1 Becoming mindful of biology and health: an introduction

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Despite the large amount of investigation devoted to cognitive development, it has been only recently that attention has come to be directed to children's understanding of biology and health. The aim of this book is to provide a comprehensive view of the research that has been accomplished to date on development of children's biological understanding, its relevance to health issues, and applications in educational and legal settings, and to offer prospects for the future.

In this introduction, we examine alternative theoretical and methodological approaches to what children know in this vital area. First, we give a historical background in terms of the knowledge and beliefs about biology and health that were held by lay adults and health professionals in the nineteenth century. Such consideration leads to the conclusion that magic and religion as well as science retain prominent roles in the explanation of illness. In this respect, three contemporary research orientations – Piagetian, naive theory and conceptual change, and adaptive-evolutionary – are discussed in terms of predictions for what children can and do know about the mind–body distinction, processes of birth and death, illness transmission, food selection, pain, and the nature of disease prevention and cure. We then turn to considering the extent to which the predictions generated by these orientations differ from adults' expectations of what children can and do know, and how different types of methodologies may reveal the extent of children's knowledge. Although young children may not be credited with a full understanding, new evidence suggests that they are constrained towards learning about biology and health and possess an implicit ''skeletal'' causal knowledge that is highly dependent on the nature of the problem and the way in which it is encountered. This knowledge may be used as a basis for preventive health education.

Views on biology and health in the nineteenth century

Knowledge of biology and the implications for health cannot be considered independently of concepts of disease that are influenced by culture.

Reznek (1987, p. 211) has addressed two key questions: "Do we invent diseases or do we discover them? Do disease judgments express value-judgments or are they purely descriptive judgments?" According to Reznek, some putative diseases are not diseases because they do the individual no harm. However, the notion of "harm" can be broadly constructed so as to extend rather than limit conferral of disease status on a person's physical or mental condition. Shweder *et al.* (1997), for example, maintain that there are three moral codes and that each have implications for health: (1) an ethics of autonomy that aims to protect individual freedom and promote individual choices; (2) an ethics of community that aims to protect the duties and hierarchies in communities; (3) an ethics of divinity that aims to protect the soul and spirit of humans against pollution and degradation. Harm may thus occur not only through restricting individual liberty but also through violating family and community obligations or engaging in behavior that jeopardizes the divinity and purity of the self such as through the ingestion of disgusting substances.

On this basis, a broad concept of disease emerges in that diseases are invented by those who make and share judgments of harm in relation to one or more moral codes. But at the same time, as Reznek (1987) points out, the conferral of disease status is restricted by the need to determine that the objects of such judgments have distinct identities that are grounded in biology. For prediction, treatment, and cure, we need to be able to determine whether the causal agents of disease share the same explanatory or unique natures. In this respect, contagious diseases such as hepatitis and tuberculosis certainly qualify as these have a biological basis and there is a consensus that such diseases cause harm in relation to one or more moral codes. Alcoholism and smoking – or even masturbation and homosexuality to use Reznek's provocative examples – can be classified as diseases if these are judged to be harmful in keeping with the ethics of divinity and if the identity of these "diseases" can be established in terms of a physiological addiction rather than one that is learned. Nevertheless, it is important to recognize that a judgment that harm has occurred is incompatible with a position of relativism in that those who judge are set against those who disagree.

During the nineteenth century, both physicians and lay people granted disease status to conditions that were viewed to reflect moral vices rather than unique biologically determined identities, and beliefs about the nature of illness that are tied to visible events have endured in the twentieth century throughout innumerable societies (Murdock, 1980). As Thomas (1997, p. 18) has observed, the commonest reaction to severe sickness throughout modern British history has been to ask, "What have I done to deserve this?" To the extent that morality accommodates the biological determination of disease, moral codes endure such as

aspects of Christianity and Judaism that focus on the importance of cleanliness and hygiene that have a clear biological utility (Thomas, 1997, p. 29).

In nineteenth-century North America, the most frequent interpretation of ailments labelled as disease was that these were due to leading an immoral lifestyle. This was the case for cholera epidemics that affected New York in 1832 and 1849. Rosenberg (1962) documents the common belief that those who succumbed to cholera were morally depraved in that they lived in filth and squalor, were intemperate, were not gainfully employed, and did not attend church. When people of substance did perish, it was suspected that they had engaged in secret moral vices. Many doctors held an ''atmospheric'' theory of the transmission of cholera in that those who breathed filthy air were likely to become ill. They often rejected the proposal that cholera has a contagious basis as the acceptance of such a theory would mean that persons from all walks of life could succumb to the epidemic and thus jeopardize the moral structure of society. Even by the time of the third epidemic of the century in 1866, only one in seven North American doctors believed in some kind of germ theory of the transmission of cholera (Rosenberg, 1962, p. 199). Instead, many subscribed to the view that the ''intemperate'' would be predisposed to drink filthy water. Only slowly did the medical profession and lay people come to accept that cholera could be prevented through destroying micro-organisms and education about hygiene rather than through fasting and prayers.

Even more vehement was the resistance against accepting the role of micro-organisms in the transmission of venereal disease. Most authorities in nineteenth-century America believed that the epidemic of syphilis and gonorrhoea in the United States was due to punishment for leading an immoral lifestyle involving sexual promiscuity and consorting with prostitutes (Brandt, 1987). The treatment prescribed by doctors was justly seen as painful and thus appropriately punitive. Doctors often attempted to conceal the cause of suffering if possible from reputable patients and their spouses. At all costs, it was to be kept out of the newspapers. Though there were those who advocated sex education as a means of preventing the spread of disease, frank discussion of venereal disease was often condemned as an exaggerated risk that could jeopardize marriage. It is often held that talking about sexually transmitted disease would encourage undue interest in sex and lead to wickedness and sin. Similar beliefs are present today among many adults in both industrial and non-industrial societies. They exist as formidable obstacles against efforts to prevent the spread of AIDS, as well as sexually transmitted diseases such as syphilis, gonorrhoea, and herpes that remain in massive numbers, affecting millions each year throughout world.

The heterogeneity of explanations for specific diseases that were held by adults in nineteenth-century America and Britain persist now. These draw on magic and religion, as well as science, and reflect an imperfect relationship between increasing age and cognitive development in the domain of biology. Rather than confining their explanations of disease to conceptions that are limited to biology and heredity, contemporary adults commonly view illness in terms of divine punishment or a "price to be paid" for genius and exceptional achievement or a "modern way of life" that involves the debilitating effects of diet and work (Herzlich and Pierret, 1986). Thus it is hardly surprising that there are numerous accounts of what children can and do know about the biological identity of specific diseases as distinct from judgments based on considerations of harm.

Approaches to conceptualizing what children can and do know about biology

Piagetian accounts

A good deal of the work on children's understanding of biology has been influenced by the seminal work of Piaget. According to Piaget ([1932]1977), young children have a belief in immanent justice. They believe that transgressors against adult authority will inevitably meet with a mishap and that adults are so powerful that they can enlist inanimate objects to punish the naughty.

Piaget's method was to present stories to children aged 6 to 12 and to probe for responses. For example,

> There was a little boy who disobeyed his mother. He took the scissors one day when he had been told not to. But he put them back in their place before his mother came home, and she never noticed anything. The next day he went for a walk and crossed a stream on a little bridge. But the plank was rotten. It gave way and he falls in with a splash. Why did he fall into the water? (And if he had not disobeyed would he have fallen in just the same?)

According to the results reported by Piaget ([1932]1977, p. 243), 86 percent of 6 year olds believe in immanent justice as an explanation for the mishap declining to 34 percent by age 11–12.

Kister and Patterson (1980) gave similar stories to children aged 4 to 9 years to examine the development of conceptions of illness. Again there was a strong relationship between age and belief in immanent justice. Compared to older children, 4–5 year olds were more likely to say that illness such as colds result from disobedience of parents. Nevertheless, from the Piagetian viewpoint on immanent justice, there is no such thing

as "clear-cut" stages (Piaget, [1932]1977, p. 257) – a qualification that has been echoed by researchers over and over again in the decades since Piaget first wrote on the topic.

Following Piaget, Bibace and Walsh (1979, 1981) proposed a stage analysis of children's knowledge of the causes of illness. Children between 2 and 6 years of age account for illness by immediate temporal or physical cues. People are said to catch colds from magic, or from the sun, trees, or God. Disease is defined in terms of a single perceptual event that is relevant to their own experience. Later children say that colds are caught when someone else goes near them and when touched by sick persons. Thus physical contact may be seen as important in the transmission of some illnesses, and that these may involve the ingestion of germs. Finally, at approximately 11 years of age, they give "formal-logical" explanations. There is a differentiation between external and internal causal agents. While a cold may be transmitted by an external agent, the illness is located within the body and develops in multiple external systems through the malfunctioning of internal structures. Children may describe colds as transmitted by viruses and consisting of blockages in the sinuses and lungs.

In fact, according to Bibace and Walsh, young children may regard all illness as contagious and believe that toothaches, as well as colds, can be caught by proximity to a sick person. Because children do not reason about causality, they may view illness as punishment. Bibace and Walsh speculate that the clinical usefulness of a Piagetian theory for the prevention and treatment of illness in children is to alert health professionals to children's immature understanding in order to promote empathy with their irrational fears. For example, health workers should be told that children may find closeness to a sick person unnerving. Because children have only a limited appreciation of the nature of contagion, they may want to be moved lest they catch the illness themselves. This situation may involve the need for health workers to prepare children for possible distress or to take measures to prevent this distress from occurring in the first place.

Though Bibace and Walsh (1979, p. 285) observe that "children's beliefs and assumptions about health, illness, and medical procedures differ dramatically and in unexpected ways from those of adults," they are careful to note that even adults may not have a well-formed scientific view of illnesses such as heart disease. They go to some lengths to recount incidents such as one in which a 30–year-old woman explained to her family doctor that the pain in her side resulted from having touched her sister who was under a "curse." Both children and adults may be prone to immanent justice explanations in an environment where alternatives are

not available or are unappealing (Siegal, 1988; Nemeroff and Rozin, 1994). In their respective chapters (2, 5, and 6), Inagaki and Hatano, Kalish, and Taplin, Goodenough, Webb, and Vogl consider the extent to which a Piagetian analysis of children's biological knowledge can apply to voluntary and involuntary bodily processes, the understanding of contamination and contagion, and knowledge of the determinants of pain. Moral overtones are also seen to be pervasive in the incisive chapter 8 by Nemeroff and Cavanagh on the development of perceptions of body image.

Theory change account

Carey (1985, 1995) has proposed that that the heterogeneity in which children respond on measures of their cognitive development reflects reasoning on tasks that is specific to the domains of knowledge in which these are situated. Thus there is no need to appeal to general Piagetian stages as an *explanation* of development.

According to Carey (1995), young children's ideas about biology go through two phases of development. In the first phase, from the preschool years to approximately age 6, children learn facts about the biological world. For instance, preschool children know that animals are alive, that babies come from inside their mothers and look like their parents, that people can get sick from dirty food or from playing with a sick friend, and that medicine makes people better. As Carey points out, knowing these facts is an impressive achievement, and children certainly benefit from having this sort of encyclopedic knowledge as a basis for making decisions and learning new facts. Having access to a mass of biological facts, however, is quite different from having a "framework theory" of biology. A framework theory (Carey, 1995; Wellman and Gelman, 1992; Keil, 1994) involves the connecting of facts to create a coherent, unified conceptual structure. Carey and her colleagues have claimed that it is not until the age of 7 years or so that children begin to construct a coherent framework theory of biology, through a process of "conceptual change."

One of the most important conceptual changes that occurs within children's biological knowledge is the construction of the category "living thing" from two initially separate categories of plants and animals. As an example, young children tend to deny that plants and animals share any biological properties. They commonly say that plants aren't alive, can't die, don't eat or move. After the age of 6 years, children's knowledge undergoes a conceptual change and restructuring, and the concepts of plants and animals become joined to create a new biological concept "living thing." Carey and her colleagues have proposed that other con-

ceptual changes occur alongside the development of a concept of living thing. For instance, the concept of "not alive" becomes more precise, so that children differentiate biological death (the cessation of bodily function) from the concepts "inanimate" (as in a telephone is not alive) and "unreal" (as in Bugs Bunny is not alive). Another concomitant conceptual change is a new concept of babies. Young children see the origin of babies in terms of the intentional behavior of parents who purchase them from stores or who manufacture them and place them in the mother's tummy; by contrast, older children and adults recognize that babies originate from intercourse that is intentional and that babies then grow by themselves through cell reproduction that occurs through nourishment and protection within the womb (Carey, 1985, p. 58).

Of particular concern is whether or not children have an understanding of properties that are transmitted through biological inheritance and those that are transmitted by cultural influences such as through non-biological, adoptive parentage. According to Solomon *et al.* (1996, p. 152), "to be credited with a biological concept of inheritance, children need not understand anything like a genetic mechanism, but they must have some sense that the processes resulting in Resemblance to Parents differ from learning or other environmental mechanisms." Based on this criterion, they claim that previous research in which it is concluded that young children have an explanatory biological framework is flawed as it does not provide a clear comparison of how children regard the respective contributions of biological and adoptive parentage (Gelman and Wellman, 1991; Springer, 1992; Springer and Keil, 1989).

To support the position that young children do not have an explanatory framework in the domain of biology, Solomon *et al.* carried out a series of four studies. In study 1, children aged 4 to 7 years were asked to indicate whether a child born to a biological parent but adopted by another would be more like one than the other in his or her physical traits and beliefs. The children were told a story about a little boy, who, depending on the counterbalanced version of the story, was born to a shepherd but grew up in the home of a king or vice versa. Before proceeding with the testing, the children were asked two control questions to ensure their comprehension in the sequence, "Where was the little boy born? Where did he grow up?" They were then asked questions concerning, for example, pairs of physical traits and beliefs such as, "When the boy grows up, will he have green eyes like the king or brown eyes like the shepherd?" and "When the boy grows up, will he think that skunks can see in the dark like the shepherd or that skunks cannot see in the dark like the king?" Many of the 4–year-olds answered that both physical traits and beliefs are determined environmentally. Not until 7 years of age did children often report that physical

traits are associated with the biological parent and beliefs with the adoptive parent. The results of study 2 indicated that preschoolers recognize that physical traits cannot change whereas beliefs can change. However, their judgments of whether beliefs can change were dependent upon whether this change was desirable or not. Study 3 replicated the results of study 1 using female story characters as did study 4, in which an attempt was made to lessen the environmental focus of the stories by showing the children only schematic pictures of the adoptive mothers rather than pictures of their homes.

The important findings of Solomon *et al.*'s research suggest that only after age 6 do children start to differentiate biological from cultural influences within a framework theory of biology (see also Solomon and Cassimatis, 1999). Resistance to training about the nature of biology simply means that the child's whole theory must undergo a restructuring. Whether children can and do understand these issues is taken up by Springer and by Slaughter, Jaakkola, and Carey in their chapters (3 and 4).

Adaptive-evolutionary accounts

Naive framework theories such as those proposed by Carey have often been viewed to operate on the basis of domain-specific constraints that reflect the problem solving that is evolutionarily adaptive (Cosmides and Tooby, 1994). Vosniadou (1994; Vosniadou and Brewer, 1992, 1994) claims that such constraints can be seen as ''entrenched presuppositions'' that are resistant to change as these are constantly confirmed by everyday experience. In the domain of physics, for example, children's early models of the earth appear to be constrained by two beliefs: (1) the earth is a flat plane (the ''flatness'' constraint) and (2) unsupported objects fall ''down'' on an up–down gradient (the ''support'' constraint). Thus they initially have the misconceptions that people live on a world that contains a flat surface, that the sky is above the earth rather than around, that the earth moves around the sun, and one could reach and fall off the ''edge'' of the earth. Theory revision can be very difficult to achieve when the information to be acquired is inconsistent with these presuppositions. In fact, in some cultures, indigenous cosmologies may come to rival those of western science in that children may readily construe the information presented by the culture as consistent with the flatness and support constraints. For example, children in India often ascribe to the Hindu religious mythology that the earth floats on an ocean that provides separation from ''nether worlds'' populated by other beings (Samarapungavan *et al.* 1996).

Yet it is by no means certain that presuppositions such as the flatness and support constraints must be entrenched and that misconceptions inevitably flow from these. The significance of evolution goes beyond the notion that exerts constraints on early cognitive development in the form of entrenched presuppositions that are confirmed by everyday experience. Rather evolution can be seen to have a more powerful role in development in relation to a process of cultural evolution. For example, Australian Aborigines have exceptional visuo-spatial memories that are highly adaptive in tracking and pathfinding in deserts (Kearins, 1981). Australian children generally are advanced in their geographical and astronomical concepts; even preschoolers often express the beliefs that the world is shaped as a sphere, that one cannot fall of the edge, and that the earth goes around the sun (Butterworth *et al.*, 1999). These beliefs seem ones that are cultivated through Australia's distinctive remoteness and position in the southern hemisphere and close cultural ties with people in the northern hemisphere – a unique set of conditions to which even very young children are exposed in the course of conversation with others. Furthermore, it is now well established that immediate experience is not all that contributes to the growth of children's scientific understanding as even infants have mental representations that go beyond immediate experience and guide their expectations of behavior (Leslie and Keeble, 1987; Mandler, 1992; Spelke, 1994).

Similarly, in the domain of biology, presuppositions from everyday experience that animals are unlike plants in that they eat, move, and are alive or that children resemble their parents irrespective of biological inheritance do not exhaust the range of constraints on early biological knowledge. As Rozin (1990, 1996) has proposed, an adaptive intelligence must to some extent be present to avoid the catastrophic consequences of illness on health and survival. In particular, solutions to the problem of procuring a safe diet require an adaptive, specialized intelligence that involves an awareness of health-endangering contaminants that involves a preparedness for knowing what to identify as safe to eat. In the same way, Hatano and Inagaki (1994) have perceptively observed that children's grasp of human biology is adaptive in that it performs three functions. First, it enables children to form predictions about the behavior of familiar natural kinds such as mammals regarding food procurement, sheltering, and reproduction. Second, it enables children to make sense of biological phenomena such as animals and plants that become unhealthy when they are fed too little or too much or with inappropriate food. Third, it helps children to learn rules for taking care of animals and plants, as well as themselves. Their knowledge of internal bodily functions constrains their choices of the variety and quality of food. Therefore

children should be capable of an early understanding in the domain of biology to the extent that they may in some respects be credited with an incipient framework theory that accurately accounts for the facts of biology.

Several studies support this view. Inagaki and Hatano (1993) examined children's understanding that some bodily characteristics such as eye colour are not modifiable in contrast to the modifiability of bodily characteristics such as the speed of running and mental characteristics such as memory. Most 4 and 5–year-olds were able to distinguish accurately among the modifiability of these three categories, and almost all were able to say that they could not stop their heartbeat or stop their breathing for a couple of days. In a series of studies carried out by Hickling and Gelman (1994), children aged as young as $4\frac{1}{2}$ years were generally able to identify that same-species plants are the sole originator of seeds for new plants of that species. Similarly, according to a series of experiments reported by Springer (1995), 4 and 5–year-olds who understand that human babies grow inside their mothers (77 percent of the total number of 56 children in his first experiment) possess a ''naive theory of kinship'' in that they could use this knowledge to predict the properties of offspring. They can say that a baby which is physically dissimilar to the mother will likely share her stable internal properties (e.g., ''gray bones inside her fingers'') and lack transitory properties (e.g., ''scrapes on her legs though running through some bushes''). Finally, Hirschfeld (1995, experiment 5) gave children aged 3 to 5 years two simple situations. In one, they were asked to indicate whether the baby of a black couple who grew up with a white couple would be black or white. The other situation involved the inverse in which the child of the white couple grew up with the black couple. Both the 4 and 5–year-olds clearly favored nurture over nature and were able to give justifications to this effect.

Hirschfeld (1995, p. 239) contends that these results differ from those of Solomon *et al.* because children in the Solomon *et al.* studies were asked to infer biological and cultural traits from the same event. According to Hirschfeld, by asking children to make many more judgments about traits that are environmentally as opposed to biologically transmitted, they may have been prompted to respond that even biological traits such as eye colour are the result of adoptive parentage. Nevertheless, Hirschfeld's method does not provide a stringent test of what children know about family resemblance as his subjects were not asked to differentiate between biologically and culturally transmitted traits. In chapter 3, Springer picks up on this theme in examining the relation between specific knowledge such as adoption and children's understanding of biological traits and resemblance to families and discusses it in relation to