was it OK for Tommy to hit Suzy and take (eat) her (item)? Will anything happen to Tommy when he takes (eats) her (item)?” The child’s responses were probed as to why or why not they gave their answers. The child was then asked if it would have been OK for Suzy to eat/play with the item to verify whether the child believed the item was OK to eat/play with in the absence of the moral transgression and why. Responses regarding Suzy eating/playing with the items should indicate whether the child believed the item was contaminated. The pretest took an average of 10 minutes.

After the pretest was finished, the mother was brought into the room with the child for the interactive story activity. They were seated at a table and asked to talk together about what they saw taking place in the picture story. The researcher used the training story as an example by pointing out the pictures, showing the sequence of events, and explaining that the discussion should be about what they see in the illustrations and what they think about the things taking place in the story. It was explained that each story is in its own booklet and the booklets were placed in the order they should be viewed. After the experimenter made sure the participants had no questions she left the room and allowed the mother and child to continue. The story activity took an average of 15 minutes.

After the story activity was finished the mother was brought out of the room to complete the survey in the second room and the child was given the posttest. The posttest had the same procedure as the pretest where children were shown pictures and

asked if it is OK/not OK/unsure to eat/drink/do what was in the picture. During this time the mother completed the germ and illness survey. The posttest took on average 12 minutes. The entire procedure was video recorded for coding purposes and typically took no more than one hour.

### **Coding**

For all following codes, independent coders, blind to the hypotheses of the study were used for reliabilities. Coders overlapped at least 20% of the data coded.

Reliabilities for the codes were conducted using the intraclass  $r$  (also referred to as a Spearman-Brown “down” reliability) (Rosenthal & Rosnow, 1991). In this way, reliabilities for each set of codes could be calculated across items or stories and by combining theoretically similar codes. Reliabilities reported below combined theoretically similar variables. For instance, all behavioral variables are combined in the reliability analysis and examines rater reliability across these variables. Reliabilities are reported at the end of each coding description.

**Pre- and posttest coding.** Pre- and posttest items were coded for two dependent variables. First, children’s acceptance of contaminated and uncontaminated items as safe to consume was recorded. Second, probe questions explaining the rejection or acceptance of each item were coded for biological concepts. Difference scores between the pre- and posttest were also analyzed for acceptance of items as safe to consume and level of biological concepts. All pre- and posttest items were divided into two groups based on the item being contaminated or uncontaminated, thus creating two groups of items referred to as *contaminated items* and *uncontaminated items*. These groups are

referred to throughout the analysis as *item types*. Pre- and posttest variables are analyzed throughout based on these item types.

The sociomoral vignettes in the pre- and posttest were also coded for two dependent variables, acceptance of vignette item and presence of immanent justice.

***Acceptance of items as safe to consume.*** The first dependent variable was children's acceptance of items as safe to consume. This code was incorporated in the study to examine children's knowledge about contamination and to aid in answering Research question 2, that interactions with mothers will improve children's understanding of contamination and biological concepts. Children were coded as either accepting or not accepting items they were presented as safe to consume. An acceptance of an item as safe to consume was coded as 1, and a rejection of an item as safe to consume was coded as 0. Responses to all contaminated items were averaged to create a *percentage of contaminated acceptances* variable, and responses to all uncontaminated items were averaged to create a *percentage of uncontaminated acceptances* variable. The range of these variables was from 0% to 100%.

***Biological concept codes.*** The second dependent variable for pre- and posttest was to measure children's biological concepts. The purpose of these codes is to further assess children's understanding of contamination in terms of biological concepts. These codes will be used for analysis in answering Research question 2.

Probe questions in the pre- and posttest were coded using codes based on a coding scheme developed by Perrin, Sayer, and Willett (1991) which was developed to assess the depth of children's conceptual understanding of the biological processes involved in

illnesses. This coding scheme was chosen because similar biological processes are involved in contamination. Because these codes deal with biological concepts, the variable is referred to in this study as the child's *general biological concepts*.

For the current study the concept codes were adjusted to reflect biological knowledge related to contamination more specifically and an additional code was added to encapsulate immanent justice explanations. The additional immanent justice item was included before "phenomenological response" because phenomenological responses involve factual feelings or characteristics (e.g., "that's not good to eat because it's blue") and an immanent justice response involves non-factual phenomenon (e.g., "that will make you sick because you will get in trouble for eating moldy bread"). Thus, when considering biological concepts, factual phenomenon such as the color of a food (which may be related to discoloration in mold or decay) is closer to relating biological level concepts than a food making you sick because it was against the rules to eat it. The codes for assessing biological explanations are hierarchical, ranging from 1 to 7 (see Appendix D for more detailed coding descriptions). The codes listed by the code number with a description of the code follows:

- 1 – NO KNOWLEDG: no knowledge or inappropriate knowledge, e.g., child states that she does not know or comments about something unrelated to the topic
- 2 – SOCIOMORAL: immanent justice (sociomoral) response, e.g., causes are not biological or phenomenological, causes based on unacceptable behavior rather than factual phenomenon.

3 – PHENOMENISM: phenomenological or circular response, no information about biological cause or process, e.g., you get sick because you feel bad, that food will make you sick because of the blue stuff.

4 – EXTERNAL AGENT: includes external factual agents, e.g., that food makes you sick because there's mold on it.

5 – INTERNALIZATION: includes understanding that something is internalized in order for illness to occur, e.g., when you breathe in sick people's germs.

6 – INTERACTION: includes an interaction between person and illness causing agent, e.g., germs get in your system and kill your cells.

7 – MECHANISMS: includes abstract knowledge of the biological mechanisms involved, e.g., germs take food away from cells within the body and then the body has no energy to keep itself healthy allowing bacteria or other illnesses to take over.

Scores below 4 (external agent) indicate a lack of information about biologically causal agents or processes involved in illness or contamination concepts. A score of 4 requires that the participant name concrete, specific causal agents or actions involved in illness or contamination. They must name factual information about the cause, treatment, or prevention of the contaminant without demonstrating knowledge of a causal mechanism. For example, "someone coughing on you" could make you sick, but the causal mechanism is not clear. If participants mention the internalization of a causal agent, they receive a score of 5. For example, germs getting inside you will make you sick, but the causal mechanism is once again not clear. In order to receive a score of 6,

the specific effect of the illness-causing (or contaminating) agent has to be stated (e.g., the virus entering the body and killing immune cells). In order to receive a score of 7, the causal mechanism or process has to be elaborated (e.g., white blood cells not working and unable to fight off other sicknesses). Scores of 6 or 7 require that participants mention specific biological causal process or mechanism of contamination or illness, not simply that they identified causal agents or other factual information. Concepts that receive a score of 4 or above are referred to as *biological level concepts*. Items were divided by contaminated and uncontaminated items and biological concepts codes were then averaged for each item type. The child's highest biological concept from each item type was noted and referred to as the child's *highest biological concept*. Therefore, children received two biological concept scores for both the pretest and the posttest and for each item type, a general biological concept scores for contaminated and uncontaminated items and a highest biological concept score for contaminated and uncontaminated items.

Concept codes were also examined categorically to uncover patterns in the types of reasoning children may be using. For each item in the pre- and posttest, each code was analyzed separately by counting the number of children who were coded for that code. The sum of these children was used to create a percentage of children (based on the entire set of 76 children) who were coded as using each code. The sum of each code was also calculated across all contaminated and uncontaminated items. Contaminated items encompassed nine items and uncontaminated items encompassed four items. The total



number of children using each code for the entire set of contaminated and uncontaminated items was summed.

Two coders were used to test the reliability of the concept codes. Reliability for concept codes was calculated using the general biological concept score averaged across all items for the pre and posttests. Reliability was high, pretest intraclass  $r = .95$ , posttest intraclass  $r = .88$ .

***Immanent justice.*** The three sociomoral vignettes were created to test for use of immanent justice. The percentage of children's acceptance of the vignette item as safe to consume (or play with in the case of the toy) was calculated. This variable is referred to as *acceptance of vignette items*. Each vignette was analyzed separately. Items accepted as safe to consume or play with were coded as 1, and items rejected were coded as 0. The percentage of acceptances was calculated for each vignette.

Next, children's explanations about why the doll should not consume or play with the item were coded for the *use of immanent justice*. The criterion for what constituted an immanent justice explanation was the same as that used in code 2 of the biological concept codes. Immanent justice (sociomoral) responses were explanation that did not use biological reasons, rather, causes are based on the doll's unacceptable behavior rather than factual or biological phenomenon. The use of immanent justice received a code of 1, and all other explanations received a code of 0. Coding of immanent justice explanations revealed too few uses to conduct reliable reliabilities. There was one use in the pretest and one in the posttest. The use of immanent justice did not occur within the

20% of overlapped participants between coders. However, the two coders discussed, and agreed upon, the two immanent justice uses.

**Interaction story activity coding.** Four distinct aspects of the interaction task were coded. First, behavioral codes based on a coding scheme used in research assessing mother-child interaction during a joint cognitive activity (Gauvain & Perez, 2008) were used to code for mother-child behaviors. Second, mothers' discussions and explanations were coded using the biological concept codes described above. Third, mothers' contamination related references during each story were counted. Finally, mothers' disgust expressions were coded. These codes are described more below. Video recordings for each dyadic interaction were divided by story (seven story segments in all). Each story segment was then edited into 30 second clips. These clips were used for coding mother-child behaviors and facial expressions. Separate sets of coders were used for each coding category. For each set of codes, coders viewed the entire 30 second clip, then a screen appeared with the word CODE. Coders then paused the video and recorded their codes. Short clips of behavior have been found to be reliable and useful in rating behaviors and expressions (Ambady & Rosenthal, 1992). Specific information about each coding category is described in more detail below.

**Mother-child behaviors.** Mother and child behaviors were used descriptively, as dependent variables, in relation to child age difference, and as independent variables, as predictors for child posttest scores. The use of these codes is meant to aid in answering all three Research questions. Though behaviors do not directly inform a person about contamination, the manner in which a mother and child interact may help to teach a child

new concepts (Gauvain & Perez, 2008). In addition, these behaviors may vary depending on the age of the child (Gauvain & Perez, 2008).

Behaviors of the mother and child were coded from the video recordings and used to describe behaviors between mother and child while discussing contamination related scenarios and as dependent variables in examining differences in those behaviors based on the child's age. Mother-child behaviors were also used as independent variables to investigate potential predictors for children's changes from pre- to posttest. The codes for this were based on mother-child interactions during a joint cognitive activity (Gauvain & Perez, 2008).

Behavior variables for the mother included whether the mother provided guidance for her child through the story, directed her child's activity, encouraged her child's independent contribution, kept her child involved, and confused the child. *Providing guidance* is the extent the mother explained rules or steps of the task, pointed out constraints in the task, or provided any information on how the task should be performed. *Direct child's activity* is the extent the mother tells the child to perform particular roles in the task or how to behave during the task, not as a suggestion but more like a demand or order. *Encouraging child's independent contribution* is the extent the mother attempts to have the child work on aspects of the task independently or have the child come up with suggestions of her own. *Keeps child involved in activity* is the extent the mother attempts to keep the child involved in executing aspects of the task. *Confuses the child* is the extent to which the mother provides unclear or incorrect information to the child as they are trying to understand the story and discuss contamination.

The variables the child was coded on included involvement in the task, level of frustration, being off-task, cooperation with mother. *Involvement in task* is the extent the child is involved in carrying out aspects of the task such as asking questions, making suggestions, describing pictures, elaborates on the story, etc. *Frustration* is the extent the child is frustrated with the task or with her mother's handling of the task. *Being off-task* is the extent to which the child engages in behaviors or comments that are not related to the task. *Cooperative with mother* is the extent to which the child cooperates and complies with mother throughout the entire planning task.

As a dyad they were rated on who was most responsible for the task. *Task responsibility* deals with who was mainly responsible for the task progressing including reading discussing pictures, making decisions about how the story will be read, etc.

Codes were on a 5-point scale with 1 being little or minimal and 5 being very much or extremely (except task responsibility where 1 was mother solely responsible and 5 was child solely responsible). Behaviors were evaluated and scored during each 30 second clip. Raters observed each video clip and at the end of each video clip rated behavior as it occurred during that clip. For each behavior a score was calculated for each story by averaging scores for all 30 second clips for that story. The number of video clips per story varied between participants based on the amount of time mother and child spent discussing stories. For example, if a mother and child spent 2.5 minutes discussing the first story this resulted in five 30 second video clips that were used for rating. Ratings for each of the five video clips were averaged together to create one rating for each behavior during that story.

An overall composite score for each behavior was then calculated across all of the seven stories. Composite scores could range between 1 and 5, in accordance with the scale described above. Stories were also divided by contamination type (contamination related stories, decontamination related stories, and the sociomoral story). Behavior ratings were then averaged over all contaminated and decontaminating stories. Because there was only one sociomoral story, the score for that story was used as is. Thus, mothers and children received an overall rating for each behavior (across all stories) and separate ratings for contamination related stories, decontamination related stories, and sociomoral story. Because this study is interested in responses based on contamination, only behavior scores based on story type are used in the analysis.

Two coders were used to test reliabilities of the behavioral codes. Because the behavioral codes can be grouped theoretically, they were tested for reliabilities together in the intraclass reliability. As stated above, the codes used in the reliability were *providing guidance, direct child's activity, encouraging child's independent contribution, keep child involved in activity, confuses the child, child involvement in task, child level of frustration, child off-task, cooperation with mother, and task responsibility*. Reliabilities were calculated based on the composite score across all stories. Reliability for the behavioral codes was high, intraclass  $r = .84$ .

***Biological concepts.*** Mothers were coded for the extent of biological understanding during discussions with their children in the interactive task. This variable helps to answer Research question 1 and 3, interested in what types of information mothers provide their children and if there are age differences. It describes mother's

level of biological concepts while discussing contamination related scenarios with her child and used as a dependent variable to assess differences in mother's biological concepts based on the child's age. Mother's biological concepts were also used as an independent variable for investigating predictors of children's changes from pre- to posttest. The same concept codes used in the pre- and posttest, as described above, were used during the interactive task. Briefly, the coding scheme ranges from 1-7 with 1 used for responses of "I don't know" or reflecting inappropriate responses and 7 indicating abstract biological knowledge. Scores of 4 and higher indicated biological level concepts. Coders used video recordings of the interactions to code biological concepts. Coders watched the video recording of the interaction during the entire story and gave mothers one concept code based on the highest level of biological concept she provided at any time during the story. For example, if at some point during the interaction for story 1 a mother tells her child that germs from the bug are in the soup that will then get inside the boy making him sick, then she is given a concept code of 5 for discussing internalization. Provided she does not give further details about how the germs might interact with the body or mechanisms involved in getting ill from germs, her concept score remains 5. One biological concept code was given for each story.

An overall composite score for the concept codes was calculated across all of the seven stories by averaging the concept code for each story. Stories were also divided by contamination type (contamination related stories, decontamination related stories, and sociomoral story). Concept codes were then averaged over all contaminated and decontaminating stories. Because the sociomoral story only encompassed one story, the

score for that story was used as is. Thus, mothers received an overall concept code (across all stories) and separate concept codes for contamination related stories, decontamination related stories, and sociomoral story. Scores for ranged from 1 to 7 based on the biological concept codes above. This variable is referred to as mother's *general concept score*.

Mothers' highest biological code for each story type was also used in the analysis. For this code the highest biological code from each story that comprised the composite score for each story type was used. For example, four stories comprise the contamination related stories. If three stories elicited a score of 3 for each story from the mother but one of the four stories elicited a score of 5, then 5 was used as the highest biological concept. This variable ranged from 1 to 7 as described by the biological concept scores above and is referred to as mothers' *highest concept code*.

Two coders were used to test the reliability of the concept codes during the interactive task. Reliability for mothers' concept codes was assessed using the overall concept codes across all stories. Reliability was good, intraclass  $r = .74$ .

***Contamination references.*** Mothers' references to contamination are used to aid in answering Research questions 1 and 3, interested in the types of information mothers provide their children and if this information varies as a function of the child's age. Coding for contamination references were conducted using the video recordings of the interaction. Mothers' statements were coded into four variables, which include contaminated (e.g., That apple's dirty, he shouldn't eat it), uncontaminated (e.g., Those are OK to eat), decontaminated (e.g., Washing vegetables makes them clean), or

immanent justice (e.g., If you do mean things you will get sick). These four variables were used to describe the types of references mothers provide their children during discussions about contamination related scenarios. In addition, these variables were used as dependent variables to examine differences in mother's references based on the child's age and as independent variables to investigate potential predictors for children's changes from pre- to posttest. *Contaminated statements* refer to an item as being unsafe to consume (as in the case of food or water) or spreading germs or bacteria (as in the case of germ transmission from person to person). *Uncontaminated statements* refer to a lack of contamination existing, or an item being safe to consume or not transmitting germs or bacteria. *Decontaminated statements* refer to potential germs or bacteria being removed from something (e.g., food, water, hands) changing it from contaminated to uncontaminated. *Immanent justice statements* refer to an action or behavior that the mother or child says is a punishment or is punishable (e.g., getting sick because someone misbehaves).

Frequencies were used to evaluate the total number of times these topics were referenced by the mother in each story. For each story, references were counted during the course of discussion between mother and child. Because references were counted, there was not a range the number of references fell between. Frequencies for mothers' references ranged from 0 to an unlimited number of references. Each reference variable (contaminated, uncontaminated, decontaminated, and immanent justice) was averaged across all of the seven stories. Stories were also divided by contamination type (contamination related stories, decontamination related stories, and sociomoral story).



Each reference variable was then averaged over all contaminated and decontaminating stories. Because there was only one sociomoral story the frequencies of each variable during this story was used as the frequencies for the sociomoral story. Thus, mothers received an overall average frequency of each reference (across all stories) and separate averages for contamination related stories, decontamination related stories, and sociomoral story. Two coders were used to test the reliability of all four contamination references during the interactive task. Reliability for references was high, intraclass  $r = .94$ .

***Disgust expressions.*** In addition to verbal content between the mother and child, disgust facial expressions were coded. Disgust is used as a dependent variable to examine mother's differences in disgust facial expressions based on the child's age and as an independent variable to investigate potential predictors for children's changes from pre- to posttest.

Expressions were evaluated and scored during each 30 second clip. Raters observed each video clip with the sound off, focusing only on the mother. At the end of each video clip mothers were rated for the highest level of disgust expressions that were displayed during that clip. Ratings were on a 5-point scale with 1 being emotion not expressed and 5 being emotion extremely expressed. Disgust was given a rating for each story by averaging scores for all 30 second clips for that story. The number of video clips per story varied between participants based on the amount of time mother and child spent discussing stories. For example, if a mother and child spent 2.5 minutes discussing the first story this resulted in five 30 second video clips that were used for rating. Ratings for

each of the five video clips were averaged together to create one rating for disgust during that story. Therefore, each story received a rating for disgust. This variable is referred to as *mother's disgust* and ranged from 1 to 5 based on the coding scheme above.

An overall composite score for disgust was then calculated across all of the seven stories by averaging all disgust scores across the stories. Stories were also divided by contamination type (contamination related stories or decontamination related stories). Expressions were then averaged over all contaminated and decontaminating stories. Thus, mothers received an overall rating for disgust (across all stories) and separate ratings for contamination related stories and decontamination related stories. These disgust scores are referred to as *general disgust* scores. To test whether a brief, but extreme, disgust expression might influence children's outcomes, mothers' highest disgust score over all clips for each story was also used in the analysis. These scores were averaged across all stories and separately for contaminating and decontaminating stories. These disgust codes are referred to as *highest disgust* scores. Three coders were used to test reliabilities of disgust facial expression codes. Reliability for the expression codes was high, intraclass  $r = .97$ .

**Parent survey.** Mothers' responses to the parent survey were coded using the concept codes described above for the level of biological concepts present in their explanations for causes, treatments, and prevention of illness or germs. Two variables were created for the parent survey, the *illness knowledge* and *germ knowledge* variables. Parent survey variables were used as independent variables to investigate potential predictors for children's changes from pre- to posttest. All questions were coded using

the biological concept coding scheme except questions 3 and 15. Questions 4, 7, and 22 were not included in the following analyses because these items did not lend themselves to biological concepts (e.g., Who taught you about stomach illness?). Two coders were used to test the reliability of biological concept codes for the parent survey. Reliability for concept codes was high, intraclass  $r = .93$ .

## **Chapter 4: Results**

Results are reported in four separate sections. First, preliminary analysis was conducted to determine if child gender can be collapsed for the remaining analyses. Second, children's performance on the pretest and posttest and differences from pre- to posttest was examined based on the child's number of accepted items as safe to consume and level of biological concepts. Due to the interest in contamination, the analysis was examined by contaminated and uncontaminated test items. Children's performance on sociomoral items were also examined in this section. Third, mothers biological concepts based on the parent survey are analyzed. Fourth, the story book interaction between mother and child examined the following: 1) references mothers make about contamination, lack of contamination, decontamination, and immanent justice; 2) the level of biological concepts expressed by mother; 3) behaviors of the mother and child which include parental guidance, directing child's activity, encourage independent contribution of the child, mother keeping the child involved, mother confusing the child, the child's involvement in the task, child's frustration, if the child is off-task, child's cooperation with the mother, and whether the mother or child was more responsible for the task; and 4) mothers' disgust facial expressions. These analyses are examined by story type. Finally, the following variables were examined as potential predictors for children's improvement on the posttest: mother's references to contamination, lack of contamination, decontamination, and immanent justice; the level of biological concepts expressed by mother; mother and child behaviors; and mother's disgust facial expressions.

## **Preliminary Analysis**

Variables were tested for gender differences to determine if participants could be collapsed by gender for the remaining set of analyses. Pretest and posttest variables are described first, followed by the story interaction variables, and ending with the parent survey.

**Pretest and posttest variables.** The percent of items children accept as safe to consume was analyzed for gender effects in the pretest and posttest items. Pretest items were divided into contaminated or uncontaminated items and tested for gender effects. A  $2$  (contamination type)  $\times$   $2$  (gender) multivariate analysis of variance (MANOVA) was used to examine gender effects on the percent of pretest items that were accepted as consumable and found no gender effects,  $F(2,73) = .31, p = .73$ . Posttest items were then divided by contamination type and a  $2$  (contamination type)  $\times$   $2$  (gender) MANOVA was used to examine gender effects on the percent of posttest items that were accepted as consumable and found no gender effects,  $F(2,73) = .17, p = .85$ . Based on these analyses genders did not differ on the acceptance of items as safe to consume on pretest and posttest items.

Next, children's biological concepts were analyzed for gender effects in the pre- and posttest. Concepts were analyzed based on child's general biological concepts scores across all stories and the sum of each concept code across all stories. For the general biological scores, a one-way ANOVA indicated there were no gender differences in the pretest,  $F(1,74) = .34, p = .56$ . Next, a one-way ANOVA indicated there were no gender differences in the posttest,  $F(1,74) = .46, p = .50$ . These analyses suggest that males and

females had similar levels of biological concepts in the pretest and posttest items. For the categorical concept codes all codes were for the pretest and posttest were combined and analyzed in two  $4$  (concept codes)  $\times$   $2$  (gender) MANOVA for the effect of gender in the pretest, and a  $5$  (concept codes)  $\times$   $2$  (gender) MANOVA (code 6 was not included in the pretest because no children used it). Results found no effect of gender on the categorical concept codes in the pretest,  $F(3,72) = 1.86$ ,  $p = .15$ , or the posttest,  $F(4,71) = 2.26$ ,  $p = .07$ , though this significance was trending.

Finally, the sociomoral vignettes were analyzed for gender effects on the acceptance of items as safe to consume or play with and for the number of explanations using immanent justice. Two  $3$  (vignette items)  $\times$   $2$  (gender) MANOVA was used to test gender effects on accepting pretest items in the sociomoral vignettes as safe to consume or play with. The vignette items included a contaminated item, an uncontaminated item, and the toy item. Males and females did not accept sociomoral vignette items differently in the pretest,  $F(3,72) = 1.03$ ,  $p = .39$ , or the posttest,  $F(3,72) = 1.33$ ,  $p = .27$ . These analyses suggest that males and females are accepting the sociomoral vignette items as safe to consume or play with similarly. Immanent justice explanations for why these items were safe to consume or play with were too few to conduct an analysis. There was only one instance of immanent justice use in the sociomoral pretest vignettes and one case in the posttest vignettes.

**Interaction variables.** Story interaction variables were analyzed for child gender differences using MANOVA. First mother's references to contamination are analyzed,

then mother's level of biological concepts, followed by mother's and child's behaviors, and finally mother's disgust facial expressions will be analyzed for gender effects.

A 4 (reference type)  $\times$  2 (gender) MANOVA was used to find differences for mother's references to contamination based on the child's gender. Reference types include contamination, no contamination, decontamination, and imminent justice. No gender effects were found on the combined variables,  $F(4,71) = .53, p = .72$ . Mothers did not refer differently to contamination based on the child's gender.

For biological concepts, a one-way ANOVA was used to find differences for mother's general biological concept levels based on the child's gender and found no differences,  $F(1,74) = .56, p = .46$ . Mothers' highest concept based on story type was also analyzed across all story types using a 3 (story type)  $\times$  2 (child gender) MANOVA. Results found no effect of age on mothers' highest biological concepts,  $F(3,72) = .09, p = .96$ . Mothers did not exhibit differences in biological concept levels based on the child's gender.

Next, behavior variables were divided into mother behaviors and child behaviors and assessed for gender effects. A 5 (behavior type)  $\times$  2 (gender) MANOVA was used to examine gender effects on mother's behaviors during the interactive story task. Behavior types include parental guidance, directing child's activity, encouraging child's independent contribution, keep the child involved, and confusing the child. No gender effects were found on the combined variables,  $F(5,70) = 1.19, p = .32$ . A 4 (behavior type)  $\times$  2 (gender) MANOVA was used to examine gender effects on the child's behaviors during the interaction. Behavior types include child's involvement in the task,

child's frustration, whether the child is off-task, and child's cooperation with mother. No gender effects were found on the combined variables,  $F(5,70) = 1.79, p = .14$ . The final behavioral variable, task responsibility, encompassed both mother and child behaviors and was analyzed separately for gender differences. A one-way ANOVA indicated no gender differences for task responsibility,  $F(1,74) = .01, p = .93$ . Mothers and children did not exhibit behavior differences based on the child's gender.

Finally, for disgust expressions a one-way ANOVA was used to examine child gender effects on mother's general disgust expressions during the interactive story task. No child gender differences were found for disgust expressions,  $F(1,74) = .04, p = .85$ . A  $3$  (story type)  $\times$   $2$  (gender) MANOVA was used to analyze whether the child's gender had an effect on mother's highest disgust across all story types. Results found no effect of child age,  $F(3,72) = 1.25, p = .30$ . Mothers did not display facial expression differently based on the child's gender.

**Parent survey.** Mothers biological concepts on the parent survey were tested for differences in illness knowledge and germ knowledge based on the child's gender using a  $2$  (knowledge type)  $\times$   $2$  (gender) MANOVA. Results indicate there was not an effect of child gender,  $F(2,73) = .39, p = .68$

Based on the above analyses, no differences based on child gender were found in the main effect variables for the pretest, posttest, or the interactive story task. Thus, further analysis was collapsed across child gender.



### **Children's Performance on the Pretest and Posttest**

The pretest and posttest included the percent of items children accepted as safe to consume and children's level of biological concepts. In addition, sociomoral vignette items were included in the pre- and posttest to test for the use of immanent justice explanations. Children's acceptance of safe items was analyzed first, then biological concept levels were examined, and lastly, performance on the sociomoral items were examined. Within each analysis set, pretest performance is examined first, followed by examination of the posttest, and ending with differences between the pre- and posttest. Where applicable, analysis is based on whether items are contaminated and uncontaminated.

**Acceptance of items as safe to consume.** Children's decision whether an item was safe to consume or not was examined by age and item type (contaminated or uncontaminated). Items were divided by contamination type and counted to create a percentage of accepted items for each item type. . Table 8 displays the mean percentage of accepted items as safe to consume by item type, test type, difficulty, and age group. Means for the following analyses in this section can be found in Table 8.

**Table 8**  
*Percentage of items accepted as safe to consume by age, difficulty type, item type, and test type.*

Item Types	5-year-olds			8-year-olds			
	Mean (SD)	Difficult Mean (SD)	Non-difficult Mean (SD)	Mean (SD)	Difficult Mean (SD)	Non-difficult Mean (SD)	
Contaminated	Pretest	21% (17%)	18% (24%)	24% (18%)	17% (15%)	25% (25%)	10% (15%)**
	Posttest	23% (19%)	22% (21%)	22% (24%)	13% (13%)*	19% (22%)	7% (11%)**
Uncontaminated	Pretest	77% (25%)			82% (13%)		
	Posttest	70% (27%)			79% (19%)		

*Note.* All mean acceptance rates were different than chance,  $p < .001$ . Age differences were \* $p < .05$ , acceptance of difficult items was greater than non-difficult items at \*\* $p < .01$ . There were no differences between pre- and posttest.

**Pretest.** Previous research suggests that children as young as 5 years olds can accurately accept contaminated or uncontaminated items as safe to consume (Siegal & Share, 1990). Thus, pretest items accepted as safe to consume were first analyzed to ensure children accepted them to be different from chance (50%). One-sample  $t$ -tests with a  $\mu$  of .5 (representing 50%) revealed that 5-year-olds accepted contaminated items,  $t(37) = -10.37, p < .001$ , and uncontaminated items,  $t(37) = 6.67, p < .001$ , significantly different from chance. Likewise, 8-year-olds performed different from chance for contaminated items,  $t(37) = -13.69, p < .001$ , and uncontaminated items,  $t(37) = 11.37, p < .001$ . These data suggest that both 5-year-olds and 8-year-olds in this study accept

items as safe to consume different from chance. Both 5- and 8-year-olds accepted contaminated items as safe less likely than chance, and uncontaminated items more likely than chance.

Next, differences for acceptance rates between item types (contaminated or uncontaminated) based on age were examined. Paired-samples *t*-tests were conducted separately for 5-year-olds and 8-year-olds to compare item types. As expected, both 5-year-olds,  $t(37) = 6.05$ ,  $p < .001$ , and 8-year-olds,  $t(37) = 6.15$ ,  $p < .001$ , accepted more uncontaminated items as safe to consume. Acceptance rates were examined for age group effects, based on item type (contaminated or uncontaminated) using a 2 (item type)  $\times$  2 (age group) MANOVA. Analysis revealed there were no age group differences for accepting items as safe,  $F(2,73) = 1.73$ ,  $p = .06$ ,  $\eta_p^2 = .07$ , though the significance was approaching significance. The pretest data support previous research (Siegal & Share, 1990) indicating that both 5-year-olds and 8-year-olds can select items as safe to consume greater than chance.

Additional analyses considered the difficulty level of the items. Some items were considered more difficult than others based on the items ability to be decontaminated (see Table 7 for specific items in this analysis). To test the difference in acceptance rates of difficult and non-difficult items by child age, a 2 (difficult or non-difficult)  $\times$  2 (age) within-between ANOVA was conducted. Results revealed no main effect of item difficulty,  $F(1,74) = 2.12$ ,  $p = .15$ , nor a main effect of age,  $F(1,74) = .84$ ,  $p = .36$ . However, there was an interaction,  $F(1,74) = 13.34$ ,  $p < .001$ ,  $\eta_p^2 = .15$ . Post hoc paired-samples *t*-tests were used to test for differences between difficult and non-difficult items

for each age group. Results indicate that 5-year-olds accepted difficult items as frequently as non-difficult items,  $t(37) = -1.63, p = .11$ . Eight-year-olds, however, accepted difficult items as safe to consume more frequently than non-difficult items,  $t(37) = 3.45, p = .001$ . These data suggest that overall difficult and non-difficult items are accepted similarly by child as safe to consume. However, an interaction with age indicates that 5-year-olds accept difficult and non-difficult items at similar rates, but 8-year-olds accepted difficult items more frequently (and at a similar rate as 5-year-olds) than non-difficult items in the pretest.

**Posttest.** For the posttest items, one-sample  $t$ -tests with a  $\mu$  set at .5 were used to test whether the percentage of accepted items was different from chance (50%) for contaminated and uncontaminated items. As in the pretest, 5-year-olds performed different from chance for contaminated items,  $t(37) = -8.89, p < .001$ , and uncontaminated items,  $t(37) = 4.63, p < .001$ . Likewise, 8-year-olds performed different from chance for contaminated items,  $t(37) = -16.74, p < .001$ , and uncontaminated items,  $t(37) = 9.46, p < .001$ . These data suggest that both 5-year-olds and 8-year-olds choose different from chance when food or water is safe to consume and that these results are similar to the pretest.

Differences for acceptance rates in the posttest by age group and item type were examined next. Paired-samples  $t$ -tests were conducted separately for 5-year-olds and 8-year-olds to compare contaminated and uncontaminated items first. Like the pretest, both 5-year-olds,  $t(37) = 10.17, p < .001$ , and 8-year-olds,  $t(37) = 20.05, p < .001$ , accepted more uncontaminated items as safe to consume than contaminated items. Age group

effects in the posttest for acceptance rates, based on item type, were examined next. A 2 (item type)  $\times$  2 (age group) MANOVA determined there were age effects for accepting items as safe in the posttest,  $F(2,73) = 5.37, p = .01, \eta_p^2 = .13$ . Post hoc between-subjects tests indicated that for contaminated items, 5-year-olds accepted more items as safe to consume than 8-year-olds,  $F(1,74) = 5.72, p = .02$ . For uncontaminated items, however, both age groups similarly accepted items as safe to consume  $F(1,74) = 2.54, p = .12$ . These data indicate that during the posttest both age groups had higher rates of selecting uncontaminated items than contaminated items as safe to consume. When considering contaminated items, 5-year-olds choose more items as safe than 8-year-olds. There was no difference between the age groups for accepting uncontaminated items as safe.

Additional analyses considered the difficulty level of the items in the posttest (see Table 7 for specific items in this analysis). To test the difference in acceptance rates of difficult and non-difficult items by child age, a 2 (difficult or non-difficult)  $\times$  2 (age) within-between ANOVA was conducted. Results revealed a main effect of item difficulty,  $F(1,74) = 4.88, p = .03, \eta_p^2 = .06$ . Pairwise comparisons indicate that 5-year-olds accepted all items more frequently ( $M = .22, SE = .03$ ) than 8-year-olds ( $M = .13, SE = .03$ ) ( $p = .02$ ). There was also a main effect of age,  $F(1,74) = 5.94, p = .02, \eta_p^2 = .07$ . Pairwise comparisons indicate that difficult items were accepted more frequently ( $M = .20, SE = .03$ ) than non-difficult items ( $M = .15, SE = .02$ ) ( $p = .03$ ). There was also an interaction,  $F(1,74) = 6.30, p = .01, \eta_p^2 = .08$ . Post hoc paired-samples *t*-tests were used to test for differences between difficult and non-difficult items for each age group. Results indicate that 5-year-olds accepted difficult items at the same rate as non-difficult

items,  $t(37) = -.22, p = .83$ . Eight-year-olds, however, were more likely to accept difficult items than non-difficult items,  $t(37) = 3.23, p = .003$ . These results suggest that acceptance rates of difficult items were accepted more than non-difficult items in the posttest and that 8-year-olds were more likely to accept difficult items than 5-year-olds were.

***Changes from pretest to posttest.*** To partially test for Hypothesis 2.1, that biological concept will change, though acceptance of items as safe will not, changes of acceptance rates by age group were analyzed using a 2 (time: pre- and posttest)  $\times$  2 (age group) within-between ANOVA. Contaminated and uncontaminated items were analyzed separately. For contaminated items, there was not a main effect of time,  $F(1,74) = .53, p = .47$ , but there was a main effect of age,  $F(1,74) = .414, p = .05, \eta_p^2 = .05$ , such that 5-year-olds accepted more items as safe ( $M = .22, SE = .03$ ) than 8-year-olds ( $M = .15, SE = .03$ ). There was not an interaction effect,  $F(1,74) = 1.97, p = .17$ . These data suggest that though 5- and 8-year-olds accepted items as safe differently, these acceptances did not change from pre- to posttest for either age group. For uncontaminated items, there was not a main effect of time,  $F(1,74) = 2.01, p = .16$ , a main effect of age,  $F(1,74) = 2.73, p = .10$ , or an interaction effect,  $F(1,74) = .37, p = .55$ . This suggests that for uncontaminated items both age groups had similar acceptance rates of uncontaminated items as safe and there were no changes from the pretest to the posttest.

Next, difficult and non-difficult items were analyzed for changes from pre- to posttest using 2 (time: pre- and posttest)  $\times$  2 (age) within-between ANOVAs. For

difficult items there was not a main effect of time,  $F(1,74) = .24, p = .62$ , nor a main effect of age,  $F(1,74) = .23, p = .63$ . However, there was an interaction effect,  $F(1,74) = 4.74, p = .03, \eta_p^2 = .06$ . Post hoc paired-samples  $t$ -tests were used to test for differences between pre- and posttest for each age group. Results indicate that for difficult items, 5-year-olds accepted pretest items at the same rate as posttest items,  $t(37) = -1.23, p = .23$ . Eight-year-olds also accept pretest items at a similar rate as posttest items,  $t(37) = 1.83, p = .08$ , though this significance was trending. For non-difficult items, there was not a main effect of time,  $F(1,74) = 1.65, p = .20$ , or an interaction effect,  $F(1,74) = .15, p = .70$ . However, there was a main effect of age,  $F(1,74) = 18.79, p < .001$ . Pairwise comparisons indicate that 5-year-olds accepted all non-difficult items more frequently ( $M = .23, SE = .02$ ) than 8-year-olds ( $M = .08, SE = .02$ ) ( $p < .001$ ). These results suggest that acceptance of difficult items does not change after interacting with mother.

In sum, these data indicate that both 5- and 8-year-olds accept contaminated and uncontaminated food and beverage similarly before interacting with their mother about contamination related scenarios. However, this is only true of contaminated items that are not considered difficult, or that cannot be decontaminated. After interacting with their mother about contamination related scenarios, 8-year-olds accepted fewer contaminated items as safe to consume than 5-year-olds. For uncontaminated items, both age groups similarly accepted items as safe to consume. However, analysis suggests that patterns for accepting items as safe to consume from the pre- to the posttest were not different based on age. These results partially support previous research that children as young as 5 years are able to recognize when food or water is considered contaminated or

safe to consume. Results also partially support Hypothesis 2.1 that children are not likely to improve their acceptance rates after interacting with their mother during contamination related scenarios.

**Biological concepts.** To test for the remaining part of Hypothesis 2.1, children’s biological concepts were examined by age and item type (contaminated or uncontaminated) for the level of biological understanding expressed in their reasons why an item is or is not safe to consume. Table 9 displays the biological concept means by item type, test type, and age group. The table also includes the children’s highest biological concept score based on item type. Means for analyses in this section can be found in Table 9.

Table 9  
*Mean levels of biological concepts by age, item type, and test type.*

Item and Test Types		5-year-olds		8-year-olds	
		General Mean (SD)	Highest Mean (SD)	General Mean (SD)	Highest Mean (SD)
Contaminated	Pretest	3.14 (.55)	3.97 (.70)	3.79 (.43)	4.53 (.51)
	Posttest	3.37 (.51)	4.00 (.62)	3.98 (.33)	4.58 (.55)
Uncontaminated	Pretest	2.94 (.51)	3.42 (.64)	3.28 (.54)	3.87 (.41)
	Posttest	2.95 (.49)	3.45 (.65)	3.41 (.51)	4.05 (.61)

*Note.* Means based on 7-point scale with 1= don’t know, and 7= highest level of biological concepts (Mechanisms). All highest means were greater than general means,  $p < .001$ . Means between ages for all test and items types were different,  $p < .01$ . Differences from pre- to posttest for contaminated items were  $p < .001$ , but there were no pre- to posttest differences for uncontaminated items.

Next, analysis was conducted to evaluate biological concept scores categorically. Each concept score is reported in association with each item in the pre- and posttest (see Table 10). Table 11 displays the sum of each concept code across each item type by child age group.



Table 10

*Percent of each concept code used for pretest and posttest items.*

Test Type	Item #	Stimuli	Contamination Type	Concept Codes				
				1 Don't Know	3 Phenom-enism	4 External Agent	5 Internal-ization	6 Inter-action
Pretest	1	Potato	Uncontaminated	15%	67%	18%	0	0
	2	Moldy bread	Contaminated	3%	38%	18%	0	0
	3	River*	Contaminated	8%	38%	53%	7%	0
	4	Juice w/ cockroach	Contaminated	3%	13%	77%	7%	0
	5	Water in pitcher	Uncontaminated	8%	58%	34%	0	0
	6	Cat eating pancakes	Contaminated	7%	43%	43%	7%	0
	7	Potato rotten	Contaminated	3%	46%	50%	1%	0
	8	Orange	Uncontaminated	5%	50%	45%	0	0
	9	Drinking water from hands*	Contaminated	13%	45%	32%	10%	0
	10	Potato w/ dirt*	Contaminated	3%	7%	87%	4%	0
	11	Woman hugs sneezing man	Contaminated	34%	32%	14%	20%	0
	12	Orange w/ dirt*	Contaminated	4%	33%	59%	4%	0
	13	Water from drinking fountain	Uncontaminated	8%	75%	16%	1%	0
Posttest	1	Tomato	Uncontaminated	4%	59%	36%	1%	0
	2	Cheese, moldy*	Contaminated	4%	21%	67%	8%	0
	3	Clear lake*	Contaminated	2%	45%	45%	8%	0
	4	Cockroaches on sandwich	Contaminated	1%	16%	75%	8%	0
	5	Boiling water in pot	Uncontaminated	17%	61%	13%	9%	0
	6	Dog drinking from a glass	Contaminated	3%	39%	45%	13%	0
	7	Tomato, moldy	Contaminated	4%	30%	59%	7%	0

8	Apple, in tree	Uncontaminated	3%	50%	46%	1%	0
9	Water in toilet*	Contaminated	3%	33%	60%	4%	0
10	Tomato w/ dirt*	Contaminated	1%	16%	79%	3%	1%
11	Man coughing over cookies	Contaminated	9%	41%	33%	17%	0
12	Apple w/ dirt*	Contaminated	3%	37%	55%	4%	1%
13	Water from kitchen faucet	Uncontaminated	11%	72%	13%	4%	0

*Note.* Only concept codes that were used by children were included in the table. No children displayed concepts that would have scored 2 or 7.

\*Indicates difficult items that can be decontaminated.

**Table 11**  
*Sum of each concept code used by item type and child age.*

	Code Number	Pretest		Posttest	
		5-year-olds Sum	8-year-olds Sum	5-year-olds Sum	8-year-olds Sum
Contaminated Items	1	42	16*	16	7
	3	173	63***	138	73**
	4	121	223***	158	236***
	5	6	40***	30	24
	6	0	0	0	2
	Uncontaminated Items	1	16	11	13
3		113	77***	102	82
4		23	63***	29	53**
5		0	1	8	4
6		0	0	0	0

*Note.* Age differences for each codes are \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$ .

Children's concept scores were also coded as either biological or non-biological based on their average biological concept scores. Based on the coding used for biological concepts, a score of 4 or higher indicates that the concepts expressed are being

understood at a biological level. For instance, children explain why an item is inedible based on biological criteria, e.g., eating that rotten food will make your stomach sick. Scores below a 4 indicate that the child has, at best, a phenomenological understanding of the concepts in question, e.g., you shouldn't eat this because it's bad. Any score below 4 was considered non-biological, while any score of 4 or higher was biological. For example, a child with an average biological concept score of 3.7 would be coded as non-biological, while a child with an average concept score of 4.2 would be coded as biological. This coding was conducted for overall items, contaminated items, and uncontaminated items in both the pretest and posttest. The means conveyed in Table 9 suggest that as a group the children did not elicit responses that would indicate biological knowledge is being communicated. Table 12 displays the percent of children who scored an average biological concept score of 4 or higher, displaying at least a basic level of biological understanding. Differences between test types, age groups, and item types for biological concept means and percentages are discussed below. Means for the following analyses in this section can be found in Tables 9 through 12.

Table 12  
*Percentage of children by age, item type, and test type who displayed concepts at a biological level.*

Item Types		5-year-olds	8-year-olds
		Mean (SD)	Mean (SD)
Contaminated <sup>a</sup>	Pretest	0%	45% (50%)
	Posttest	5% (23%)	53% (51%)
Uncontaminated	Pretest	0%	8% (27%)
	Posttest	0%	21% (41%)

*Note.* All percentages were different by age,  $p$ 's < .01, except for in the uncontaminated pretest. <sup>a</sup>For 8-year-olds, biological level concepts were significantly more frequent for contaminated items than uncontaminated.

**Pretest.** General biological concept means and highest biological concept means were analyzed first followed by analysis based on categorical concept codes, and finally percentages of children who express concepts at a biological level were analyzed. General biological concepts were examined for differences based on item types (contaminated and uncontaminated). A 2 (contaminated and uncontaminated)  $\times$  2 (age) within-between ANOVA revealed a main effect of item type,  $F(1,74) = 56.59, p < .001, \eta_p^2 = .43$ , such that contaminated items elicited higher level biological concepts ( $M = 3.47, SE = .06$ ) than uncontaminated items, ( $M = 3.11, SE = .06$ ). There was a main effect of age,  $F(1,74) = 21.50, p < .001, \eta_p^2 = .23$ , such that 5-year-olds had lower level biological concepts ( $M = 3.04, SE = .08$ ) than 8-year-olds, ( $M = 3.54, SE = .08$ ). There was also an interaction effect,  $F(1,74) = 10.52, p = .002, \eta_p^2 = .12$ . Post hoc paired-samples *t*-tests were used to test for differences between item types for each age group. Results suggest that higher biological concepts were displayed for contaminated items than uncontaminated items by both 5-year-olds,  $t(37) = 3.10, p = .004$ , and 8-year-olds,  $t(37) = 7.43, p < .001$ .

Highest biological concepts were compared with general biological concepts to test for differences between children's averaged score and their highest biological concept using paired-samples *t*-tests. Results revealed that for 5-year-olds, highest biological concepts were significantly higher than general biological concepts for both contaminated items,  $t(37) = 12.91, p < .001$ , and uncontaminated items,  $t(37) = 6.21, p < .001$ , and also for 8-year-olds, both contaminated items,  $t(37) = 12.56, p < .001$ , and uncontaminated items,  $t(37) = 8.14, p < .001$ , highest concept scores were higher than

general concept scores. Highest biological concepts were then examined for differences based on item types (contaminated and uncontaminated). A 2 (contaminated and uncontaminated)  $\times$  2 (age) within-between ANOVA revealed a main effect of item type,  $F(1,74) = 86.04, p < .001, \eta_p^2 = .54$ , such that contaminated items elicited higher level biological concepts ( $M = 4.25, SE = .07$ ) than uncontaminated items, ( $M = 3.65, SE = .06$ ). There was also a main effect of age,  $F(1,74) = 18.46, p < .001, \eta_p^2 = .20$ , such that 5-year-olds had lower level biological concepts ( $M = 3.70, SE = .08$ ) than 8-year-olds, ( $M = 4.20, SE = .08$ ). However, there was not an interaction,  $F(1,74) = .65, p = .42$ . Together the results for children's general and highest biological concepts in the pretest suggest that 8-year-olds display higher levels of biological concepts, whether the items are contaminated or not. Contaminated items elicited higher biological concepts than uncontaminated items by both age groups.

Additional analyses were conducted to test whether children's biological concepts were different based on the difficulty level of the contaminated item. Items that could be decontaminated were considered more "difficult" in that knowledge about decontaminated processes requires understanding many levels of contamination. Table 10 indicates which items were considered difficult. Paired-samples *t*-tests were used to compare biological concept codes between difficult items and non-difficult items (note that only contaminated items were used). No general biological concepts were different between difficult ( $M = 3.22, SD = .60$ ) and non-difficult items ( $M = 3.08, SD = .58$ ) for 5-year-olds,  $t(37) = 1.97, p = .06$ , though this significance is trending. No general

biological concepts were different between difficult ( $M = 3.77$ ,  $SD = .48$ ) and non-difficult ( $M = 4.01$ ,  $SD = .49$ ) items for 8-year-olds,  $t(37) = -.40$ ,  $p = .69$ .

Next, concept codes were assessed individually using the sum of each code across all items for contaminated and uncontaminated items. In order to treat the codes categorically, separate one-way ANOVAs are conducted for each code to assess age differences in code usage. For contaminated items, 5-year-olds did not know the answer,  $F(1,74) = 4.48$ ,  $p = .04$ , and had phenomenism responses,  $F(1,74) = 48.70$ ,  $p < .001$ , more than 8-year-olds, while 8-year-olds used external agent responses,  $F(1,74) = 42.92$ ,  $p < .001$ , and internalization responses,  $F(1,74) = 15.87$ ,  $p < .001$ , more than 5-year-olds. For uncontaminated items, 5-year-olds used phenomenism more than 8-year-olds,  $F(1,74) = 14.35$ ,  $p < .001$ , and 8-year-olds used external agent more than 5-year-olds,  $F(1,74) = 23.74$ ,  $p < .001$ . There were no age differences between not knowing,  $F(1,74) = .50$ ,  $p = .48$ , and internalization,  $F(1,74) = 1.00$ ,  $p = .32$ . No children used immanent justice, interaction responses, or biological mechanisms in the pretest. Analysis of the categorical codes suggests that, for contaminated items, 8-year-olds were more likely to use biological level reasoning in explaining their answers for why an item could or could not be consumed, e.g., reasoning using external agents as causes and internalization as a process. For uncontaminated items, 8-year-olds were still more likely to use biological level explanations (external agents), but the use of higher level biological explanations (internalization) was not different between the age groups. The use of the categorical codes support age differences based on biological concept means, that 8-year-olds display more biological level reasoning.

Finally, the recoded data reporting the percentages of children who express concepts at a biological level were analyzed. Because no 5-year-olds received a biological level mean, age differences cannot be compared due to 0% violating assumptions of testing. Though some 8-year-olds displayed biological level concepts, note that only 8% did so for uncontaminated items. Next, biological level concepts were compared between contaminated and uncontaminated items within age groups. Due to contaminated and uncontaminated variables being within-subjects variables, McNemar chi-square was used (McNemar, 1947). No 5-year-olds expressed biological level explanations for why an item may or may not be safe to consume. Thus, analysis was not conducted for this age group. For 8-year-olds, McNemar chi-square revealed 8-year-olds were more likely to express biological level concepts for contaminated items (45%) than uncontaminated items (8%) ( $p < .001$ ) (see Table 12). Results for children expressing biological level concepts during the pretest indicate that 5-year-olds did not express any concepts at a biological level. Eight-year-olds, on the other hand, did express concepts at a biological level, but mostly for contaminated items.

**Posttest.** For the posttest items, biological concept means were analyzed first followed by analysis of percentages of biological level explanations. Biological concepts were examined for differences based on item types (contaminated and uncontaminated). A 2 (item type)  $\times$  2 (age group) repeated measures ANOVA revealed a main effect between contaminated and uncontaminated items,  $F(1,74) = 103.58$ ,  $p < .001$ ,  $\eta_p^2 = .58$ , indicating contaminated items elicited higher level biological concepts ( $M = 3.68$ ,  $SE = .05$ ) than uncontaminated items, ( $M = 3.18$ ,  $SE = .06$ ). There was also a main effect of

age,  $F(1,74) = 31.34, p < .001, \eta_p^2 = .30$ , such that 5-year-olds had lower levels of biological concepts ( $M = 3.16, SE = .07$ ) than 8-year-olds, ( $M = 3.69, SE = .07$ ). However, there was no interaction with age,  $F(1,74) = 2.10, p = .15$ .

Highest biological concepts were compared with general biological concepts in the posttest to test for differences between children's averaged score and their highest biological concept using paired-samples  $t$ -tests. Results revealed that for 5-year-olds, highest biological concepts were significantly higher than general biological concepts for both contaminated items,  $t(37) = 12.83, p < .001$ , and uncontaminated items,  $t(37) = 6.48, p < .001$ , and for 8-year-olds, both contaminated items,  $t(37) = 8.43, p < .001$ , and uncontaminated items,  $t(37) = 9.34, p < .001$ . Highest biological concepts were then examined for differences based on item types (contaminated and uncontaminated). A 2 (contaminated and uncontaminated)  $\times$  2 (age) within-between ANOVA revealed a main effect of item type,  $F(1,74) = 49.80, p < .001, \eta_p^2 = .40$ , such that contaminated items elicited higher level biological concepts ( $M = 4.29, SE = .07$ ) than uncontaminated items, ( $M = 3.75, SE = .07$ ). There was also a main effect of age,  $F(1,74) = 25.86, p < .001, \eta_p^2 = .30$ , such that 5-year-olds had lower level biological concepts ( $M = 3.72, SE = .08$ ) than 8-year-olds, ( $M = 4.32, SE = .08$ ). However, there was not an interaction,  $F(1,74) = .03, p = .86$ . Results for children's biological concepts in the posttest suggest that 8-year-olds display higher levels of general and highest biological concepts than 5-year-olds whether the items are contaminated or not. Like in the pretest, biological concepts were higher with contaminated items than uncontaminated items.



Additional analyses were conducted to test whether children's general biological concepts were different based on the difficulty level of the contaminated item. Table 10 indicates which items were considered difficult on the posttest. Paired-samples *t*-tests were used to compare biological concept codes between difficult items and non-difficult items (only contaminated items were used). No general biological concepts were different between difficult and non-difficult items for 5-year-olds,  $t(37) = 1.72$ ,  $p = .09$ , though this significance is trending, or for 8-year-olds,  $t(37) = -1.10$ ,  $p = .28$ .

Next, concept codes were assessed individually using the sums of each code across all items for contaminated and uncontaminated items. Separate one-way ANOVAs are conducted for each code to assess age differences in code usage in the posttest. For contaminated items, 5-year-olds used phenomenism more than 8-year-olds  $F(1,74) = 10.04$ ,  $p = .002$ , while 8-year-olds used external agent responses, more than 5-year-olds,  $F(1,74) = 16.67$ ,  $p < .001$ . There were no age differences between not knowing,  $F(1,74) = .89$ ,  $p = .35$ , and internalization responses,  $F(1,74) = .25$ ,  $p = .62$ . For uncontaminated items, 8-year-olds used external agent more than 5-year-olds,  $F(1,74) = 7.58$ ,  $p = .007$ . There were no age differences between not knowing,  $F(1,74) = .00$ ,  $p = 1.00$ , phenomenism,  $F(1,74) = 3.16$ ,  $p = .08$  (though this is trending), and internalization,  $F(1,74) = .78$ ,  $p = .38$ . Though a few children used interaction responses in the posttest, there were not enough to complete an analysis. However, it should be noted that the interaction responses were only used for contaminated items. Results for the categorical analysis suggest that for contaminated items in the posttest 8-year-olds were still more likely than 5-year-olds to use the biological level explanation off external

agents and 5-year-olds were more likely to use phenomenological responses. However, both age groups did not know the answer and used internalization similarly. For uncontaminated items, only external agents were used more by 8-year-olds. Immanent justice and biological mechanisms were not used in the pretest.

Finally, the recoded data reporting the percentages of children who express biological level concepts were analyzed. Chi-square tests of independence were used to examine differences in the proportion of biological level concepts between age groups. Results indicated that 8-year-olds were more likely than 5-year-olds to use concepts at a biological level for all items combined,  $\chi^2(1) = 8.61, p = .003$ . Items were separated by type and tested for age differences with each type, however, only results for contaminated items can be calculated due to no 5-year-olds reaching biological level concepts for uncontaminated items. Results indicated that for contaminated items, 8-year-olds were more likely than 5-year-olds to express biological level concepts,  $\chi^2(1) = 20.73, p < .001$  (see Table 12). Biological level concepts were then compared between contaminated and uncontaminated items within age groups. McNemar chi-square was used to test item types within age groups. Too few 5-year-olds expressed biological level explanations for why an item may or may not be safe to consume to run an analysis. McNemar chi-square revealed that 8-year-olds expressed biological level concepts differently for contaminated and uncontaminated items in the posttest ( $p = .002$ ). Eight-year-olds were more likely to express biological level concepts for contaminated items (53%) than uncontaminated items (21%) (see Table 12).

*Changes from pretest to posttest.* Changes from pre- to posttest for the biological concept means are examined first, followed by an examination of changes from pre- to posttest for the sum of concepts codes, and finally differences between pre- and posttest for occurrences of biological level concepts is examined.

Biological concept means are examined first item type. To analyze changes from pre- to posttest overall and by item type,  $2$  (time: pretest and posttest)  $\times$   $2$  (age) within-between ANOVAs were used. For contaminated items, there was a main effect for time,  $F(1,74) = 19.11, p < .001, \eta_p^2 = .21$ , such that children had higher biological concepts in the posttest ( $M = 3.68, SE = .05$ ) than the pretest, ( $M = 3.68, SE = .05$ ). There was also a main effect for age,  $F(1,74) = 43.38, p < .001, \eta_p^2 = .37$ , such that 5-year-olds had lower biological concepts ( $M = 3.26, SE = .07$ ) than 8-year-olds for contaminated items, ( $M = 3.89, SE = .07$ ). There was no interaction effect,  $F(1,74) = .24, p = .62$ . For uncontaminated items, there was not a main effect of time,  $F(1,74) = 1.22, p = .27$ , and there was no interaction effect,  $F(1,74) = .98, p = .32$ . However there was a main effect of age,  $F(1,74) = 15.75, p < .001, \eta_p^2 = .18$ , which indicated that for uncontaminated items 5-year-olds had lower levels of biological concepts ( $M = 2.94, SE = .07$ ) than 8-year-olds ( $M = 3.35, SE = .07$ ).

Together, these results supported Hypothesis 2.1 that children's biological concepts would increase after interactions with their mothers. Specifically, results indicated that both age groups improved similarly from the pretest to the posttest when all items were combined. When examined by item type, children had higher biological concept means on the posttest for contaminated items, but there was no change for

uncontaminated items. No interaction with age suggests that age groups changed from pre- to posttest similarly.

Next, changes from pre- to posttest for individual codes were examined. Each code and contaminated and uncontaminated items are examined separately using 2 (time: pretest and posttest)  $\times$  2 (age) within-between ANOVAs. Contaminated item codes were examined first. For not knowing the answer there was a main effect of time,  $F(1,74) = 5.44$ ,  $p = .02$ ,  $\eta_p^2 = .07$ , with the pretest having more “don’t know” answers ( $M = .76$ ,  $SE = .16$ ) than the posttest ( $M = .30$ ,  $SE = .13$ ). There was also a main effect of age,  $F(1,74) = 4.72$ ,  $p = .03$ ,  $\eta_p^2 = .06$ , with the 5-year-olds using more don’t know answers ( $M = .76$ ,  $SE = .15$ ) than 8-year-olds ( $M = .30$ ,  $SE = .15$ ). There was no interaction,  $F(1,74) = 1.28$ ,  $p = .26$ . For phenomenism there was no main effect of time,  $F(1,74) = .99$ ,  $p = .32$ , and there was no interaction,  $F(1,74) = 3.20$ ,  $p = .08$ , though this significance was trending. There was a main effect of age,  $F(1,74) = 43.41$ ,  $p < .001$ ,  $\eta_p^2 = .37$ , with the 5-year-olds using more phenomenism answers ( $M = 4.09$ ,  $SE = .25$ ) than 8-year-olds ( $M = 1.79$ ,  $SE = .25$ ). For there was a main effect of time,  $F(1,74) = 4.72$ ,  $p = .03$ ,  $\eta_p^2 = .06$ , with the posttest having more external agent answers ( $M = 5.18$ ,  $SE = .25$ ) than the pretest ( $M = 4.53$ ,  $SE = .21$ ). There was also a main effect of age,  $F(1,74) = 47.28$ ,  $p < .001$ ,  $\eta_p^2 = .39$ , with 8-year-olds using more external agent answers ( $M = 6.04$ ,  $SE = .24$ ) than 5-year-olds ( $M = 3.67$ ,  $SE = .25$ ). There was no interaction,  $F(1,74) = 1.09$ ,  $p = .30$ . For internalization there was no main effect of time,  $F(1,74) = .31$ ,  $p = .58$ , and no main effect of age,  $F(1,74) = 3.47$ ,  $p = .07$ , though this significance is trending. However, there was an interaction,  $F(1,74) = 7.63$ ,  $p = .007$ ,  $\eta_p^2 = .09$ . Post hoc analysis was

conducted using paired-samples *t*-tests to test for age group differences. Five-year-olds used code 5 more internalization explanations in the posttest ( $M = .79$ ,  $SD = 1.71$ ) than the pretest, ( $M = .16$ ,  $SD = .37$ ),  $t(37) = -2.14$ ,  $p = .04$ , but 8-year-olds did not use internalization more in the posttest ( $M = .63$ ,  $SD = .94$ ) than the pretest ( $M = 1.05$ ,  $SD = 1.33$ ),  $t(37) = 1.75$ ,  $p = .09$ , though this significance is trending.

Uncontaminated itemcodes were examined next. For not knowing there was no main effect of time,  $F(1,74) = .01$ ,  $p = .92$ , no main effect of age,  $F(1,74) = .30$ ,  $p = .59$ , and no interaction,  $F(1,74) = .28$ ,  $p = .60$ . For phenomenism there was no main effect of time,  $F(1,74) = .17$ ,  $p = .68$ , and there was no interaction,  $F(1,74) = 1.23$ ,  $p = .27$ . There was a main effect of age,  $F(1,74) = 13.86$ ,  $p < .001$ ,  $\eta_p^2 = .16$ , with the 5-year-olds using more phenomenism answers ( $M = 2.83$ ,  $SE = .14$ ) than 8-year-olds ( $M = 2.09$ ,  $SE = .14$ ). For external agents there was no main effect of time,  $F(1,74) = .13$ ,  $p = .72$ , and there was no interaction,  $F(1,74) = 2.00$ ,  $p = .16$ . There was a main effect of age,  $F(1,74) = 25.77$ ,  $p < .001$ ,  $\eta_p^2 = .26$ , with the 8-year-olds using more external agents answers ( $M = 1.53$ ,  $SE = .12$ ) than 5-year-olds ( $M = .68$ ,  $SE = .12$ ). For internalization there was a main effect of time,  $F(1,74) = 5.59$ ,  $p = .02$ ,  $\eta_p^2 = .07$ , with the posttest having more internalization answers ( $M = .16$ ,  $SE = .06$ ) than the pretest ( $M = .01$ ,  $SE = .01$ ). There was also no main effect of age,  $F(1,74) = .42$ ,  $p = .52$ , and no interaction,  $F(1,74) = 1.16$ ,  $p = .29$ . In sum, results for changes from pre- to posttest on the concept codes suggest that for contaminated items, code 1 (don't know answer) was used less in the posttest and code 4 (external contaminant agents stated) was used more in the posttest, while codes 3 (phenomenism) and 5 (internalization) remained the same. For uncontaminated items

only code 5 (internalization of contaminant needed for illness to occur) increased in the posttest. Codes 1, 3, 4 did not change between pre- and posttest.

Next, though biological concept levels increased from pre- to posttest, post hoc analyses were conducted using the percentage of children with biological level concepts to test if more children obtained biological level concepts from pre- to posttest. The percentages of children with biological level concepts were compared from pre- to posttest. Because so few 5-year-olds displayed biological level concepts pre- and posttest scores could not be examined. In the pretest, 0% of 5-year-olds expressed general biological level concepts, though in the posttest 5% of 5-year-olds had general biological level concepts and only for contaminated items. For 8-year-olds, paired-samples *t*-tests were used to compare pre- and posttest scores. For overall items there was no difference between pre- and posttest,  $t(37) = .00$ ,  $p = 1.00$ . Items were then separated into contaminated and uncontaminated items. For both contaminated items,  $t(37) = -1.00$ ,  $p = .32$ , and uncontaminated items,  $t(37) = -1.53$ ,  $p = .13$ , there was no difference between pre- and posttest.

These results suggest that the percentage of children expressing concepts at a biological level did not change from pre- to posttest regardless of the item type or age. More 8-year-olds exhibited biological level concepts than 5-year-olds across tests. These results support researchers who suggest that children younger than 8 years old do not possess a naïve biology based on the use of biological mechanisms as explanations for biological phenomenon (Carey, 1985; Solomon et al., 1996).

**Immanent justice.** Three short vignettes tested children’s use of immanent justice in support of Hypothesis 2.2. First, children’s acceptance of vignette items (food and toy) were analyzed. Next, analysis for whether children provided immanent justice as an explanation for what will happen to the child after they hit, steal, and then eat (or play with) the item they stole was examined. Table 13 displays the percent of acceptances for whether the item was safe to consume or play with by item type, test type, and age group.

Table 13  
*Percentage of children who accepted the vignette items as acceptable to eat or play with.*

Item Types		5-year-olds Mean (SD)	8-year-olds Mean (SD)
Contaminated	Pretest	50% (.51)	24% (.43)*
	Posttest	63% (.49)	24% (.43)***
Uncontaminated	Pretest	71% (.46)	90% (.31)
	Posttest	82% (.39)	79% (.41)
Toy	Pretest	84% (.37)	90% (.31)
	Posttest	84% (.37)	92% (.27)

*Note.* Age differences were \*  $p < .01$ ; \*\*\*  $p < .001$ .

For the pretest and posttest analyses below, the probability of items accepted as safe different from chance was examined for each item type first. Then rates of acceptance for the contaminated and uncontaminated food items were compared. Finally, explanations for acceptance (or not) of items was examined for the presence of immanent justice. Following this was an examination of changes from pre- to posttest.

**Pretest.** First, acceptance of vignette items in the pretest was analyzed for acceptance different from chance (50%). One-sample  $t$ -tests with  $\mu$  set at .5 (50%) were used to test the percentage of accepted items for each vignette item. Tests concluded that

5-year-olds did not accept the contaminated items different from chance,  $t(37) = .00$ ,  $p = 1.00$ . Five-year-olds did accept items different from chance for the uncontaminated item,  $t(37) = 2.82$ ,  $p = .01$  and for the toy,  $t(37) = 5.71$ ,  $p < .001$ . For 8-year-olds, the contaminated item,  $t(37) = -3.77$ ,  $p = .001$ , uncontaminated item,  $t(37) = 7.82$ ,  $p < .001$ , and the toy,  $t(37) = 7.82$ ,  $p < .001$ , were all accepted different from chance. These data suggest that both 5-year-olds and 8-year-olds were more likely than chance to accept the uncontaminated food and the toy. For the contaminated item, however, 5-year-olds accepted it at chance, while 8-year-olds were less likely than chance to accept the item.

To examine the effect of age on vignette types in the pretest, a 3 (vignette type: uncontaminated, contaminated, or toy)  $\times$  2 (age) MANOVA was conducted. Results reveal an effect of age,  $F(3,72) = 2.73$ ,  $p = .05$ ,  $\eta_p^2 = .10$ . Post hoc between-subjects effects determined 5-year-olds accepted the contaminated item in the pretest more than 8-year-olds,  $F(1,74) = 5.95$ ,  $p = .02$ ,  $\eta_p^2 = .07$ . However, age groups were equally likely to accept the uncontaminated item,  $F(1,74) = 1.96$ ,  $p = .78$ , or the toy item,  $F(1,74) = .00$ ,  $p = 1.00$ . These data indicate that 5-year-olds were more likely than 8-year-olds in accepting the contaminated item to eat during a sociomoral vignettes (see Table 13 for means). When an uncontaminated item or a toy was presented, both age groups accepted the items as safe to consume similarly.

Explanations for why the food or toy was or was not acceptable to eat or play with were analyzed for the presence of immanent justice. One immanent justice explanation was given by a 5-year-old for why the contaminated food item could not be eaten and no immanent justice explanations were given by 8-year-olds for the contaminated food. No



immanent justice explanations were given for the uncontaminated food item or the toy item by either age group. These data support previous research that children are not likely to give an immanent justice explanation for consequences of actions or illnesses (Raman & Winer, 2002).

The patterns of accepted items differ from those of the main pretest items, specifically in the case of the contaminated item for 5-year-olds. The set of contaminated items in the pretest were accepted as safe to consume by 5-year-olds different from chance, however, this was not the case when a contaminated item was presented in a sociomoral scenario. Some researchers contend that children will answer questions related to contamination differently based on how the question is framed (Kiel, 1992a). Rates of acceptance for the contaminated and uncontaminated food items during the sociomoral stories were compared with responses for the regular pretest items in post hoc analysis using a 2 (testing type: vignette items and pretest items)  $\times$  2 (age) within-between ANOVA. Contaminated and uncontaminated items were tested separately. For contaminated items, there was a main effect for item type,  $F(1,74) = 12.02$ ,  $p = .001$ ,  $\eta_p^2 = .14$ , suggesting that acceptance of contaminated items was higher for the sociomoral vignette item ( $M = .37$ ,  $SE = .05$ ) than for regular test items ( $M = .19$ ,  $SE = .02$ ). There was a main effect of age,  $F(1,74) = 6.26$ ,  $p = .02$ ,  $\eta_p^2 = .08$ , suggesting 5-year-olds were more likely to accept the contaminated items ( $M = .36$ ,  $SE = .04$ ) than 8-year-olds ( $M = .20$ ,  $SE = .04$ ). There was also an interaction effect,  $F(1,74) = 4.40$ ,  $p = .04$ ,  $\eta_p^2 = .06$ , suggesting age groups choose contaminated items differently based on testing type. Post hoc paired-samples  $t$ -tests were used to analyze how age groups performed differently.

Analysis indicated 5-year-olds accepted contaminated food more frequently during the sociomoral vignette than during regular pretest items,  $t(37) = -3.62$ ,  $p = .001$ , but 8-year-olds did not accept contaminated food differently,  $t(37) = -1.07$ ,  $p = .29$ . Because the vignette item would be considered a non-difficult item as described above, acceptance rates of the contaminated vignette item was compared with the non-difficult items. Results revealed a main effect for item type,  $F(1,74) = 16.40$ ,  $p < .001$ ,  $\eta_p^2 = .18$ , suggesting that acceptance of contaminated items was higher for the sociomoral vignette item ( $M = .37$ ,  $SE = .05$ ) than for regular non-difficult test items ( $M = .17$ ,  $SE = .02$ ). There was a main effect of age,  $F(1,74) = 9.89$ ,  $p = .002$ ,  $\eta_p^2 = .12$ , suggesting 5-year-olds were more likely to accept the contaminated items ( $M = .37$ ,  $SE = .05$ ) than 8-year-olds ( $M = .17$ ,  $SE = .05$ ). There was not an interaction,  $F(1,74) = 1.54$ ,  $p = .22$ . When considering the non-difficult items, the interaction emerged with different results than the combined contaminated pretest items. Non-difficult items did not reveal 5- and 8-year-olds different patterns in accepting the vignette and the non-difficult items, however, all regular contaminated items did reveal age differences in the patterns of accepting vignette and regular items.

For the uncontaminated item, there was not a main effect for testing type,  $F(1,74) = .05$ ,  $p = .83$ , and there was not an interaction effect,  $F(1,74) = .61$ ,  $p = .44$ . However, there was a main effect of age,  $F(1,74) = 4.45$ ,  $p = .04$ ,  $\eta_p^2 = .06$ , suggesting that more 8-year-olds accepted uncontaminated items ( $M = .86$ ,  $SE = .04$ ) than 5-year-olds ( $M = .74$ ,  $SE = .04$ ). Together, these results suggest in general 8-year-olds are better at accepting food as edible than 5-year-olds. In addition, 5-year-olds have a more difficult time than

8-year-olds recognizing food as inedible when contaminated food is presented within the framework of a sociomoral vignette. Presenting uncontaminated food in different frameworks does not seem to affect acceptance of food as consumable.

**Posttest.** Next, posttest items that were accepted in the sociomoral stories were analyzed for acceptance different from chance (50%). One-sample *t*-tests with  $\mu$  set at .5 were used to test the percentage of accepted items for each vignette item. Tests concluded that 5-year-olds did not accept the contaminated items different from chance,  $t(37) = 1.66, p = .11$ . For the uncontaminated item,  $t(37) = 4.96, p < .001$  and for the toy,  $t(37) = 5.71, p < .001$ , 5-year-olds did accept items more likely than chance. For 8-year-olds, the contaminated item,  $t(37) = -3.77, p = .001$ , was less likely than chance to be chosen, and the uncontaminated item,  $t(37) = 4.32, p < .001$ , and the toy,  $t(37) = 9.50, p < .001$ , were more likely than chance to be accepted. For the uncontaminated item and the toy, data reflected those in the pretest suggesting that both age groups accepted the uncontaminated food and the toy as acceptable to eat or play with better than chance. For the contaminated item, however, 5-year-olds could not accept it as acceptable different from chance, while 8-year-olds could.

To examine age differences within vignette types in the posttest, a 3 (vignette type)  $\times$  2 (age) MANOVA was conducted. Results reveal an effect for age on the vignettes,  $F(3,72) = 6.45, p = .001, \eta_p^2 = .21$ . Post hoc between-subjects effects determined 5-year-olds accepted the contaminated item as safe to eat more than 8-year-olds,  $F(1,74) = 16.48, p < .001, \eta_p^2 = .18$ . However, age groups did not perform differently for the uncontaminated item,  $F(1,74) = .08, p = .78$ , or the toy item,  $F(1,74) =$

.11,  $p = .74$ . These results were similar to the pretest and indicate that 5-year-olds performed worse than 8-year-olds in accepting the contaminated during a sociomoral scenario. When an uncontaminated item or a toy was presented both ages performed similarly.

Explanations for why the food items and toy was or was not acceptable to eat or play with were then analyzed for the presence of immanent justice. Only one immanent justice explanation was given by a 5-year-old for why the doll should not play with the toy item. No other immanent justice explanations were given by 5-year-olds for the food items. No immanent justice explanations were given by 8-year-olds for any of the sociomoral story items. These data, similar to those in the pretest, suggest that when children are presented with misbehaving scenarios, they are not likely to give an immanent justice explanation for consequences of the actions.

As was done in the pretest analysis, rates of acceptance for the food items during the posttest sociomoral stories were compared with responses to the regular posttest items using 2 (testing type: vignette items and posttest items)  $\times$  2 (age) within-between ANOVAs. Contaminated and uncontaminated items were tested separately. For contaminated items, there was a main effect for testing type,  $F(1,74) = 26.73$ ,  $p < .001$ ,  $\eta_p^2 = .27$ , suggesting that acceptance of contaminated items in regular test items was lower ( $M = .18$ ,  $SE = .02$ ) than the sociomoral vignette item ( $M = .43$ ,  $SE = .05$ ),  $p < .001$ , for the posttest. There was a main effect of age,  $F(1,74) = 15.17$ ,  $p < .001$ ,  $\eta_p^2 = .17$ , suggesting that 5-year-olds accepted contaminated items more frequently ( $M = .43$ ,  $SE = .04$ ) than 8-year-olds ( $M = .19$ ,  $SE = .04$ ), for the posttest. There was also an interaction

effect,  $F(1,74) = 9.55, p = .003, \eta_p^2 = .11$ , suggesting the age groups choose contaminated items differently based on testing type. Paired-samples  $t$ -tests were used to conduct post hoc analysis of age-group differences based on testing type. Analysis indicated that 5-year-olds accepted food as acceptable to eat more frequently during the sociomoral vignette than during regular posttest items,  $t(37) = 5.59, p < .001$ , but 8-year-olds did not accept contaminated food differently based on testing type,  $t(37) = 1.54, p = .13$ .

Acceptance rates for the posttest contaminated vignette item were compared with the non-difficult items. Results revealed a main effect for item type,  $F(1,74) = 31.02, p < .001, \eta_p^2 = .30$ , suggesting that acceptance of contaminated items was higher for the sociomoral vignette item ( $M = .43, SE = .05$ ) than for regular non-difficult test items ( $M = .15, SE = .02$ ). There was a main effect of age,  $F(1,74) = 20.11, p < .001, \eta_p^2 = .21$ , suggesting 5-year-olds were more likely to accept the contaminated items ( $M = .43, SE = .04$ ) than 8-year-olds ( $M = .15, SE = .04$ ). There was also an interaction effect,  $F(1,74) = 5.19, p = .03, \eta_p^2 = .07$ . Paired-samples  $t$ -tests were used to conduct post hoc analysis of age-group differences based on testing type. Analysis indicated that both 5-year-olds,  $t(37) = 5.52, p < .001$ , and 8-year-olds,  $t(37) = 2.34, p = .03$ , accepted the contaminated food as acceptable to eat more frequently during the sociomoral vignette than during regular posttest items. When considering the non-difficult items, acceptance rates were similar as the combined posttest contaminated items.

For uncontaminated items, there was not a main effect for test item type,  $F(1,74) = 1.34, p = .24$ , nor a main effect of age,  $F(1,74) = .26, p = .61$ , or an interaction effect,  $F(1,74) = 1.34, p = .24$ . This suggests that acceptance of uncontaminated items in the

posttest was not different between regular test items and the sociomoral vignette item, and that age groups choose uncontaminated items similarly between the testing types. Together, these data are similar to those in the pretest and suggest that 5-year-olds have a more difficult time than 8-year-olds recognizing food as inedible when contaminated food is presented within the framework of sociomoral behaviors. Presenting uncontaminated food in different frameworks does not seem to affect acceptance of the food as consumable.

***Changes from pretest to posttest.*** Acceptance of sociomoral vignette items is compared from pre- to posttest. Due to so few children providing immanent justice explanations during the vignettes analysis comparing pre- and posttest could not be conducted. To test pre- to posttest changes in acceptances of sociomoral vignette items, three  $2$  (time: pre- and posttest)  $\times$   $2$  (age) within-between ANOVAs were conducted for each vignette. For the contaminated food there was no effect of time,  $F(1,74) = 1.33$ ,  $p = .25$ , and no interaction effect,  $F(1,74) = 1.33$ ,  $p = .25$ . However, there was a main effect of age,  $F(1,74) = 13.28$ ,  $p < .001$ ,  $\eta_p^2 = .15$ , suggesting that 5-year-olds accepted contaminated items more frequently ( $M = .57$ ,  $SE = .06$ ) than 8-year-olds ( $M = .24$ ,  $SE = .06$ ). For the uncontaminated food, there was no effect of time,  $F(1,74) = .00$ ,  $p = 1.00$ , or a main effect of age,  $F(1,74) = .98$ ,  $p = .33$ . However, there was an interaction effect,  $F(1,74) = 5.59$ ,  $p = .02$ ,  $\eta_p^2 = .07$ . Post hoc analysis was conducted using paired-samples  $t$ -tests to test for age group differences. However, neither 5-year-olds,  $t(37) = -1.6$ ,  $p = .10$ , nor 8-year-olds,  $t(37) = 1.67$ ,  $p = .10$ , accepted uncontaminated items differently from pre- to posttest. For the toy, there was no effect of time,  $F(1,74) = .09$ ,  $p = .77$ , nor

a main effect of age,  $F(1,74) = 1.11$ ,  $p = .30$ , and no interaction effect,  $F(1,74) = .09$ ,  $p = .77$ .

In sum, results for the presence of immanent justice suggest that children in both age groups did not change their acceptance of the sociomoral scenario items as acceptable to eat or play with between the pre- and posttests. Results for the use of immanent justice as an explanation for the dolls behaviors also support Hypothesis 2.2 that children will not change their use of immanent justice after discussing stories with potentially contaminated scenarios.

### **Parent Survey**

Results from the parent survey were examined next. Two variables were used in these analysis, illness knowledge and germ knowledge. These variables were delimited by the survey's question type, either illness or germs. This was done to examine whether having more biological knowledge about germs or illness may be correlated with biological level information mothers provide to their children. In addition, some mothers may have more biological level information about germs and how they function or illness and its causes and treatments. These scores are meant to provide a baseline for the mothers' biological concepts when not discussing these concepts with their children to test whether mothers may be altering their biological concepts with their children different than what they may report knowing.

Analysis was conducted to test for differences on the survey based on child's age using a one-way ANOVA. Results indicated there were no differences based on child's

age,  $F(1,74) = 2.54, p = .12$ . Results for mothers' survey scores are collapsed by child's age. Table 14 displays the means for biological concept scores by the child's age.

Knowledge Type	Means (SD)
Germ	2.93 (.47)
Illness	3.04 (.34)*

*Notes.* Means based on 7-point scale with 1= don't know, and 7= highest level of biological concepts (Mechanisms). Knowledge type,\*  $p < .05$ .

Knowledge type was divided into germ and stomach illness and examined for differences using a paired-samples  $t$ -test. Results indicate mothers had higher biological concepts for stomach illness than for germs,  $t(75) = 2.48, p = .02$ .

Next, mothers' survey scores divided by knowledge type were correlated with household income and mother's education level using Pearson's correlation. No significant correlations were found. Table 15 displays the correlation matrix.

	Household Income	Mother Education
Germ survey score	.07	.18
Illness survey score	.11	.17



## **Mother-Child Interactions**

Socio-cultural theory contends that children learn important concepts from social partners (Vygotsky, 1978). Thus, in the following sections, interactions between mothers and children were examined while they discussed stories related to contamination. First, mothers' references to contamination and immanent justice during the interactive story task are examined. Second, mothers' biological concepts during the interaction were examined. These scores were compared with biological concept scores from the parent survey. Finally, mother and child behaviors, including collaboration related behaviors and facial expressions, were examined. The following analyses describe interactions between mother and child and the types of information mothers provide their children during an interactive task involving contamination related scenarios. Mothers' information and behaviors is examined by child's age and by child's biological level concepts in the pretest.

**Mothers' references to contamination and immanent justice.** Mothers' references to contamination, no contamination, decontamination, and immanent justice were examined to test Hypotheses 1.1 and 1.3 that mothers will discuss contamination related topics with their children and point out contamination specifically and will do so more than make reference to immanent justice. References were summed for each story and averaged over all stories, and for each story type. Table 16 displays mothers' mean references for all story types and by the child's age group.

Table 16  
*Mothers' mean sum of contamination related references by age group and story type.*

Reference Type	Age Group	Contamination Stories Mean ( <i>SD</i> )	Decontamination Stories Mean ( <i>SD</i> )	Sociomoral Story Mean ( <i>SD</i> )
Contamination	5-year-olds	1.76 (1.30)	0.26 (.45)	.11 (.31)
	8-year-olds	2.05 (1.27)	0.37 (.59)	.18 (.39)
No contamination	5-year-olds	0.05 (.23)	0.05 (.23)	0
	8-year-olds	0	0	0
Decontamination	5-year-olds	0.39 (.50)	0.58 (.83)	0
	8-year-olds	0.37 (.67)	0.58 (.76)	0
Immanent Justice	5-year-olds	0.03 (.16)	0	.13 (.34)
	8-year-olds	0	0	.13 (.34)

*Note.* Significant differences between all reference types except No Contamination and Immanent Justice,  $p < .001$ .

Means suggest that mothers do make contamination related comments to their children, but very few comments that something is not contaminated or that the use of immanent justice is occurring. A 4 (reference type: contaminated, not contaminated, decontaminating, immanent justice)  $\times$  2 (child age) within-between ANOVA was conducted over all stories to test for differing number of contamination references by age. Results revealed a main effect of reference type,  $F(3,222) = 62.20$ ,  $p < .001$ ,  $\eta_p^2 = .46$ . Pairwise comparisons show differences between each type of reference ( $p$ 's  $< .001$ ) except between no contamination and immanent justice. Table 16 shows that references to contamination were most common, followed by references to decontamination. There was no main effect of child age,  $F(1,74) = .08$ ,  $p = .77$ , and no interaction effect,

$F(3,222) = .94, p = .43$ , suggesting that mothers' contamination references do not differ based on the child's age.

References were then examined by story type (contamination, decontamination related, and sociomoral). Because children performed differently with contaminated and uncontaminated items in the pretest and posttest, analysis was conducted to test whether specific reference types were more or less present based on the scenario of the stories. Table 16 displays all means for each story type by child's age group. To analyze differences for each reference type by story type and child age,  $3(\text{story type}) \times 2(\text{child age})$  within-between ANOVAs were used. References were also analyzed by whether the child had an average biological level concept score using  $3(\text{story type}) \times 2(\text{child bio concept level})$  within-between ANOVAs.

For references to contamination, there was an effect for story types,  $F(2,148) = 120.22, p < .001, \eta_p^2 = .62$ , no main effect of age,  $F(1,74) = 1.65, p = .20$ , and no interaction effect,  $F(2,148) = .42, p = .66$ . Post hoc pairwise comparisons revealed there were significant differences between all story types ( $p$ 's  $< .05$ ). Means displayed in Table 16 suggest that contamination references happen most frequently during contamination related stories. Together, these data indicate that mothers make reference to contamination and will do so differently based on the scenarios they are presented with. Mothers are especially likely to make reference to contamination during stories where contamination is present, but will also make reference to contamination during stories where decontamination is present and during a story where both contamination and socially unacceptable behavior is occurring. In addition, mothers make references

similar to children in both age groups. Differences for contamination reference based on child's biological concept level revealed a main effect for story type,  $F(2,148) = 51.15$ ,  $p < .001$ ,  $\eta_p^2 = .41$ , no main effect of child concept level,  $F(1,74) = .23$ ,  $p = .63$ , and no interaction effect,  $F(2,148) = .13$ ,  $p = .88$ . Post hoc pairwise comparisons revealed that contamination related stories were significant different from decontamination related stories and the sociomoral story ( $p$ 's  $< .001$ ). There was no difference between decontamination related stories and the sociomoral story. These results were similar to the results examining references based on child's age.

Mothers made very few references to contamination not being present (no contamination). Testing for mothers' reference to no contamination revealed no main effect of story type,  $F(2,148) = 2.06$ ,  $p = .13$ , no main effect of age,  $F(1,74) = 2.06$ ,  $p = .16$ , nor an interaction effect,  $F(2,148) = 2.06$ ,  $p = .13$ . Analysis by child biological concept level revealed, no main effect of story type,  $F(2,148) = .30$ ,  $p = .74$ , no main effect of age,  $F(1,74) = .30$ ,  $p = .58$ , nor an interaction effect,  $F(2,148) = .30$ ,  $p = .74$ . Means for references to no contamination suggest that mothers do not make frequent mention of contamination not being present and the few references made do not differ by the story types in this study.

For decontamination references, there was a main effect of story type,  $F(2,148) = 24.26$ ,  $p < .001$ ,  $\eta_p^2 = .25$ , no main effect of age,  $F(1,74) = .01$ ,  $p = .92$ , and no interaction effect,  $F(2,148) = .02$ ,  $p = .98$ . Post hoc pairwise comparisons showed there were significant differences between the sociomoral story and both contamination and decontamination related stories ( $p$ 's  $< .001$ ) but there was not a difference between

contamination related stories and decontamination related stories. Analysis based on child's biological level concepts revealed similar results. There was a main effect of story type,  $F(2,148) = 9.77, p < .001, \eta_p^2 = .12$ , no main effect of child concept level,  $F(1,74) = .23, p = .64$ , and no interaction effect,  $F(2,148) = .09, p = .91$ . Post hoc pairwise comparisons showed there were significant differences between the sociomoral story and both contamination and decontamination related stories ( $p$ 's  $< .01$ ) but there was not a difference between contamination related stories and decontamination related stories. These data suggest that mothers make reference to decontamination similarly during stories that specifically address contamination (e.g., either something is being contaminated or something is being decontaminated). They did not make decontamination references during a story where unacceptable behavior is occurring.

Mothers made very few references to immanent justice during the stories. However, there was a main effect for story type,  $F(2,148) = 9.05, p < .001, \eta_p^2 = .11$ , no main effect of age,  $F(1,74) = .10, p = .75$ , and no interaction effect,  $F(2,148) = .10, p = .91$ . Post hoc pairwise comparisons indicated there were significant differences between the sociomoral story and both contamination and decontamination related stories ( $p$ 's  $< .05$ ) but there was not a difference between contamination related stories and decontamination related stories. Based on the means, mothers were more likely to make reference to immanent justice during the story where unacceptable behavior occurs. During stories where contamination and decontamination occurs, mothers make similar (almost no) references to immanent justice. Analysis based on child biological concept level revealed a main effect for story type,  $F(2,148) = 3.45, p = .03, \eta_p^2 = .04$ , no main

effect of child biological level,  $F(1,74) = .18, p = .67$ , and no interaction effect,  $F(2,148) = .07, p = .94$ . Post hoc pairwise comparisons indicated there were no significant differences between stories.

These findings support Hypothesis 1.1. When mothers interact with their children during stories related to contamination, mothers will make references about contamination (e.g., something being not safe to consume due to some form of contamination). Expectedly, mothers make more references to contamination during stories where contamination is taking place. Mothers also make references to decontamination (e.g., rendering food or water safe to eat or drink) and do so equally during stories where contamination and decontamination is occurring. In support of Hypothesis 1.3, mothers very infrequently made references to immanent justice. In addition, Hypothesis 3.1 was not supported. Mothers did not change the types or amount of information regarding contamination based on the child's age or based on whether the child had biological level concept.

**Mothers' biological concepts.** Next, mothers' biological concepts are examined to test Hypotheses 1.1 and 3.2, that mothers will provide important information regarding contamination to their children (in this case biological concepts) and that this information will differ based on the child's age. Mothers' discussions with their children during the interactive story task were coded for the level of biological concepts they expressed. Table 17 shows general and highest mean biological concepts by story type.

Table 17  
*Mothers' mean biological concepts by story type and child age during the interactive story task.*

Story Type	5-year-olds		8-year-olds	
	General Mean (SD)	Highest Mean (SD)	Mean (SD)	Highest Mean (SD)
Contaminated	2.97 (.75)	4.37 (.75)	3.33 (.91)	4.24 (1.05)
Decontaminating	2.55 (1.05)	3.37 (1.50)	2.51 (1.15)	3.53 (1.35)
Sociomoral	2.16 (1.37)	2.45 (1.57)	3.27 (1.59)**	2.97 (1.55)

*Notes.* Means based on 7-point scale with 1=don't know, and 7=highest level of biological concepts (Mechanisms). Child age differences were \*  $p \leq .05$ ; \*\*  $p < .01$ .

First, overall biological concepts during the interactive story task were related to mothers' biological concept scores on the parent survey to examine relationships between the level of biological concepts the mother might share with her child versus the level she may report on a general survey. Pearson's correlation was conducted and the results are reported in Table 18. Though germ and illness scores were significantly correlated with concept scores in contamination and decontamination related stories, these correlations are considered medium in strength (Cohen, 1977).

Table 18  
*Correlations between mothers' survey scores and concept scores based on story type.*

	Contamination stories concept score	Decontamination stories concept score	Sociomoral story score
Germ survey score	.33**	.35**	-.01
Illness survey score	.31**	.29**	.12

Note. Correlation significant at \*\* $p \leq .01$ .

To examine mean differences between overall concept scores on the survey and those expressed during the interaction, a paired-samples *t*-test was used. Results indicate there was no difference between mothers' scores on the survey and their biological concept scores with their children,  $t(76) = -.78, p = .44$ . Together with the correlations, these results suggest that mothers express similar level biological concepts with their children as they do on a general survey about germs and illness. Thus mothers' biological concepts as reported on a germs and illness survey may constrain the level they express with their children.

Next, stories were divided by type (contaminated, decontaminating, and sociomoral) to test whether the child's age and biological concept level (general concepts that were at a biological level or not) had an effect on mothers' biological concepts based on story type. Two  $3(\text{story type}) \times 2(\text{child age})$  MANOVA were conducted. Results revealed a main effect for child age,  $F(3,72) = 4.66, p = .01, \eta_p^2 = .16$ . Between-subjects tests revealed no age effect for contaminated stories,  $F(1,74) = 3.53, p = .06$ , though this result is trending, and no age effect for decontaminating stories,  $F(1,74) = .02, p = .88$ . However, there was an age effect for the sociomoral story,  $F(1,74) = 10.58, p = .002, \eta_p^2 = .13$ . Based on the means (see Table 17), mothers expressed higher biological concepts with 8-year-olds than 5-year-olds. Results based on child's biological level concepts revealed no main effect of child's concept,  $F(3,72) = .56, p = .64$ . Mothers' highest level of biological concept was also tested for child age effects and child's biological level concepts. Results revealed that child's age did not have an effect on mothers' highest level of biological concept expressed,  $F(3,72) = 1.08, p = .37$ . Child's biological concept



level also did not have an effect on mothers' highest level of biological concept expressed,  $F(3,72) = .81, p = .50$ . These results suggest that the child's age has an effect on mother's general biological concepts but not her highest level of biological concepts, though the level of the child's biological concepts does not have an effect on either general or highest biological concepts.

In the children's pre- and posttest, biological concept levels were recoded based on the level of biological concept expressed such that those who reached a score of 4 (external agent) were expressing explanations at biological level. The same recoding was conducted for mothers' discussions with their children during stories. Mothers' general biological concept scores of or above 4 indicate biological concepts are being conveyed and require naming specific causal agents or actions involved contamination. Scores below 4 do not indicate that biological concepts were conveyed. Table 19 displays the percent of mothers who expressed biological level concepts by story type.

Table 19  
*Percentages of mothers who expressed biological level concepts with their children by story type and child age.*

Story Type	5-year-olds	8-year-olds
	Mean (SD)	Mean (SD)
Contaminated	38% (.27)	54% (.33)*
Decontaminating	34% (.33)	34% (.35)
Sociomoral	16% (.37)	47% (.51)**

*Note.* Child age differences were \*  $p \leq .05$ ; \*\*  $p < .01$ .

A 3 (story type)  $\times$  2 (child age) MANOVA was conducted to test for child age effects based on the story types. Results indicated a main effect for child age,  $F(3,72) =$

4.92,  $p = .004$ ,  $\eta_p^2 = .17$ . Post hoc between-subjects tests indicated that more mothers expressed biological level concepts with 8-year-olds than 5-year-olds for contamination related stories,  $F(1,74) = 5.17$ ,  $p = .03$ ,  $\eta_p^2 = .07$ , and the sociomoral story,  $F(1,74) = 9.65$ ,  $p = .003$ ,  $\eta_p^2 = .12$ . However, mothers did not express biological level concepts differently for the decontamination related stories,  $F(1,74) = .00$ ,  $p = 1.00$ . When data were analyzed by child's biological level concepts results revealed no main effect of child's concept level,  $F(3,72) = .61$ ,  $p = .61$ . These results are similar to those examining mothers' biological concept means in that child age had an effect on the percent of mothers who expressed biological level concepts, but child concept level did not.

In sum, these results partially support Hypothesis 1.1 and 3.2, that mothers express biological concepts with their children and do so at a higher level with 8-year-olds than 5-year-olds. Support was partial because mothers only expressed higher level biological concepts with 8-year-olds during the sociomoral story. When mothers' highest biological concepts are considered, mothers' do not express higher biological concepts based on the child's age. The same is true for mothers' biological concepts expressed to children with biological level concepts. Mothers express similar level biological concepts despite the child's biological concept level. When mothers' level of biological concepts is considered, mothers on average do not overall express concepts at a biological level when discussing contamination concepts with their children. The percent of mothers who express biological level concepts suggests that some mothers do express concepts at a biological level. For those who did, more did so with 8-year-olds than 5-

year-olds during contaminated stories and the sociomoral story, but not during the decontaminating stories.

**Mother and child behaviors.** Behaviors between the mother and child were coded for parental guidance, directing child's activity, encourage independent contribution of the child, mother keeping the child involved, mother confusing the child, the child's involvement in the task, child's frustration, if the child is off-task, child's cooperation with the mother, and whether the mother or child was more responsible for the task. Table 20 displays means for all behavior types by child's age.

Based on the means presented in Table 20 the following behavior variables were removed from subsequent analyses: parental guidance, mother directs child activity, mother confuses child, child frustration, and child off-task. The means for these variables indicate that these behaviors were exhibited rarely or not at all. To gain an idea how the behavior variables related to one another, a Pearson's correlation was conducted. Table 21 displays the correlations between the behavior variables divided by age group. Task responsibility was removed because this scale is examined differently than the other variables.

Table 20

*Behavior type means by child's age during the interactive story task.*

Behavior Type	5-year-olds	8-year-olds
	Mean (SD)	Mean (SD)
Parental guidance	.05 (.10)	.08 (.13)
Mother directs child's activity	.10 (.13)	.10 (.18)
Mother encourages independent contribution <sup>a</sup>	3.50 (.73)	2.96 (.99)**
Mother keeps child involved <sup>a</sup>	3.13 (1.02)	2.40 (1.31)**
Mother confuses child	0	0
Child's involvement in the task <sup>a</sup>	3.16 (.85)	3.24 (.85)
Child's frustration	.03 (.08)	.01 (.04)
Child off-task	.32 (.40)	.32 (.49)
Child's cooperation with mother <sup>a</sup>	4.79 (.34)	4.76 (.37)
Task responsibility <sup>a</sup>	2.61 (.40)	2.79 (.50)

*Note.* Means based on 5-point scale with 1= behavior rarely present and 5= behavior extremely present. Age differences were \*\* $p = .01$ .

<sup>a</sup>Indicates items retained in the analyses.

Table 21

*Correlation matrix of behavioral codes divided by child age.*

	Mother encourages independent contribution		Mother keeps child involved		Child's involvement in the task	
	5 yr	8 yr	5 yr	8 yr	5 yr	8 yr
Mother encourages independent contribution	-	-				
Mother keeps child involved	.39*	.46**	-	-		
Child's involvement in task	-.002	-.18	-.004	-.17	-	-
Child's cooperation with mother	-.23	-.36*	-.31	-.50**	-.15	.29

Note. Correlation significant at \* $p < .05$ , \*\* $p < .01$

The task responsibility variable was meant to reflect whether the mother or the child is more responsible for the task. Scores ranged from 1 = only child responsible to 5 = only mother responsible. The means reported suggest the child had somewhat more responsibility than mothers. A one-sample  $t$ -test with  $\mu$  set at 3 (mother and child equally responsible for task) was conducted to test whether mother and child equally contributed to the task. Age groups were analyzed separately. Results indicate that for 5-year-olds,  $t(37) = -6.01$ ,  $p < .001$ , and for 8-year-olds,  $t(37) = -2.63$ ,  $p = .01$ , means were significantly different from 3, suggesting the contribution of the child as somewhat more than the mother was significant.

To test for differences based on the child's age for the remaining variables a 4 (behavior type)  $\times$  2 (age group) MANOVA was conducted. Results reveal a main effect

for age,  $F(5,70) = 2.83$ ,  $p = .02$ ,  $\eta_p^2 = .17$ . Post hoc between-subjects tests indicate that mothers encouraged independent contribution,  $F(1,74) = 7.14$ ,  $p = .01$ ,  $\eta_p^2 = .09$ , and kept the child involved,  $F(1,74) = 7.39$ ,  $p = .01$ ,  $\eta_p^2 = .09$ , more for 5-year-olds than 8-year-olds (see Table 10 for means). None of the other variables demonstrated age differences. These data suggest that mothers exhibit different behaviors with 5-year-olds and 8-year-olds. Specifically, mothers encourage independent contributions with 5-year-olds and keep 5-year-olds involved more than with 8-year-olds.

Behavioral means were then examined by story type. Table 22 displays behaviors by story type and age group. Behavior types were examined separately for differences between story types and by age groups using  $3$  (story type)  $\times$   $2$  (age group) within-between ANOVAs.

Table 22  
*Behavioral means by story type and child age.*

Behavior Type	Story Type	5-year-olds	8-year-olds
		Mean (SD)	Mean (SD)
Mother encourages independent contribution	Contaminated	3.46 (.74)	2.98 (1.02)
	Decontaminating	3.53 (.82)	2.95 (1.06)
	Sociomoral	3.60 (.85)	2.92 (1.16)
Mother keeps child involved***	Contaminated	2.95 (1.10)	2.32 (1.33)
	Decontaminating	3.40 (1.06)	2.45 (1.38)
	Sociomoral	3.30 (1.16)	2.61 (1.42)
Child's involvement in task	Contaminated	3.13 (.86)	3.22 (.86)
	Decontaminating	3.20 (.91)	3.33 (.96)
	Sociomoral	3.20 (1.03)	3.19 (.95)
Child's cooperation with mother	Contaminated	4.75 (.37)	4.77 (.36)
	Decontaminating	4.83 (.47)	4.76 (.42)
	Sociomoral	4.87 (.23)	4.71 (.54)
Task responsibility	Contaminated	2.60 (.43)	2.77 (.51)
	Decontaminating	2.60 (.49)	2.82 (.55)
	Sociomoral	2.62 (.49)	2.79 (.62)

*Notes.* Means based on 5-point scale with 1=behavior rarely present and 5=behavior extremely present. Differences between story types, \*\*\* $p < .001$ .

For mother encouraging independent contribution there was not a main effect for story type,  $F(2,148) = .17$ ,  $p = .85$ , or an interaction effect,  $F(2,148) = .93$ ,  $p = .40$ . However, there was a main effect of age,  $F(1,74) = 8.20$ ,  $p = .01$ ,  $\eta_p^2 = .10$ , suggesting that 5-year-olds received more encouragement ( $M = 3.53$ ,  $SE = .14$ ) than 8-year-olds ( $M = 2.95$ ,  $SE = .14$ ). For keeping the child involved there was a main effect for story type,  $F(2,148) = 8.07$ ,  $p < .001$ ,  $\eta_p^2 = .10$ . Pairwise comparisons indicate that keeping the child involved happened significantly less in the contamination related stories than the decontamination and sociomoral stories ( $p$ 's  $< .01$ ). There was also a main effect for age,  $F(1,74) = 7.95$ ,  $p = .01$ ,  $\eta_p^2 = .10$ , suggesting that 5-year-olds received more

encouragement ( $M = 3.22$ ,  $SE = .19$ ) than 8-year-olds ( $M = 2.46$ ,  $SE = .19$ ). However, there was no interaction effect,  $F(2,148) = 1.89$ ,  $p = .16$ . For child's involvement in the task there was no main effect of story type,  $F(2,148) = 1.04$ ,  $p = .36$ , or a main effect of age,  $F(1,74) = .11$ ,  $p = .74$ , nor an interaction effect,  $F(2,148) = .63$ ,  $p = .54$ . For child's cooperation with mother there was no main effect for story type,  $F(2,148) = .46$ ,  $p = .64$ , or a main effect of age,  $F(1,74) = .66$ ,  $p = .42$ , but there was an interaction effect,  $F(2,148) = 3.23$ ,  $p = .04$ ,  $\eta_p^2 = .04$ . Post hoc paired-samples  $t$ -tests were conducted within age groups for differences. Only one paired-sample was significant. Five-year-olds cooperated more with their mother during the sociomoral story than during the contamination related story,  $t(37) = 2.69$ ,  $p = .01$ . For task responsibility, there was no main effect for story type,  $F(2,148) = .13$ ,  $p = .89$ , no main effect of age,  $F(1,74) = 3.15$ ,  $p = .08$ ,  $\eta_p^2 = .04$ , though it is trending toward significance, and no interaction effect,  $F(2,148) = .20$ ,  $p = .82$ .

Together these results indicate that most behaviors were displayed equally across story types, except for keeping children involved. Mothers kept their children involved less during contamination related stories than decontamination related and sociomoral stories. There was one age-related difference that suggested 5-year-olds cooperated more during the sociomoral story than during the contamination related story.

**Disgust expressions.** Next, Hypotheses 1.2 and 3.3 were tested, that mothers would use disgust when discussing contamination and will display more disgust expressions with younger children. Disgust facial expressions may be associated with children's acceptance of contaminated items (Stevenson et al., 2010). Table 23 displays



mean levels of general and highest disgust facial expressions overall, by story type, and by child's age.

Table 23  
*Mothers' mean general and highest disgust expressions by story type and child age.*

Story Type	5-year-olds		8-year-olds	
	General Mean (SD)	Highest Mean (SD)	General Mean (SD)	Highest Mean (SD)
Contaminating	1.49 (.70)***	3.00 (1.51)	1.38 (.47)	2.92 (1.34)
Decontaminating	1.06 (.11)	1.55 (1.08)	1.05 (.12)	1.37 (.75)
Sociomoral	1.13 (.52)	1.40 (.86)	1.09 (.20)	1.34 (.78)

*Note.* Means based on 5-point scale with 1=disgust not expressed and 5=disgust extremely expressed. Disgust displayed more in Contaminating stories \*\*\* $p < .001$ . There were no age differences.

To test whether general and highest disgust expressions were different, paired-samples  $t$ -tests were conducted by story type. General disgust scores were lower than highest disgust scores overall,  $t(75) = -11.43, p < .001$ , for contaminating stories,  $t(75) = -4.21, p < .001$ , decontaminating stories,  $t(75) = -4.09, p < .001$ , and the sociomoral story,  $t(75) = -3.76, p < .001$ . Based on these differences, highest disgust scores will also be analyzed in conjunction with general disgust scores.

Stories were divided by type (contamination, decontamination, and sociomoral) and general disgust was examined by story type and child age group for disgust differences using a 3 (story type)  $\times$  2 (child age) within-between ANOVA. Results indicate there was a main effect for story type,  $F(2,148) = 20.30, p < .001, \eta_p^2 = .22$ , but no main effect of age,  $F(1,74) = .81, p = .37$ , and no interaction effect,  $F(2,148) = .34, p = .71$ . Pairwise comparisons suggest higher levels of disgust were expressed during contamination related stories than both decontamination related stories and the

sociomoral story ( $p$ 's  $< .001$ ). There was no difference between decontamination related stories and the sociomoral story. Highest disgust was then analyzed for differences between story types and child age group and found a main effect for story type,  $F(2,148) = 70.73$ ,  $p < .001$ ,  $\eta_p^2 = .49$ , but no main effect of age,  $F(1,74) = .34$ ,  $p = .56$ , and no interaction effect,  $F(2,148) = .09$ ,  $p = .90$ . Pairwise comparisons suggest higher levels of disgust were expressed during contamination related stories than both decontamination related stories and the sociomoral story ( $p$ 's  $< .001$ ). There was no difference between decontamination related stories and the sociomoral story. Together, these results suggest that mothers expressed disgust more during contamination stories than other stories and these patterns of expressions were similar for both ages. In addition, though highest levels of disgust were significantly different from the mean, mothers expressed highest levels of disgust in similar patterns as mean levels of disgust (general disgust) with their children.

In accordance with sociocultural theory, that caregivers adjust information based on the abilities of the child, analysis was conducted to examine whether the level of disgust a mother exhibits is based on the child possessing biological concepts. Both general and highest disgust were analyzed by story type and child's biological level concept using a 3 (story type)  $\times$  2 (child concept level: non-biological level  $\times$  biological level) within-between ANOVA. For general disgust there was a main effect for story type,  $F(2,148) = 9.17$ ,  $p < .001$ ,  $\eta_p^2 = .11$ , but no main effect of concept level,  $F(1,74) = .34$ ,  $p = .56$ , and no interaction effect,  $F(2,148) = .03$ ,  $p = .97$ . Pairwise comparisons suggest higher levels of disgust were expressed during contamination related stories than

both decontamination related stories and the sociomoral story ( $p$ 's  $< .05$ ). There was no difference between decontamination related stories and the sociomoral story. For highest disgust there was a main effect for story type,  $F(2,148) = 31.43$ ,  $p < .001$ ,  $\eta_p^2 = .30$ , but no main effect of concept level,  $F(1,74) = .02$ ,  $p = .90$ , and no interaction effect,  $F(2,148) = .04$ ,  $p = .96$ . Pairwise comparisons suggest higher levels of disgust were expressed during contamination related stories than both decontamination related stories and the sociomoral story ( $p$ 's  $< .001$ ). There was no difference between decontamination related stories and the sociomoral story. These results suggest that mothers are not adjusting their disgust expressions based on the whether the child is discussing concepts at a biological level. The results suggest a similar response pattern on the part of the mother based on child age.

Based on the mean scores in Table 23 disgust either occurred infrequently or at low levels. Recall that the facial expression code ranged from 1= not expressed to 5= extremely expressed. Means for disgust did not reach a score of 2. Thus, disgust was recoded for whether it occurred despite the level of disgust expressed during stories. In this way the percent of mothers who display disgust expression could be examined, rather than at what level disgust was exhibited. Table 24 displays the percent of mothers who displayed disgust facial expressions overall and by story type.

Table 24  
*Percentage of mothers who expressed disgust with their children by story type and child age.*

Story Type	5-year-olds	8-year-olds
	Mean (SD)	Mean (SD)
Contaminated	33% (27%)	38% (31%)
Decontaminating	18% (26%)	12% (24%)
Sociomoral	18% (37%)	21% (41%)

*Note.* There were no age-related differences.

To investigate differences in the percent of mothers who display disgust between story types and by age, a 3 (story type)  $\times$  2 (age group) within-between ANOVA was used. Results indicate there was a main effect for story type,  $F(2,148) = 12.81, p < .001, \eta_p^2 = .15$ , but no main effect of age,  $F(1,74) = .19, p = .67$ , and no interaction effect,  $F(2,148) = .69, p = .50$ . Pairwise comparisons indicated that contamination stories were significantly higher than the decontamination stories and the sociomoral story ( $p$ 's  $< .01$ ) (see Table 23 for means). There was no difference between the decontaminating stories and the sociomoral story. When analyzed by child concept level results were similar those by age and indicate there was a main effect for story type,  $F(2,148) = 7.97, p = .001, \eta_p^2 = .10$ , but no main effect of child concept level,  $F(1,74) = .07, p = .79$ , and no interaction effect,  $F(2,148) = .55, p = .58$ . Pairwise comparisons indicated that contamination stories were significantly higher than the decontamination stories ( $p$ 's  $< .001$ ) but not the sociomoral story (see Table 24 for means). There was no difference between the decontaminating stories and the sociomoral story. These results indicate that more mothers express disgust during contamination stories than decontaminating or

sociomoral stories. This pattern was similar for both age groups. The results for mothers' disgust facial expressions support Hypothesis 1.2, that mothers will incorporate disgust facial expressions when discussing contamination with their children. However, Hypothesis 3.3, that mothers will exhibit more disgust with younger children was not supported.

### **Child Posttest Predictors**

Very little research has directly investigated factors contributing to children's improved understanding of contamination and no studies have investigated this for children under the age of 8 years (Au et al., 2008). Researchers suggest that children learn about contamination through instruction from mothers (e.g., Solomon & Cassimatis, 1999). Other researchers suggest that we are born with innate mechanisms that provide a predisposition for learning about biological concepts like contamination (e.g., Hatano & Inagaki, 1994). In this perspective, special instruction is not necessarily needed for children to build their understanding that something is rendered unsafe to consume. The above analysis examining changes from pre- to posttest found that children's biological concepts improved in the posttest, but their selection of items as safe to consume stayed the same. In this section, predictors for children's biological concepts in the posttest will be explored but accepting items as safe to consume were excluded since changes from pre- to posttest did not occur. Analysis will be conducted based on contaminated and uncontaminated posttest scores and separated by child age and child biological concept level. The variables included in this analysis will be mother's references to contamination, mother's biological concepts, mother and child behaviors, and mother's

disgust facial expressions. All analyses were split by age to explore age differences specifically. The analyses described below are exploratory. All variables were tested separately in their own model. To keep the results concise, only variables that were shown to significantly predict posttest scores are reported below.

**Mother's reference to contamination.** First, mother's references to contamination were examined as predictors for the child's scores in the posttest. Multiple regression analysis was conducted to control for pretest scores and further evaluate if references to contamination may be predicting posttest scores for children. For references to contamination all four reference types were examined including contamination, no contamination, decontamination, and immanent justice. For biological concepts, reference types across all stories, and age groups were analyzed in separate models.

***Predictors for contaminated posttest scores.*** Predictors for biological concept changes from pre- to posttest for contaminated items were explored next. For contaminated items, two predictors were found based on child's age. The first predictor was that mothers' references to a lack of contamination over all stories predicted 5-year-olds' posttest biological concept scores for contaminated items. A multiple regression, split by age, and conducted with contaminated pretest items and overall mothers' references to a lack of contamination as predictor variables. The model produced an  $R^2$  of .58, which was statistically significant,  $F(2,35) = 23.65, p < .001$ . Contaminated pretest scores and lack of contamination references account for 58% of the variance in contaminated posttest scores for 5-year-olds. Contaminated pretest scores were

positively related to contaminated posttest scores ( $B = .66, t = 6.43, p < .001$ ). Lack of contamination references were positively related to contaminated posttest scores ( $B = .25, t = 2.05, p = .05$ ). The results of the regression analysis are shown in Table 25.

Table 25  
*Regression output for mothers' overall references to a lack of contamination predicting 5-year-olds' posttest scores for contaminated items.*

Predictor	<i>B</i>	$\beta$	<i>t</i>	<i>p</i>
Constant	1.28		3.92	<.001
Contaminated Pretest	0.66	0.71	6.43	<.001
Overall immanent justice references	0.25	0.23	2.05	.05

The second predictor was that mothers' references to immanent justice across all stories predicted contaminated posttest scores for 8-year-olds. A multiple regression, split by age, and conducted with contaminated pretest and overall immanent justice references as predictor variables. The model produced an  $R^2$  of .29, which was statistically significant,  $F(2,35) = 7.23, p = .002$ . Contaminated pretest scores and immanent justice references can account for 29% of the variance in contaminated posttest scores for 8-year-olds. Contaminated pretest scores were positively related to contaminated posttest scores ( $B = .26, t = 2.35, p = .03$ ). Immanent justice references were positively related to contaminated posttest scores ( $B = .37, t = 2.66, p = .01$ ). The results of the regression analysis are shown in Table 26. Though this model was significant, it accounted for a low percent of the variance for changes from pre- to posttest for contaminated items.

Table 26  
*Regression output for mothers' overall immanent justice references predicting increases in 8-year-olds' biological concepts for contaminated items.*

Predictor	<i>B</i>	$\beta$	<i>t</i>	<i>p</i>
Constant	2.95		7.11	<.001
Pretest	.26	.34	2.35	.001
Overall immanent justice references	.37	.38	2.66	.003

Next, one predictors was found based on child's biological concept level in the pretest. Mothers' references to immanent justice predicted posttest scores for children who had biological level concepts. A multiple regression, split by child concept level, and conducted with contaminated pretest and overall immanent justice references as predictor variables. The model produced an  $R^2$  of .65, which was statistically significant,  $F(2,9) = 6.38, p = .03$ . Contaminated pretest scores and immanent justice references can account for 65% of the variance in contaminated posttest scores for children with biological level concepts. Contaminated pretest scores were not significantly related to contaminated posttest scores ( $B = -1.30, t = -1.62, p = .15$ ). Immanent justice references were positively related to contaminated posttest scores ( $B = 1.48, t = 3.37, p = .01$ ). The results of the regression analysis are shown in Table 27.

Table 27  
*Regression output for mothers' overall immanent justice references predicting biological concepts for contaminated items in children with biological level concepts.*

Predictor	<i>B</i>	$\beta$	<i>t</i>	<i>p</i>
Constant	2.95		7.11	<.001
Pretest	.26	.34	2.35	.001
Overall immanent justice references	.37	.38	2.66	.003



***Predictors for uncontaminated posttest scores.*** Predictors for biological concept in the posttest for uncontaminated items were explored next. For uncontaminated items, one predictor was found. Mothers' references to immanent justice across all stories predicted uncontaminated posttest scores for 8-year-olds. A multiple regression, split by age, was conducted with uncontaminated pretest and overall immanent justice references as predictor variables. The model produced an  $R^2$  of .24, which was statistically significant,  $F(2,35) = 5.53$ ,  $p = .008$ . Uncontaminated pretest scores and immanent justice references can account for 24% of the variance in uncontaminated posttest scores for 8-year-olds. Uncontaminated pretest scores were positively related to uncontaminated posttest scores ( $B = .30$ ,  $t = 5.07$ ,  $p = .04$ ). Immanent justice references were positively related to uncontaminated posttest scores ( $B = .49$ ,  $t = 2.21$ ,  $p = .03$ ). The results of the regression analysis are shown in Table 28. Though this model was significant, it accounted for a low percent of the variance for changes from pre- to posttest for contaminated items.

Table 28  
*Regression output for mothers' overall immanent justice references predicting 8-year-olds' biological concepts for uncontaminated items.*

Predictor	$B$	$\beta$	$t$	$p$
Constant	2.37		5.07	<.001
Pretest	.30	.31	2.10	.04
Overall immanent justice references	.49	.33	2.21	.03

In sum, these results indicate that mothers' references to immanent justice predicted posttest scores for both uncontaminated and contaminated items for 8-year-

olds. Mothers' references to a lack of contamination predicted posttest scores for contaminated items for 5-year-olds. When considering biological concept level, mothers' references to immanent justice was the only reference that predicted posttest scores for children whose concepts were at a biological level. There were no reference predictors for children whose concepts were not at a biological level.

**Mothers' biological concepts.** Next, mothers' general and highest biological concepts were explored as predictors for the child's scores in the posttest. Multiple regression analysis was conducted to control for pretest scores and further evaluate if mothers' biological concepts predicted posttest scores for children based on child's age and child's biological level concepts.

***Predictors for uncontaminated posttest scores.*** Mothers' highest biological concept in the decontamination stories was found to predict 5-year-olds' posttest scores for uncontaminated items. A multiple regression, split by age, was conducted with uncontaminated pretest and mothers' highest biological concepts in the decontaminated stories as predictor variables. The model produced an  $R^2$  of .51, which was statistically significant,  $F(2,35) = 18.00, p < .001$ . Uncontaminated pretest scores and mothers' highest biological concepts in the decontaminated stories can account for 51% of the variance in uncontaminated posttest scores for 5-year-olds. Uncontaminated pretest scores were positively related to uncontaminated posttest scores ( $B = .59, t = 5.17, p < .001$ ). Mothers' highest biological concepts in the decontaminated stories were negatively related to uncontaminated posttest scores ( $B = -.12, t = -3.02, p = .005$ ). The results of the regression analysis are shown in Table 29. In sum, this predictor suggests

that the higher the mother's biological concepts expressed in the decontamination related stories, the lower the 5-year-olds posttest scores for uncontaminated items.

Table 29  
*Regression output for mothers' highest biological concepts in the decontaminated stories predicting 5-year-olds' biological concepts for uncontaminated items.*

Predictor	<i>B</i>	$\beta$	<i>t</i>	<i>p</i>
Constant	1.61		4.43	<.001
Pretest	.59	.61	5.17	<.001
Highest biological concepts in the decontaminating stories	-.12	-.36	-3.02	.005

**Mother and child behaviors.** Behaviors were explored as predictors for children's scores in the posttest. Age groups were examined separately. Multiple regression analysis was conducted and found that for contaminated posttest items, mother's encouragement of independent contribution predicted 8-year-olds' scores. There were no predictors for 5-year-olds. The regression analysis is reported below based on posttest type.

**Predictors for contaminated posttest scores.** A multiple regression, split by age, and conducted with contaminated pretest and mother's encouragement of independent contribution as predictor variables. The model produced an  $R^2$  of .30, which was statistically significant,  $F(2,35) = 7.62, p = .002$ . Contaminated pretest scores and mother's encouragement of independent contribution can account for 30% of the variance in contaminated posttest scores for 8-year-olds. Contaminated pretest scores were positively related to contaminated posttest scores ( $B = .23, t = 2.06, p = .05$ ). Mother's encouragement of independent contribution was negatively related to contaminated

posttest scores ( $B = -.13$ ,  $t = -2.79$ ,  $p = .01$ ). The results of the regression analysis are shown in Table 30. As mother's give less encouragement for independent contribution, 8-year-olds' contaminated posttest scores increase.

Table 30  
*Regression output for mothers' encouragement of independent contribution predicting 8-year-olds' biological concept posttest scores for contaminated items.*

Predictor	<i>B</i>	$\beta$	<i>t</i>	<i>p</i>
Constant	3.52		7.43	<.001
Pretest	.23	.30	2.06	.05
Overall immanent justice references	-.13	-.40	-2.79	.01

In sum, behavior predictors indicate that mother's encouragement for independent contribution has a negative influence on 8-year-olds' posttest scores, specifically the contaminated posttest scores. This was not the case for 5-year-olds, however.

**Mother's disgust facial expressions.** Disgust expressions were explored as a predictor for posttest scores. Multiple regression analysis was conducted to control for pretest scores and further evaluate if mothers' general and highest disgust expressions predicted posttest scores for children. Neither mothers' general nor highest disgust expressions predicted children's posttest scores for contaminated or uncontaminated items in the posttest.

In the following chapter, results reported here will be discussed in relation to previous research and the hypotheses of the study. In addition, limitations and future research will be addressed.

## **Chapter 5: Discussion**

The purpose of this study was to examine the contributions mothers provide to children's developing sensitivity to contamination of water and food. Research has investigated children's development of contamination sensitivity, but has not examined social factors that influence contamination sensitivity. Three research questions were examined: 1) Do mothers provide information about contamination to their children during discussions about potentially contaminated situations? 2) Do discussions with mothers about contamination improve children's understanding of contamination? 3) Do mothers provide different kinds of information to 5- and 8-year old children about contamination during an interaction involving stories some of which involve contaminated situations? Overall, results revealed that mothers do provide contamination related information to their children, that these discussions improve children's biological understanding or concepts, and that mothers alter some of their information and behaviors based on the age of their child. Below, the results will be discussed as they relate to the above research questions and the hypotheses derived from these research questions. First, the information mothers provide for their children during the interaction will be discussed followed by a discussion of how the interactions related to differences in the children's performance as measured on the pre- and posttest. Age-related findings will be discussed throughout the discussion of the first two research questions. The discussion will end with the current study's limitations and concluding remarks.

## **Mothers Provision of Information about Contamination and Immanent Justice**

The first research question was interested in whether or not mothers would provide information to their children about contamination. As expected (Hypothesis 1.1), mothers did provide information about contamination during the interactions with their children. Some mothers included biological level concepts, though few incorporated disgust expressions. Information mothers provided for their children is discussed below in relation the type of information (contamination references, biological concepts, and disgust expressions). Mother-child behaviors will also be discussed below.

**References to contamination and immanent justice.** Most of the mothers' contamination related references were references directly about contamination and were mainly made during contamination related stories. This supports Hypothesis 1.1 that predicted that mothers would be explicit about contamination with their children when presented with scenarios depicting contamination. However, mothers also made references to decontaminating processes during contamination and decontamination related stories. This indicates mothers are also interested in teaching children about how to make food or water safe to consume. Because decontamination references occurred significantly less than contamination references, this may suggest that mothers are more interested in pointing out contamination than decontamination to children at these ages.

Mothers referring to contamination more than decontamination during the interaction may have occurred for two reasons. First, it could be that decontamination is a practice that requires a higher level of understanding that children at these ages are still developing. Based on Vygotsky's (1978) notion of ZPD, the expert scaffolds the

information she provides the novice based on the novice's ability. Mothers, therefore, may be less likely to make a point of explaining how a contaminated substance can be decontaminated, either because the child is unable to understand decontamination or mothers think their children are unable to understand the concepts. Understanding decontamination requires the child first understand what is acting as the contaminant and then know that the contaminant can be eradicated. Decontamination, therefore, requires understanding many biological aspects of a contaminant, such as its vitality (that it moves), that it is alive and can die, and how to intercept its movement or life. It may not be until the child is older than 8 years of age that these concepts can be fully realized, thus, mothers may not make specific reference to decontaminating processes or opportunities as frequently as contamination. Mothers' levels of biological concepts may support this idea. Mothers provided higher level biological concepts for contamination stories than decontamination stories, possibly because they saw their children as being able to understand the biological concepts related to contamination. For decontamination stories, the lower level of biological concepts could have reflected the mother's doubt that her child would be able to comprehend the biological elements necessary to explain decontamination. In opposition to this explanation, mothers made similar number of references to children whether the child expressed biological level concepts or not.

A second possible reason for mothers referring less to decontaminating processes could be culturally driven. Mothers in a suburban area of the United States may have less incentive to discuss decontaminating issues with their children. In the United States young children are exposed to situations that may require decontamination, such as

washing hands after using the bathroom. However, American children do not typically have many responsibilities that require using decontaminating processes. For example, in some communities in developing countries children are responsible for activities requiring decontamination on a daily basis, such as preparing food for meals or boiling water for consumption. A child whose responsibility it is to ensure the family receives meals that are safely cooked, or water that is safely purified may receive more instruction at a young age regarding decontamination processes. American mothers may feel it is less necessary to point-out examples of decontamination than examples of contamination for 5- and 8-year-olds.

This explanation seems possible given the lack of age patterns for contamination and decontamination references. It also supports sociocultural theory's assertion that caregivers provide information they see as necessary for making their child a competent member of the community (Gauvain, 1995; Rogoff, 2003). Mothers' rare references to an explicit lack of contamination may also reflect cultural values. American mothers may expect a lack of contamination to be the norm, and therefore do not feel a need to point it out to their children. For these reasons, children in a community where they have more responsibilities for the welfare of the family, such as helping to prepare food, may exhibit stronger contamination sensitivity such as exhibiting more knowledge about decontaminating processes.

Mothers also made very few references to immanent justice. This supports Hypothesis 1.3, which predicted that mothers would provide more contaminated related references than immanent justice references. Previous research has suggested that



children accept immanent justice as an explanation for contamination related concepts like illness (Kister & Patterson, 1980). More recent research suggests that adults are more likely to use immanent justice as an explanation for illness than children are (Raman & Winer, 2004). Such findings point to the possibility that mothers may use immanent justice as explanation for illness when talking to their children about contamination or illness. The findings in this study, however, indicate that mothers rarely use immanent justice to explain consequences of contamination to their children during a story where a character was portraying bad behavior (stealing money). Differences between the studies are notable. Raman and Winer provided a number of scenarios to participants and offered possible explanations, one of which was an immanent justice option. In the current study, no options were provided as explanations for the outcomes in the interactive stories. It is possible that if given the option, mothers may have chosen immanent justice as one explanation. Despite these differences, it is notable that mothers rarely spontaneously chose immanent justice as an explanation for the character in the story's illness.

Keil (1999) explains results in some previous research regarding immanent justice by pointing out that participants are often questioned using vignettes where the prominent character is associated with some form of bad behavior. He goes on to suggest that children will use the salient aspects of the story (character misbehaving) to explain the illness. Raman and Winer (2004) suggest that adults may possess an increased likelihood to rely on immanent justice because they have more knowledge about their culture through experience in that culture than children and are able to apply multiple reasons for

illness. Immanent justice is considered a culturally created explanation for illness that appears in many cultures as a way of explaining events that seem otherwise unexplainable and to too teach appropriate moral behavior (Medin & Atran, 2004). Thus, immanent justice is learned through interactions with others. If assumptions of sociocultural theory are to be met, that mothers provide information to their children they see as important to the child's development, then mothers would likely provide immanent justice as an explanation during a story where a thief steals money then becomes ill after drinking a glass of milk. In the current study very few mothers provided such an explanation to their children, which suggests mothers may see this type of explanation as unimportant or not useful. This claim is speculative in that procedures in the current study were somewhat different than other research. Primarily, the current study did not provide options for story outcomes and did not force responses regarding story outcomes.

**Biological concepts.** In addition to references to contamination it was expected that mothers would provide biological level explanations to their children regarding contamination. Below, mothers' responses to the survey as compared to their discussions with their children are discussed. Then, mothers' general and highest biological scores and the percentage of mothers expressing concepts at a biological level are discussed.

The purpose of the survey about stomach illness and germs that mothers filled out following the interaction was to determine whether mothers discussed contamination using similar biological level concepts with their children as they would when reporting about contamination or contamination related concepts on a survey. Survey scores were correlated with household income and mother's education level to determine if these

variables may be related to the level of biological concepts reported in the survey. However, mothers' household income and education level was not related to mothers' biological concepts in the survey. Research has not been conducted on adults' biological concepts and demographic factors that may influence them. The finding that responses on a survey were not correlated with household income and mothers' education suggests that (for lay adults) these factors may not play a role in biological concept knowledge. However, this is preliminary and more research is warranted in order to make further assumptions about this claim. When mothers' biological concepts during the interaction were compared to the parent survey about germs and illness, mothers received similar biological concept scores on the survey as they did during conversations with their children. This suggests that when mothers are asked to answer surveys regarding their knowledge about germs and illness, these answers may be similar in terms of biological concepts as conversations with their children about contamination. Future research investigating the development of children's contamination sensitivity and naïve biology would benefit from gathering information about mothers' biological knowledge. Incorporating mother's biological concepts, as reported on a survey, may provide insight into the level of biological concepts she is using to discuss contamination.

Survey findings for mothers in the current study differed from other research using a similar survey with South African Sesotho-speaking populations, which found that adults exhibited biological levels for their explanations of causes, treatments, and preventions of AIDS and the flu (Legare & Gelman, 2009). Mothers' scores on the current study's survey also differed from other research using a similar survey and coding

scheme that included healthy American 16-year-olds who scored higher than a basic biological level for illness concepts (Perrin, Sayer, & Willet, 1991). It may be that concepts like contamination elicit less biological level explanation than illness concepts like the flu. However, this does not account for the parent survey in the current study which directly probed for mothers' knowledge about stomach illness including causes, treatments, and preventions. It is also possible that the mothers in the current study may not have taken the time to thoroughly complete the survey. The survey was given at the end of the study and mothers may have felt rushed or that full explanation was not necessary, resulting in less thorough answers. This explanation does not seem likely given that mothers were provided unlimited time to finish the survey. One additional reason for the differences in the current study's survey with others could be due to the manner in which other surveys collected their data (Legare & Gelman, 2009; Perrin et al., 1991). In both studies, interviews were conducted orally. It may be that the presence of a researcher elicited higher biological concepts from participants in those studies.

In regards to mothers' biological concepts discussed with the child, despite mothers' low average general biological concept scores, many mothers did exhibit biological level concepts with their children, which supported Hypothesis 1.1. Nearly half of mothers expressed concepts at a biological level (i.e., biological concept scores at or above 4, using external agents to explain contamination) with their 8-year-olds and about a third of mothers exhibited biological level concepts with 5-year-olds. The age differences provide support for Hypothesis 3.1, that mothers will alter their information based on the child's age. The percentage of mothers who use biological level

explanations demonstrates that mothers utilize biological level concepts to discuss contamination related scenarios and do so more with 8-year-olds than 5-year-olds. Expectedly, the use of biological level concepts occurred more during contamination related stories than decontamination related stories, but this was only true for interactions with 8-year-olds. This was also true for the sociomoral story, though this is not surprising given the inclusion of contamination in that story. The percentage of mothers who demonstrated biological level concepts during the decontamination related stories was the same for 8-year-olds and 5-year-olds. These findings provide some support for sociocultural theory that mothers will adjust information for children based on the child's needs or what the mother sees as important for the child (Gauvain, 1995). When contamination is present in a story, more mothers expressed biological level concepts with 8-year-olds than 5-year-olds. When considering children's biological level concepts, however, mothers' did not alter the level of their biological concepts. ZPD research suggests that more expert social partners will adjust their information based on the ability of the novice (Wood et al., 1976). However, the percentage of mothers in this study who displayed biological level concepts did not change based on the child's expression of biological level concepts. In addition, mothers did not adjust their highest biological concepts based on the child's biological level concept, but rather, adjusted their biological concepts based on the child's age.

These age-related patterns suggest that, while discussing contamination related stories, mothers may see 8-year-olds as more able to understand biological level concepts than 5-year-olds and so employ these types of concepts more with 8-year-olds during

these stories. Pretest scores for 5- and 8-year-olds support this assumption. Eight-year-olds exhibited higher general and highest biological concepts than 5-year-olds and a higher percent of 8-year-olds provided biological level explanations. Yet, results for mothers' biological concepts based on child's biological level concepts do not support this. Sociocultural factors may explain this contradictory finding. Rather than child ability, it may be that mothers use more biological level concepts with 8-year-olds based on the child's education level. Children are generally expected to perform well in school and parents in the United States typically socialize their children towards this end (Rogoff, 2003). Children at the age of 5 years have not or are just entering school in the United States. Due to the lack of experience with formal schooling, mothers may not expect their child to know biological information in regards to contamination. An 8-year-old, on the other hand, has already completed about three years of schooling. Mothers may have higher expectations in terms of what their child should understand about biology and contamination. The same task administered in communities where formal education is unavailable or unaffordable for children, would likely reveal different results. In cultures where there is less cultural expectation regarding formal education, mothers may adjust their biological information differently than in a culture where formal schooling expectations are prominent.

The same explanation may be applicable for the sociomoral story results. More mothers exhibited biological level concepts with 8-year-olds than 5-year-olds during the sociomoral story. Along with the sociomoral aspect of the story, potential contamination was present during this story. Recall that the story included a potentially soured glass of

milk that had been sitting on a counter in the night. This provided the opportunity for mothers to discuss the potential contamination and/or the sociomoral aspects of the story. More mothers used biological level concepts to discuss the sociomoral story with 8-year-olds than 5-year-olds, despite the fact that mothers provided a similar number of contamination references during this story to both age groups. In addition, mothers did not have different biological concepts in the sociomoral story based on the child's biological concept levels. This further supports the assertion that mothers may see 8-year-olds as able to understand the biological concepts presented in the story more than 5-year-olds and thus, provided higher concepts.

An alternative explanation to the age-related differences may be related to the dynamic nature of the interaction. It is possible that 8-year-olds were interacting with mothers in such a way that elicited higher level biological concepts from their mothers. Sociocultural theory suggests that cognitive development is a dynamic process that requires the input of both the developing person and social partners (Gauvain, 2001). Using questions is one way children can extract specific information from social partners. By the age of 5 years, children use questions effectively to gather new information and solve problems (Mills, Legare, Bills, & Mejias, 2010). In the current study, 8-year-olds may have asked more questions regarding events in the stories that required higher level biological responses than 5-year-olds. Therefore, it is difficult to know in this study if children's questions had an effect on the biological concepts mothers expressed. This explanation would also compliment the cultural expectations of formal schooling discussed above. Children's questions were not specifically measured and tested in this

study because the focus of the study was information mothers provide their children. Follow-up research in contamination sensitivity development will expand the current study to include contributions of both mother and child in a dynamic interaction. The use of questions may also account for the age differences during specific stories. Eight-year-olds may have more questions regarding contamination versus decontamination and draw mothers' explanations out during these stories. Regardless, findings for these age-related differences support Hypothesis 3.1, that mothers would provide different types of information to their children based on the child's age.

**Disgust expressions.** Hypothesis 1.2 predicted that mothers would use disgust facial expressions during contamination related scenarios. Mothers did express disgust and more so during contamination related stories. However, only a third of the mothers expressed disgust during these stories and mothers expressed disgust to both age groups equally, which did not support Hypothesis 3.3, which predicted that mothers would express more disgust facial expressions with younger children. Other research has found that contamination will elicit disgust from mothers and that disgust expressions are more frequent with younger versus older children (Stevenson et al., 2010). Stevenson and colleagues found that 93% of parents displayed at least one disgust expression, though it is not known what percent of mothers specifically expressed disgust during a set of items, but only one item was considered a contaminant. Therefore, it is difficult to know if all mothers exhibited disgust during their one contamination item or not. Regardless of the number of mothers who displayed disgust, it is possible that the disgust elicitors in Stevenson's study evoked more disgust due to the nature of the item (offering food to be



eaten from the bottom of a potty). In addition, Stevenson and colleagues used one contamination elicitor, while in this study there were four contamination elicitors, water in a toilet, an apple on the ground, soup with a bug in it, and two girls playing a hand game in which one girl coughed on her hands during the game. Stevenson and colleagues found that children and mothers express disgust in response to animals, specifically bugs, and body excrement, thus the elicitors in each study are similar. It is possible that the procedures of the present study influenced the difference in disgust between the current study and Stevenson's study. In Stevenson's study participants were in direct contact with elicitors, whereas in the current study participants looked at pictures of contamination. Researchers suggest that the action of coming into direct contact with a contaminant will elicit stronger responses than not coming into direct contact (Rozin & Fallon, 1987). Because participants in the current study did not come into direct contact with the disgust elicitors, it may have resulted in fewer mothers displaying disgust.

The innate nature of disgust may provide another explanation for mothers' disgust expressions being low and few in number in this study. Although Stevenson and colleagues (2010) suggested that disgust could be used as a teaching mechanism between parent and child, it could be that expressing disgust may not always be used as an *overt* teaching mechanism (Rozin & Fallon, 1987). For example, sociocultural research has found that children learn important behaviors and knowledge through observing more experienced social partners (Paradise & Rogoff, 2009; Rogoff, 2003). Parents may not consciously be using disgust (specifically with children in the age groups of this study) as a teaching tool, yet children may be acquiring knowledge through the observation of

disgust expressions as they occur in everyday interactions (Rozin & Fallon, 1987). The disgust scores may support the idea that mothers in this study were not overtly using disgust to teach children, but perhaps the expressions happened naturally and automatically, thus the low to medium level of disgust expression. General disgust expressions did not exceed a mean of 2 (disgust expressed at a low level) on a 5-point scale, and highest disgust scores did not exceed a mean of 3 (disgust moderately expressed). Though the highest disgust scores were significantly higher than the mean disgust, the highest disgust scores reached a level that indicates the highest levels of disgust were expressed at a moderate level. Highest disgust scores may reflect the assumption that mothers were not using disgust explicitly as a teaching mechanism. However, if disgust, as an innate mechanism (Rozin & Fallon, 1987), is learned from through everyday interactions (Rozin et al, 2008), learning from disgust may be more additive, in that many repeated exposures to the display of disgust and the body behaviors associated with it are needed to have an impact in learning about contaminants. The above assertions on disgust, based on the findings of this study, are speculative. Further research is needed to examine the types of circumstances mothers may use disgust as an overt teaching mechanism. Observations of mothers and children in natural settings may inform such a study. Regardless, further research is needed to understand the contributions of disgust as a social and innate mechanism that informs the development of contamination sensitivity.

In regards to the hypotheses of the study, the hypothesis that mothers will express disgust while discussing contamination was somewhat supported. Some mothers did

demonstrate disgust, specifically during contamination related stories, however most mothers did not express disgust and did not do so at a very high level. This may indicate that mothers were not attempting to use disgust as an explicit teaching mechanism. Perhaps the general and highest disgust scores may reflect a natural and innate expression of disgust on the part of the mother that children are learning from (Rozin & Fallon, 1987).

**Mother-child behaviors during the interactive story activity.** Mother and child behaviors were also examined during the interaction. Though these behaviors do not provide insight into contamination related information mothers may discuss with their children, they do paint a picture of how mothers interact with their children during stories with contamination related scenarios. Of all the behaviors measured, four emerged as prominent. These were encouraging child's independent contribution, keeping the child on task, child's involvement in the task, and child's cooperation with mother. All other behaviors did not or rarely occurred. Thus, mothers exhibited two behaviors that were assessed in this study. First, mothers offered some encouragement for children's independent contribution to the interactive story task, and did so more for 5-year-olds than 8-year-olds. Second, mothers kept their child somewhat involved, more so for 5-year-olds than 8-year-olds. Though Hypothesis 3.1 did not specifically predict age-related behavioral differences, these results indicate that, when instructed to work together on a task, mothers will behave differently with their children based on the child's age. Specific behaviors may promote learning about concepts like contamination (discussed more below in regards to predictors). Mothers were more encouraging with

younger children and were more inclined to keep them involved in the interactive task. These age differences may be due to varying abilities to maintain attention during a story book activity. Five-year-olds' attention is less developed than 8-year-olds and mothers may be more active in keeping younger children engaged in the story books for this reason (Zelazo, Carter, Reznick, & Frye, 1999). In addition, 8-year-olds are likely to have more experience with book activities through school or at home and are likely to be reading books of their own. Thus, 8-year-olds may need less encouragement and need to be kept involved less in order to contribute to the task.

Children also exhibited two specific behaviors. Children displayed some involvement in the task and were very cooperative with their mothers. These behaviors showed no age differences. Child's involvement is not surprising given that mothers were keeping their children involved. Likewise, child's cooperation is expected due to mothers' encouragement to contribute and keep the child involved. The lack of age differences in the children's behaviors may reflect developmental differences in attention and experiences with books. Children in both age groups were equally involved and cooperative, though mothers of 5-year-olds encouraged their children to contribute and kept them involved more than mothers of 8-year-olds. The combination of the mother and child behaviors may be supported with the above explanation regarding children's attention. Though mothers encouraged and kept 5-year-olds involved more than 8-year-olds, children in both age groups were similarly involved in the task. It is possible that mothers expected similar involvement from their children, but had to put more effort in obtaining involvement from 5-year-olds. In regards to task responsibility, the finding that

both mothers and children were responsible for the task, with children offering a little more responsibility than mothers, support the collaborative efforts between mother and child discussed above. In addition, there was no age difference in task responsibility, which helps to support the finding that both ages were similarly involved.

Together, the collaborative nature of the behaviors displayed by mother and child support research that caregivers and children, when instructed to do so, will work together collaboratively on tasks involving cognitive processes (Gauvain, 2001). In accordance with sociocultural theory, social interactions are adjusted to suit the abilities and knowledge of the child. In regards to the behaviors assessed in this study, mothers adjusted their encouragement of children and keeping the child involved and did so in an appropriate manner for the child's ability in order to complete the task of discussing the stories.

In sum, Hypotheses 1.1, 1.2, and 1.3, that mothers will provide biological information, display disgust expressions, and provide more biological explanations than immanent justice explanations, were generally supported when considering all results during the interaction between mother and child. Mothers provide contamination related information to their children while looking at stories that involve potentially contaminated scenarios. Mothers make direct reference to contamination and decontamination, and many (though not most) mothers incorporated biological level concepts when discussing contamination related scenarios with their children. Some mothers also expressed disgust while discussing contamination, though only about a third of mothers did so. Hypotheses 3.1, 3.2, and 3.3, that mothers would adjust contamination

information based on child's age, that youngest children would receive lower level biological explanations, and that disgust expressions would be more with younger children, were supported only in regards to biological concepts. Mothers made reference to contamination and displayed disgust similarly with 5-year-olds and 8-year-olds. However, more mothers used biological level concepts with 8-year-olds, specifically during the sociomoral and contamination related stories. The behavioral data demonstrated the collaborative effort put forth, and compliant nature, by both the mother and child, while the stories were being discussed, and that 5-year-olds received more encouragement and were kept involved more by mothers. Next, children's improvements from the pre- to the posttest and potential predictors for these improvements will be discussed.

### **Children's Improvements from Pretest to Posttest**

Next, Hypotheses 2.1 and 2.2, that mothers' contamination and biological information will support children's learning about contamination and that children will not use more immanent justice after interactions with mothers, will be addressed in regards to children's pre- and posttest performance and contributing factors to those improvements. First, pre- to posttest changes will be discussed for acceptance of items as safe to consume, children's biological concepts, and use of immanent justice. Then, predictors of those changes are discussed.

**Accepting items as safe to consume.** In the pretest children accepted items as safe to consume similar to previous research (Hejmadi et al., 2004; Siegal & Share, 1990). There were no age differences in acceptance rates, which did not support Hejmadi

and colleagues' research that 8-year-olds would have higher acceptance rates of contaminated items. One reason for the difference between the current study and Hejmadi's research may be due to the number of items used to test for contamination acceptance in the current study. Hejmadi and colleagues reported percentages for individual items. In the current study acceptance of contaminated and uncontaminated items was aggregated across nine and four items respectively. The greater number of items provides greater possibility of accepting contaminated items or rejecting uncontaminated items. The inclusion of multiple items in the current study may result in children overextending contamination attributions leading to incorrect acceptance rates (Keil, 1999). Incorporating more test items, however, may also provide a broader picture of children's acceptance of contamination. For example, for contaminated items, some items that were included were considered to be more "difficult" in terms of contamination sensitivity because these items could be decontaminated. When acceptances for these items were compared with less difficult contaminated items (those items that could not be decontaminated), 8-year-olds accepted the difficult items more often than the less difficult items. Therefore the acceptance rates in this study are not completely analogous to other studies on contamination sensitivity. Using only one item, as other studies did, may limit generalizability of children's contamination sensitivity to other items.

There was no change from pre- to posttest for accepting items as safe to consume for either age. Thus, predictors for pre- to posttest changes were not examined. The lack of change from pre- to posttest may represent a ceiling in acceptance rates for these age

groups due to a ceiling for understanding contamination concepts specifically. If Carey (1985) is correct that children 8 years and younger do not possess biological concepts that are separate from psychological concepts, then Carey's assertion may explain the lack of age differences and the lack of change from pre- to posttest. It is also possible that children in these age groups lack the necessary experience with contaminated items to show age differences or changes from pre- to posttest. Recall that mothers' references to contamination were less than one reference per story. Thus, though mothers made reference to contamination, they did not do so in each story, or in each contamination related story. The same was true for references to no contamination, decontamination, and immanent justice. This may also account for the lack of change from pre- to posttest. Mothers may not see some of the instances of contamination in the stories as important or beneficial to point out to their children.

**Biological concepts.** Unlike accepting items as safe, children's biological concepts changed from pre- to posttest, however, this was only true for contaminated items. In the pretest, 8-year-olds displayed higher level biological concepts than 5-year-olds, whether the items were contaminated or not. This supports previous research that children's biological understanding is developing until around the age of 8 years old. Notably, 8-year-olds did not exhibit, on average, a level of biological concepts that indicated biological knowledge was explicitly expressed. The percent of children who displayed biological level concepts being less than half supported the general biological concept means that did not reach a biological level. More 8-year-olds exhibited biological level concepts but only about a quarter of these children did so over all stories.



During contamination related stories, almost half of 8-year-olds displayed biological level concepts. No 5-year-olds exhibited biological level concepts in the pretest. These data support Carey's (1985) assertion that children younger than 8 years old do not hold an autonomous framework for biological concepts, that children this age will not use only biological explanations for biological phenomenon. In other words, according to Carey, children younger than 8 years do not understand biological concepts as different from other concepts, such as psychological concepts. The data in the current study somewhat support Carey's assertion that autonomous biological concepts emerge around the age of 8 years. Many, though not most, 8-year-olds displayed biological level concepts. Changes from the pre- to posttest indicate that both age groups exhibited higher biological concepts in the posttest, however, these changes only occurred for contaminated items.

When the codes were considered categorically, the main difference between the ages was the use of phenomenism and external agents. Not many children reported not knowing and even fewer used internalization and interaction as explanations for why items could or could not be consumed. However, children not knowing and using external agents as explanation were the only codes that exhibited change. This suggests that children who did not know a reason why an item could or could not be consumed may be using more phenomenism explanations in the posttest, and those who use phenomenism, use more external agent explanations in the posttest. Thus, the number of children using phenomenism does not change from pre- to posttest. Only the use of internalization explanations revealed an interaction with time and age which indicates

that 5-year-olds used internalization more in the posttest, but 8-year-olds did not. This suggests that, though 8-year-olds had higher biological concept scores and both age groups increased these scores in the posttest, only 5-year-olds increased their use of a higher biological code, internalization. These results imply that though both age groups improved, 5-year-olds may have a higher ceiling for improvement because they started using more lower level biological explanations. Thus, it may be that children at this age can learn to use biological level concepts after interactions with their mothers. This supports researchers who propose naïve biology is available to children at a young age (Keil, 1992b; Medin & Atran, 2004). It should be clarified, however, that very few 5-year-olds used internalization (that contaminants, when internalized, can have an effect physically). These results hint that young children are capable of improving their biological understanding but further research is needed to investigate individual factors, such as experience with animals or plants, that may contribute to this change. It should be noted that the biological codes allowed for coding immanent justice responses during the regular pre- and posttest items. However, no children spontaneously used immanent justice to explain why these items should or should not be consumed.

In general, these changes support Hypothesis 2.1, that children will show signs of learning about contamination (in this case biological concepts about contamination) after discussions with their mothers regarding contamination.

**Immanent justice.** Children's application of immanent justice was tested using three vignettes. During these vignettes children were asked whether a food or toy item was OK to eat or play with after one doll hits and steals it from another doll. There was a

contaminated food item, an uncontaminated food item, and a toy. The purpose of these vignettes was to create scenarios that may determine if the participants would use immanent justice. According to Keil (2007), when questions regarding illness or contamination are framed around a specific scenario (sociomoral in this case) children may provide more or less biological responses based on how the questions are framed. Keil's assertion provides a basis for why the vignettes were included. The vignettes in this study were based on a sociomoral event that involved food (and a toy) to uncover potential immanent justice responses. The contaminated food item elicited varying age-related responses. For the contaminated item, 5-year-olds were worse than 8-year-olds at accepting it as safe to consume, and 5-year-olds did not choose the contaminated item better than chance. This may have been due in part to the nature of the question (Is it OK for him/her to eat this food?). Many of these 5-year-olds provided socially motivated responses such as "It's OK because she took it and now it's hers" or "He can share it and it will be OK." Despite the fact that the food was visibly rotten, many of these children overlooked the contamination and focused on the social aspects of the vignette. When performance on the sociomoral vignettes was compared with performance on the regular test item, only 5-year-olds chose the contaminated item in the vignette different from the regular pretest contaminated items. This supports Kiel's (1992a) assertion that children will respond differently to biologically based questions depending on the framework in which the question is presented. Children's acceptance of items as acceptable to eat or play with did not differ in the posttest. Direct application of immanent justice as an explanation about what will happen if the doll eats or plays with the stolen item was

nearly absent in the pretest and posttest. Only one child provided such a response in both the pre- and posttest. These findings support Hypothesis 2.2, that children's application of immanent justice as an explanation for consequences would not change between the pre- and posttest.

Results for children's performance in the sociomoral pre- and posttests indicate that 5-year-olds are less likely to focus on the contaminated aspect of a rotten food when the food is presented in a scenario with sociomoral themes. Children in both age groups are also not likely to use immanent justice as an explanation as to why a food item or toy should not be consumed or played with. This result supports immanent justice research that suggests children are less likely to use immanent justice than biological reasoning as an explanation for illness over folklore or biological responses (Raman & Winer, 2002). Children in this study also seemed to focus on the social aspects of vignettes. Along with providing biological reasoning as to why the contaminated food could be consumed, many children responded that the food was not acceptable to consume because it was taken from the other doll and should be shared. Many children focused on the lack of sharing in the vignettes. The procedure for the vignettes was deliberate in not asking about immanent justice possibilities. In not doing so, it allowed the child to generate spontaneous reasons for their responses. That 5-year-olds focused more on the social aspect of the contaminated food rather than the contamination may explain why other research has found that children use psychological or social explanations for biological phenomenon (Carey, 1985).

**Predictors for children's improvements from pretest to posttest.** Next, predictors for children's improvements regarding biological concepts from pre- to posttest are discussed. Of the predictors explored, three groups of predictors emerged. The first predictor group was associated with contamination related references. The second predictor group was mothers' highest biological concept in the decontamination related stories. The third group of predictors was the mother-child behaviors.

*Contamination reference predictors.* Two contamination related references were found to predict biological concepts in the posttest. First, mother's references to immanent justice were found to predict biological concepts for 8-year-olds and specifically, children with biological level concepts. Mothers made few references to immanent justice, yet these references across all stories predicted biological concept scores for 8-year-olds in the posttest contaminated and uncontaminated items, and for contaminated items of children with biological level concepts. Biological concepts for 8-year-olds (and specifically for children who have reached biological level concepts) may be at a stage where they are making clearer distinctions than 5-year-olds between social consequences and biological consequences. However, children as young as 5 years have been found to differentiate between psychological domains and biological domains (Ericson et al., 2010). By 8 years old children have a well-developed sense of the influence of invisible mechanisms that influence contamination (Au et al., 1993). It is possible that a well-developed ability to understand that biological mechanisms are involved in contamination is necessary for references to immanent justice to affect biological concepts. For example, immanent justice explains biological consequences

(getting sick) using social behaviors (he became sick because he misbehaved), thus it is possible that when mothers make reference to immanent justice it provides an inconsistency with what the child understands about biological mechanisms. This inconsistency in turn may act as stimulation for further thought on the child's part about what she might know regarding biological concepts. Rather than adopting the immanent justice explanation, the child further justifies her own biological explanation.

This finding may support Raman and Winer's (2004) research with college students and children demonstrating that college students use more immanent justice beliefs than third graders. According to them, adults possess a greater ability for multi-focused thinking than children, and adults are more knowledgeable about one's cultural values and norms. Because, according to Raman and Winer, adults can multi-focus (consider more than one reason for outcomes involving illness), cultural norms providing explanations for illness can be adopted and integrated with the biological knowledge adults have about illness. They assert that younger children, on the other hand, are only able to adopt one explanation. Thus, when an adult uses an explanation that does not fit with the child's working explanation it may provoke the child to justify her own explanation. Thus, the finding that children did not use more immanent justice explanations after interactions with their mother, but that interactions that included mothers' use of immanent justice predicted biological concept posttest scores may support Raman and Winer's assertions above.

The other contamination related predictor was that mothers' references to a lack of contamination predicted 5-year-olds biological concepts for contaminated items on the

posttest. There were very few references made by mothers to a lack of contamination, but these references predicted higher biological concept scores on the posttest and accounted for nearly 60% of the explained variance. In other research young children have been shown to over-extend their use of contamination type concepts such as contagion (Kalish, 1999). When mothers make explicit references of when food or drink is not contaminated this may demonstrate an overt counter-example for when contamination is present. Such an explicit counter-example may aid children in building on their current contamination concepts. For example, if children over-extend their application of contamination then they may be more likely to choose an item as contaminated when they are unsure. If mothers point out specific instances where contamination does not exist (e.g., “Look the apple is OK to eat because there is no dirt on it”) then children can use these examples and apply them to their current biological and contamination concepts. Essentially, mothers have expanded, or made salient, criteria that inform the child’s biological concepts, thus, improving the child’s score after such interactions. This assertion warrants further research, however, because 5-year-olds did not alter their acceptance of contaminated (difficult or non-difficult) or uncontaminated items in the posttest, which would have provided stronger support for this assertion.

***Highest biological concept predictor.*** Mothers’ highest expressed biological concept during both decontamination related stories was found to negatively predict 5-year-olds’ posttest scores for uncontaminated items. In other words, the higher the mother’s biological concept during decontamination stories, the lower the child’s

biological concepts in the posttest for uncontaminated items. Recall that decontamination may be considered a more difficult process due to the child needing to know various aspects of contamination, such as knowing that the contaminant is alive, can be killed or removed, and that doing so leaves no traces of the contaminant. Also, the decontamination stories include images of food items that appear edible. It is possible that the higher the level biological concepts were during the decontamination stories mothers discussed with 5-year-olds, the more confused children became about how to understand biological concepts in regards to food or water items that are not contaminated.

This finding may support researchers who suggest children under the age of 8 years of age do not have an autonomous theory of biology, or are not able to understand biological concepts separate from other concepts like psychological concepts (Carey, 1985). However, if it true that 5-year-olds had no ability to separate biological concepts from other concepts, then mothers' highest biological concept may have also negatively predicted biological concepts for contaminated items as well. Rather, it seems that this predictor may be suggesting developmental changes in how children learn about contamination and the biological concepts related to it.

Raman and Winer's (2002) suggestion that young children are not able to multi-focus (consider more than one aspect) in regards to the causes of illness may shed light on the above assertion. They suggested this idea as an explanation for why adults use more immanent justice to explain illness than young children. However, it may be that 5-year-olds are not able to focus on the many aspects of the decontamination process in a



similar manner as not being able to focus on the many reasons one may become ill. Thus, when mothers express higher-level biological concepts during situations where decontamination is taking place, this may provide an overload of information and confuse the child, leading to a decreased ability to explain items that are not contaminated using biological concepts. As children develop and their ability to multi-focus improves, they are then able to better understand how biological concepts can be applied to an item that is not contaminated.

***Behavior predictors.*** One mother-child behavior predictor was found, that mother's encouragement of independent contribution had a negative impact on 8-year-olds' biological concept scores for contaminated items. In other words, as mothers provided less encouragement of independent contribution to their 8-year-olds, the child's biological concept scores increased in the posttest. This finding was surprising but may be explained when considering the child's age and the nature of the activity. By 8 years of age children are typically accustomed to looking at and reading books. If the activity is not carried out at home, it is likely conducted in school. Five-year-olds, on the other hand, have less experience with this type of activity (Purcell-Gates, 2000). Children at 8 years of age are familiar with the process of looking at the book page by page and reading, or in the case of this study talking about, each page and following the sequence of the story. Though, given that 5-year-olds in many homes have sufficient experience with books to understand the process of looking at books, this explanation may not fully explain the finding above.

It is possible that mothers expect 8-year-olds to contribute to the story more than 5-year-olds. Efforts on the mother's part to encourage more independent contributions may reflect a less attentive or less interested 8-year-old. The medium and strong negative correlations help support this assertion. The more cooperative the 8-year-old was, the less the mother encouraged the 8-year-old to contribute or attempted to keep the child involved. These negative correlations also mean that the less cooperative the 8-year-old was, the more the mother encouraged contribution and kept them involved. However, the same correlation was not found for 5-year-olds, despite the lack of age differences in cooperation scores. Thus, 5- and 8-year-olds were cooperating similarly, yet mothers responded differently to these children based on their age. In turn, the interactions between the mother and child, for the 8-year-olds, had a negative impact on their posttest scores. This finding also supports sociocultural theory that children contribute to their own learning (Gauvain, 2001). Here, 8-year-olds may be impacting their learning of biological concepts, specifically by not cooperating at a level mothers may be expecting.

In addition, it is possible that children 8 year of age were bored with the protocol. An already inattentive or less interested child is less likely to perform well on a posttest as they may be less willing to provide extensive answers to the test questions that allow biological concepts to be coded. While collecting the data, there were cases of children who seemed bored or struggled to focus by the end of the procedure, though these were few. Some had difficulty focusing enough to provide extensive answers as to why an item might be unsafe to consume, and others showed difficulty in remaining seated for the final posttest. There were also rare cases of children who, by the end, were less

enthusiastic and provided rushed and abbreviated responses. It is possible the results for this predictor may be capturing these types of children.

Results involving social interactions and learning about contamination and biological concepts provide important findings for children's development of contamination sensitivity and acquisition of a theory of biology. The results suggest that contamination sensitivity development, like other concept development, is impacted by social interactions with more experienced social members. Given that the content of the stories was focused on contamination related topics, it is possible that the nature of the task created a situation that had an impact on the children's concept scores. However, this task was created to simulate a common activity that children and mothers may carry out together in an everyday setting. It is true that not all books mothers and children look at together will discuss contamination, however, this task (and findings associated with it) points out that mothers highlight important information in books and that interactions between those taking part in discussing the book may improve cognitive functioning, in this case, contamination sensitivity.

In sum, Hypotheses 2.1 and 2.2, that interactions with mothers would support children's learning about contamination and that the use of immanent justice would increase after interactions with mother, were somewhat supported. Children's biological concepts increased after interacting with their mothers while looking at stories containing contamination related scenarios. Specifically, children's biological concepts for contaminated items improved. However, children's acceptance for items as safe to consume did not improve after interacting with their mothers. In addition, children did

not use more immanent justice during the vignettes after interactions with their mothers. Direct references and behaviors predicted children's scores on the posttest. Mothers' references to immanent justice predicted 8-year-olds' biological concepts and references to a lack of contamination predicted 5-year-olds' biological concepts. Mothers' references to contamination and biological concepts expressed during discussions did not predict children's posttest scores as expected. One behavior also predicted children's posttest scores. The less mothers encouraged independent contribution from 8-year-olds the higher their biological concept scores. Behaviors predicting children's concept scores supports sociocultural theory, which emphasizes the influence of social interaction on children's cognitive development.

### **Limitations**

Five limitations are discussed in regards to the current study. The first limitation addresses the coding of contamination and biological concepts and the second limitation addresses how contamination and biological concepts may be measured. The third limitation addresses the protocol used for the mother-child interaction, and the fourth limitation addresses the age groups used in the current study. The final limitation addresses the generalizability of the findings.

The first limitation pertains to the method in which biological concepts were coded. The codes used in this study for the parent survey did not reveal biological level concepts in mothers. This may be a limitation in that, the current study's codes for the survey were based on coding schemes that had revealed biological level concepts in adults in other research (Legare & Gelman, 2009; Perrin et al., 1991). The original codes

that the current study's codes were based on were created to measure biological concepts as related to illness specifically. Concepts were considered to be at biological levels when a participant was able to explain that specific and factual external agents were involved in contracting the illness. Higher biological levels were coded if participants could expand on internalization, interactions, and mechanisms involved in contracting the illness. In the current study, the codes described above were altered and used to measure biological concepts as related to contamination rather than illness. It is possible that biological codes meant for illness do not translate as well for contamination concepts. However, this explanation does not seem likely given that the parent survey directly asked questions about stomach illness and yet did not elicit biological level concepts from mothers as previous studies did (Legare & Gelman, 2009). In regards to contamination, specific aspects of the biological concept codes may reflect aspects of contamination. For example, external factual agents, such as dirt or germs, must be present for contamination to occur. Thus, it is proposed that these codes are likely to measure biological concepts regarding contamination, but could be a limitation to the study. This coding scheme should be incorporated into future research and refined for such purposes.

Second, children's understanding of biological concepts is debated in the literature. Some researchers contend that in order for children to possess a coherent framework for biological concepts they must be able to reliably distinguish biological processes as separate from psychological processes (Carey, 1985). Others argue that such stringent criteria for labeling a child's biological theory as coherent does not take

into account children's intuitions about biological and living kinds and that children are able to categorize biological kinds appropriately at the ages of 3 and 5 years (Hatano & Inagaki, 1994; Keil et al., 1999; Leddon et al., 2008). The biological codes in this study adhere to a somewhat stringent measure of biological concepts as they require participants to state, at minimum, external factual agents that cause contamination. It does not account for implicit knowledge children may have about contamination but are unable to communicate (Keil, 1992). For example, when asked why a piece of rotten food is not safe to consume children sometimes respond with reasons such as "you can just see that it is not good." This indicates an understanding of contamination but would not elicit a biological level concept score. For this reason acceptance of items as safe to consume were included an additional measurement of contamination. In addition, using these codes creates findings in the current study that support both theoretical views, that biological concepts are not autonomous until around the age of 8 years and that young children at the age of 5 years are able to reliably identify contaminated items. This means that both theoretical views may be correct, but tapping in to different stages of biological concept development. Thus, because contamination sensitivity may be using implicit knowledge driven by innate aspects of naïve biology, examining contamination sensitivity provides a unique perspective into the development of biological concepts.

The third limitation pertains to explaining that there were only a few predictors for children's improved posttest scores. This could be due to mothers not being instructed to point out specifically or explain contamination to their children. It may be that if mothers had been given specific instruction to discuss and explain the

contamination in the stories then more predictors may have emerged for children's posttest scores and children's acceptance of items as safe to consume. However, mothers were intentionally not instructed in this way because the study was interested in whether or not mothers would point out contamination spontaneously and provide the level of information they saw as important. This protocol should be extended in future research to include instructions for mothers to identify and explain contamination with their children. Such a change to the protocol would allow for examination of direct instruction and potential improvements for children as a result (Gauvain, 1992). Mothers being instructed to directly discuss contamination would also help identify whether direct instruction between mothers and children regarding contamination and biological concepts can improve children's understanding in these areas. Such findings would be beneficial for health interventions and education, as Au and colleagues (2008) have demonstrated with older children. Regardless, the current study helps to describe the type of information mothers may provide their children in a somewhat naturalistic setting during a common mother-child activity.

The fourth limitation pertains to the child's age. The ages of children included in this study reflect pivotal points in the development of children's contamination and biological development, because children can identify when food or water is contaminated at 5 years old and 8 year olds are expected to have autonomous theories of biology (Carey, 1985; Hejmadi et al., 2004; Siegal & Share, 1990). Studies have shown that by 5 years of age children are able to identify when contamination of food or water has occurred (Siegal & Share, 1990) though contamination identification continues to

develop past the age of 5 years (Hejmadi et al., 2004). Thus the development of identifying contamination may be taking place during preschool years. However, this study was also interested in how the use of biological concepts to explain contamination may contribute to the development of contamination sensitivity beyond the age of 5 years of age, hence 8-year-olds were included in the current study. Future research should extend the age groups considered for a similar study to include preschool children as a way of capturing contamination sensitivity development during years when children may be unreliable in accepting food or water as safe to consume. Though preschoolers were not included, the current study contributes new information to the literature regarding social contributions during pivotal ages for contamination sensitivity and biological concepts.

Finally, generalizing the findings of this study should be done so with caution. To date, no study has investigated the types of information mothers provide their children over the age of 4 years in regards to contamination. Though this study was conducted in a laboratory, it attempted to create an unprompted, naturalistic activity familiar to many mothers and children. During the activity, mothers may point out information they feel is important for their children to know regarding contamination. However, findings should be extended beyond the scope of the study carefully. It is possible that within a more naturalistic situation, such as helping mother prepare a meal at home, mothers may provide more biological information about contamination or refer more frequently to contamination. Research regarding contamination sensitivity would benefit from naturalistic observations of children's behaviors during contaminated situations and their



interactions with other social partners during these situations. In addition, the task involved in this study is specific to mothers and children in industrialized cultures. The activity of looking at and talking about pictures in a book is common for families in the United States (Purcell-Gates, 2000), however, in developing countries where contamination may be especially important due to rampant disease or unsafe water, mothers and children may be less likely or able to interact with picture books. Thus, these results should only be considered to be extended to children living in cultures where formal schooling, and reading books with parents are regular and expected activities.

### **Summary**

Research on children's development of contamination sensitivity has primarily focused on age-related patterns (e.g., Hatano & Inagaki, 1994; Hejmadi et al., 2004; Siegal & Share, 1990). Sociocultural theory contends that interactions with social partners, such as parents, aid the development of cognitive processes (Gauvain, 2001; Vygotsky, 1978), yet very little research has investigated factors influencing the development of contamination sensitivity, especially through social factors (Inagaki, 1990; Toyama, 2000). The primary purpose of the current research was to investigate how interactions with mothers influence children's development of contamination sensitivity.

Hypotheses for the first research question, that mothers would provide information about contamination, were generally supported. Mothers made specific references to contamination and decontamination while looking at picture books depicting contamination and decontamination. In addition, many mothers incorporated

biological level concepts during their discussions with their children. Some mothers also exhibited disgust expressions, especially during contamination related stories.

Expressing disgust indicates that mothers not only make direct references about contamination, but use nonverbal cues to communicate that contamination is present.

Hypotheses for the second research question, that discussions with mothers about contamination will improve children's understanding of contamination and biological concepts, were somewhat supported. Children did not improve on their ability to accept items as safe to consume, though their biological concepts explaining why items were (un)safe did improve. Mothers' references to immanent justice and a lack of contamination predicted improvements on children's biological concepts. Mothers' highest biological concept discussed during the decontamination related stories negatively predicted 5-year-olds' biological concept scores in the posttest. Mother and child behaviors also predicted improvements in biological concepts. Specifically, mothers who encouraged independent contributions predicted lower biological concepts. Also, the more children cooperated with their mothers the more their biological concepts improved.

Hypotheses for the third research question, that mothers would provide different types of information to their child based on the child's age, was somewhat supported. Mothers did not make different amounts or types of contamination related references to their children based on the child's age, nor did mothers display disgust expressions differently based on child's age. However, more mothers used biological level concepts with 8-year-olds to discuss the stories during the interaction. Predictors for children's

improvement in biological concepts also exhibited age differences. References to immanent justice predicted improvement in 8-year-olds' biological concepts, and references to a lack of contamination predicted improvement in 5-year-olds' biological concepts. None of the mother-child behaviors predicted improvements for 5-year-olds. Mothers who encouraged independent contribution predicted a decrease in 8-year-olds' biological concepts, but cooperation with their mother predicted improvement in 8-year-olds' biological concepts. Together these data suggest that mothers only express biological concepts differently based on the child's age.

## **Conclusion**

Future research should consider extending this study in three ways. First, research has suggested that while contamination sensitivity and biological understanding are seemingly universal, some information regarding contamination, such as germ theory, may be culturally constrained (Keil, 1992a; Medin & Atran, 2004). Thus, research should include observation of social practices in naturalistic settings with children over the age of 4 years within and outside the United States, specifically in cultural settings where food and water contamination is a greater threat than in the United States (see Toyama, 2000). Observing interactions between children and caregivers in a natural setting would provide information regarding the types of information and behaviors that caregivers provide about contamination. Such research would help address assertions researchers have about children learning about biological concepts and contamination through interacting and observing the world around them (Carey, 1985). Second, given that mothers' contamination references and biological concepts did not play an important

role in children's improved biological concepts, follow-up research should investigate more closely the dynamic between mother and child during discussions about contamination. Behaviors on the child's part such as asking specific questions or pointing out specific aspects in the story may influence children's level of biological concepts or their ability to accept food and water as safe to consume. Third, future research should continue evaluating children's ability to recognize contamination in parallel with children's developing biological concepts. These studies should incorporate decontamination processes in tandem with contamination concepts. Decontamination may represent a deeper biological understanding of contamination concepts. Such research would help further define a developmental pattern for contamination sensitivity.

To conclude, this study contributes to the literature by providing evidence for how mothers may be discussing contamination and biological concepts with children ages 5 and 8 years old while looking at stories containing potential contamination. In addition, this research shows that these interactions improve children's biological concepts, specifically in regard to contamination items. This research also supports previous research that 8-year-olds are more likely to have biological level concepts than 5-year-olds and extends this literature to show that biological concepts may increase when children discuss contaminated versus uncontaminated items with more experienced social partners while looking at picture books. Because this study offers potential predictors for improving children's understanding of contamination, these results may be beneficial for those interested in creating educational or intervention efforts to improve children's biological understanding of contamination.

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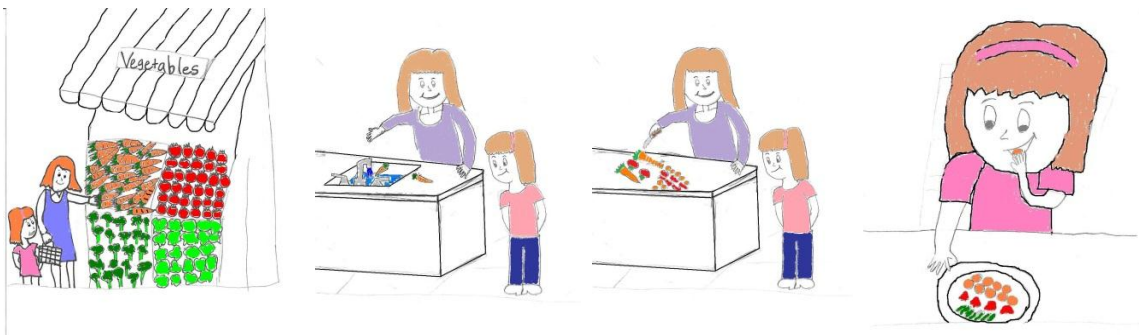
## Appendix A

### Interactive Story Images

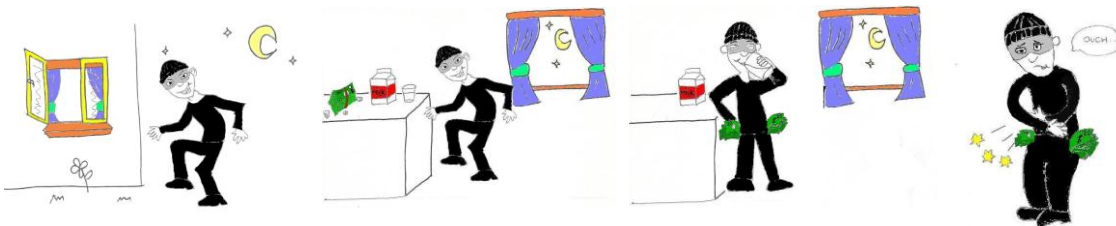
#### Story 1: Joey



#### Story 2: Mommy and Me



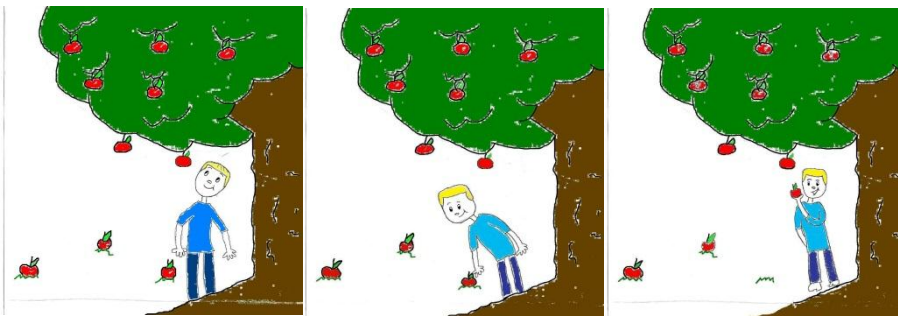
#### Story 3: At Night



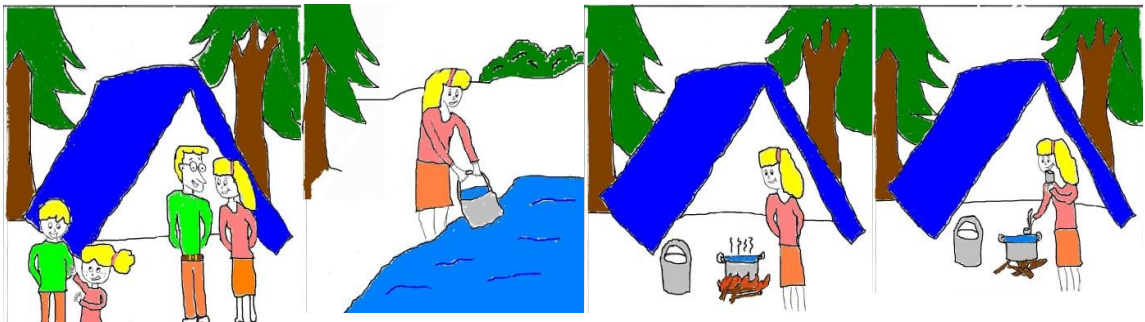
Story 4: Abbey and Becka



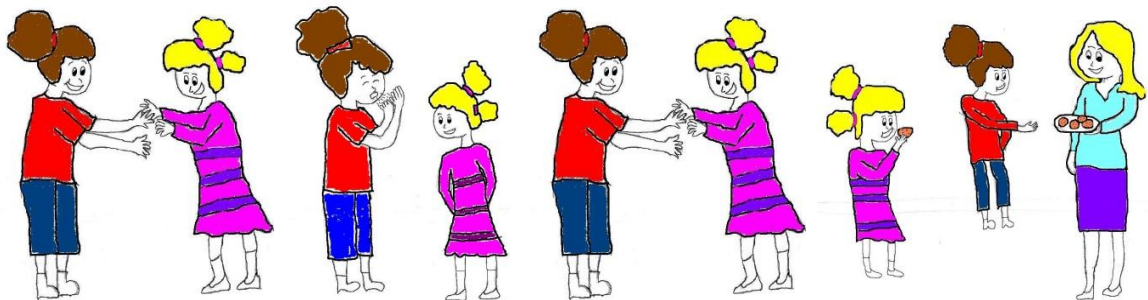
Story 5: Danny



Story 6: A Family



Story 7: Sarah and Lizzy



## Appendix B

### Parent Survey

1. How does someone get an illness?
2. How does someone get a stomach illness?
3. Can someone get a stomach illness from someone else who has a stomach illness?  
YES NO
  - a. (if yes) How?
  - b. (if no) Why not?
4. Can someone get a stomach illness from misbehaving or being bad? YES NO
  - a. (if yes) Why?
5. How can you tell if you have a stomach illness?
6. Are there treatments or cures for stomach illnesses? YES NO
  - a. What are they?
  - b. Who can treat it?
7. Who do you go to to get better when you have a stomach illness?
8. What do you do so you don't get stomach illnesses?
9. Who taught you about how people get stomach illnesses?
  - a. What did they teach you?
10. Have you taught your children about stomach illness? YES NO
  - a. What have you taught them?
11. Briefly describe what germs are.
12. Are germs are alive? YES NO
  - a. (if yes) Briefly explain why germs are alive.
13. Can germs die? YES NO
  - a. (if yes) How?
  - b. (if no) Why not?

14. Can germs move from one place to another? YES NO
- a. (if yes) How?
  - b. (if no) Why not?
15. How do you know if something has germs on or in it?
16. Can you get germs on or in you? YES NO
- a. (if yes) How?
  - b. (if no) Why not?
17. What happens if germs get on or in you?
18. What would you do if germs get on or in you?
19. What can you do to keep germs from getting on or in you?
20. Can germs hurt you? YES NO
- a. (if yes) How?
  - b. (if no) Why not?
21. Who taught you about germs?
- a. What did they teach you?
22. Do your children know about germs? YES NO
- a. (if yes) How do they know about germs?

Appendix C

Demographic Questions

Child's name \_\_\_\_\_ Child's birthday: Month \_\_\_\_ Day \_\_\_\_ Year \_\_\_\_\_

Was your child in school in this previous school year (2010-2011)? Yes No

If YES what grade did they attend? \_\_\_\_\_

Will your child attend school in the upcoming school year (2011-2012)? Yes No

If YES what grade will they attend? \_\_\_\_\_

Zip code where child lives: \_\_\_\_\_

Child's ethnicity (circle one)

Black/African American	Native American	Other/Mix _____
Latino/Hispanic	White/Caucasian	_____
Asian	Decline to answer	

Mother's age \_\_\_\_\_ Mother's occupation \_\_\_\_\_

Mother's employment status (circle one)

Fulltime	Not employed	Disabled
Part-time	Student	Decline to answer
Retired	Homemaker	Other _____

Mother's highest education level (circle one)

8 <sup>th</sup> grade	Some College	Master's Degree
Some High School	Associates Degree	Doctoral or Professional
High School	Bachelor's Degree	Other _____

Mother's ethnicity (circle one)

Black/African American	Native American	Other/Mix _____
Latino/Hispanic	White/Caucasian	_____
Asian	Decline to answer	



Father's age \_\_\_\_\_ Father's occupation \_\_\_\_\_

Father's employment status (circle one)

Fulltime	Not employed	Disabled
Part-time	Student	Decline to answer
Retired	Homemaker	Other_____

Father's highest education level (circle one)

8th grade	Some College	Master's Degree
Some High School	Associates Degree	Doctoral or Professional
High School	Bachelor's Degree	Other_____

Father's ethnicity (circle one)

Black/African American	Native American	Other/Mix_____
Latino/Hispanic	White/Caucasian	_____
Asian	Decline to answer	

Household (in which the child lives) yearly income, before taxes (circle one)

Less than \$10,000	\$30,000-\$39,999	\$60,000-\$74,999	Decline to answer
\$10,000-\$19,999	\$40,000-\$49,999	\$75,000-\$99,999	
\$20,000-\$29,999	\$50,000-\$59,999	Over \$100,000	

How many brothers and sisters does the child have? \_\_\_\_\_

Where amongst the siblings does the child fit (youngest, 2<sup>nd</sup> oldest, etc.)? \_\_\_\_\_

What is the primary language spoken at home? \_\_\_\_\_

Are there other languages spoken at home? Yes No

If so, what are they? \_\_\_\_\_

## Appendix D

### Biological Concept Codes

- 1 No response; do not know; inappropriate or off-task response
- 2 **SOCIOMORAL:** response involves moralistic behaviors  
“you can't eat that because you could get in trouble”; “doing that wrong (behavior) will make you sick”; “he got sick because he was bad”
- 3 **PHENOMENISM:** circular or phenomenistic response  
“water is good to drink because it is clean”; “you can drink that because it is good to drink”; “it will make you sick (provides no further explanation)”; “the water is good because it is white”; “you can eat it because you can see it is ok”
- 4 **EXTERNAL AGENTS:** concrete, external causes cited; no explanation of how the agents interacts biologically to result in, or prevent illness or contamination  
“dirty things are in the water”; “there is dirt on it”; “it's ok to eat because nothing is on it”
- 5 **INTERNALIZATION:** internalization and/or relativity in understanding of contamination; once agent is internalized illness follows invariably; understanding that germs or bacteria have movement  
“Germs get in and spread all over your body”; “when you breathe in sick people's germs”; “when you eat moldy food, you can get sick”; “boiling water kills the germs in the water”; “when someone coughs the germs go from them to you”
- 6 **INTERACTION:** interaction of person and contaminant described; some effect of contaminant on body; process of contamination or illness is mentioned but not elaborated  
“Germs get in your system and start to eat/kill your cells”; “it interferes with (normal body process)”; “germs may get in you from bad food then affect your stomach which makes you sick”
- 7 **MECHANISMS:** processes of illness causation or contamination, prevention, or treatment described; includes notion of biological bodily response  
“Germs take away food from the body and then the body has nothing to use for power”; “you must kill the bacteria that live in the water through boiling or filtering if you want to keep them from entering your system and making you sick”