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Gender differences in preschoolers' understanding of the concept of life

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Abstract

This study investigated gender differences in North American preschoolers' biological reasoning about the concept of 'life'. Four-year-olds (M = 4.6, SD = 3.3 months) and five-year-olds (M = 5.6, SD = 3.8 months) were asked about the function of 13 body parts, organs, and bodily processes. Results indicated that the likelihood of mentioning the importance of body parts, organs, and bodily processes for maintaining life or preventing death was predicted by age. A concept of life was more likely to occur in boys rather than girls. Although boys had a greater understanding of life they did not outperform girls in their responses to organ/body part function. The results demonstrate that gender differences in biological reasoning emerge during the preschool years. Implications for early science education are discussed.

Keywords

biology, biological reasoning, folkbiology, gender, life theorizer, preschool, vitalism

The relationship between gender and science achievement has received a great deal of empirical attention especially within the North American literature, likely prompted by concern that women are underrepresented in associated science disciplines, especially at the elite level (Long, 2001; Valentine, 1998). According to the National Science Foundation (1999), only four to six percent of full professors in science and math were women. Throughout the school years, gender differences

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in science achievement have been found across all age groups with boys generally scoring higher than girls (e.g. Beaton et al., 1996; Martin et al., 1997; Mullis et al., 2000; Smith et al., 1997). The goal of the present study was to examine the emergence of gender differences in science with a specific focus on the biological reasoning of preschoolers. A scant amount of research has examined gender differences at such an early age, but between the ages of four and six, a large amount of foundational knowledge about biology is established (Carey, 1985; Schroeder et al., 2007; Wellman and Gelman, 1998). As children mature, they assimilate new information into these foundational knowledge frameworks and organize the information for further learning (Carey and Spelke, 1994; Case, 1985; Piaget and Inhelder, 1969). If children already show gender differences during the establishment of early conceptual understanding, there may be implications for how new knowledge is assimilated in the framework. In addition, the understanding and identification of gender differences in science can support educators and teachers in differentiating instruction that addresses the individual learning needs of boys and girls (Tomlinson, 1999; Vygotsky, 1962).

Gender differences in science

Studies have demonstrated that gender differences in science achievement emerge fairly early in development. For example, Qualter (1995) examined seven- to 11-year-olds' understanding of sources of electricity. Although there was an increase in understanding with age, girls were less likely than boys to identify a source of electricity and to make connections between the generation of electricity and electrical appliances. In another study, Brophy and Alleman (2003) interviewed students from Kindergarten to Grade 3 about their knowledge of utilities supply (i.e. water, heat, and light) to modern homes. They found that boys had more knowledge than girls about aspects of utilities.

As they mature, boys and girls continue to have different science experiences. Girls, for example, are more likely to be exposed to biology related topics and less likely to engage in mechanical or electrical topics (American Association of University Women [AAUW], 1992). Differences in scientific academic performance continue to grow from Grades 4 to 12. That is, science proficiency for nine-year-old girls and boys was roughly the same, but widened by age 13 and increased even more by age 17 (Blake, 1993; Willingham and Cole, 1997).

Reasons for gender differences

There are many theories to explain why gender differences in science achievement occur in school-age children. One proposed reason is that girls become disinterested in science early in the educational process (Clarke, 1972; Kotte, 1992). The social context in which young girls and boys grow up appears to affect their interest in science. According to Jewett (1996), perceptions, behavior, and expectations of parents, teachers and peers can discourage girls from science in subtle ways and lead to less interest in science. It is believed that girls are taught, directly and indirectly, about the social expectations of females. For example, one study demonstrated that parents treated boys and girls, aged one to eight, differently during a trip to a science museum (Crowley et al., 2001). Parents in the study were more likely to provide explanations of the exhibits to boys, but gave more description of the exhibits to girls. When parental beliefs are conveyed in social interactions with their children, the parents' internalization of cultural values is unintentionally passed on. Furthermore, if parents engage their sons more in science-related activities, boys will gain more experience and skills in these activities than girls. Boys are also more likely to develop greater confidence and interest in science when they receive positive reinforcement (Tenenbaum and Leaper, 2003).

Science is still seen as a non-traditional career for females and these perceptions are often reinforced by instructional techniques that are a disadvantage to girls. Unconscious teacher bias, for example, can contribute to treating girls and boys differently. In the classroom, girls are often not encouraged to excel in science and are not given the same opportunities as males to learn (AAUW, 1992). Furthermore, girls are sometimes treated differently by teachers who overlook their abilities because girls tend to be more compliant than males (AAUW). Finally, peer pressure to conform to traditional sex roles, and a lack of positive female role models also influence girls' attitudes toward science (Jewett, 1996).

Research has demonstrated that young children are sensitive to these differential messages about science. For example, Hanson (1992) found that boys and girls already identified math and science as 'male' by the second grade, and in a 1991 Michigan Board of Education study, male and female students agreed that math, science, and gym favored males. Lupart et al. (2004) investigated adolescent gender and age differences in perceptions of academic achievement, interests, values, and future life role choices. Results of a survey showed that girls believed that they had to work harder than boys to learn science.

Interest in science can also influence knowledge acquisition and, in turn, school performance (Jones et al., 2000; Pope et al., 2006). Specific fields in science vary in their popularity with women. Physical sciences tend to be the least popular, biological science in the middle, and social sciences the most popular (Feist, 2006). Although girls and boys tend to like science equally when they are in their elementary years, like adults, some science topics also appeal much less to girls than boys (Woodward and Woodward, 1998). Boys seem to have a broader liking for all areas of science whereas girls have a preference for topics in biological science and less interest in physical science (e.g. electricity). However, there may even be gender differences within biological topics with girls liking some specific areas more than others.

Besides the influence of society on gender differences, there may be differences in how boys and girls process scientific information that has roots at a very young age (Gurian, 2001). By 18 months of age, children typically have already begun to form gender-related expectations about objects and activities typically associated with girls and boys (Poulin-Dubois et al., 2002; Serbin et al., 2001, 2002). By 24 months, infants have, on average, acquired masculine conventional and metaphorical gender knowledge as indicated by their tendency to relate items such as fire hats, hammers, fir trees, and bears with males (Eichstedt et al., 2002; Hill and Flom, 2007). By the age of 36 months, children use gender terms such as *boy* and *girl* and can correctly label their own gender (Fenson et al., 1994). Children's behavior also becomes more gender-differentiated at this time, particularly in the area of play where boys and girls tend to engage in specific types of activities (Maccoby, 1998).

The tendency to attend to gender-specific activities is one factor that shapes children's performance. A second contributing factor involves children's capacity to unconsciously encode frequency counts for events (Siegler, 1986). Humans automatically note how frequently events occur with the result that frequently experienced events are marked as important and schemas are constructed for them. Together these two factors result in boys aligning themselves with typical male actions and girls aligning themselves with typical female actions. To illustrate, children typically see males driving heavy machinery, and only rarely see females engaged in such an activity. Hence, boys, who identify themselves as male, show more interest in such vehicles, compared to girls.

This delineation of activities as male and female may influence how much emphasis boys and girls place on science related activities and the type of information they search out. Tunnicliffe (1997) examined the types of questions 23 eight- and nine-year-olds asked about pregnancy, birth, and babies during parent and baby visits to their class. Over 470 questions were analyzed and grouped into categories. There were distinct gender differences in the topics that interested boys and girls. Girls asked more questions than boys about the feelings of the parents about the birth and labor. Boys asked more information about feeding and other aspects of care such as playing with the baby. Both boys and girls wanted information about babies, but boys wanted data such as names and birthdays whereas more girls asked to touch the baby. Finally, almost twice as many boys than girls sought out factual details such as eye color and size.

Preschooler biological understanding

To understand gender differences in the specific domain of biology, which was the aim of the current study, it is necessary first to understand the research that has investigated early biological reasoning, in general. A large corpus of work, done throughout the last decade (Carey, 1985; Inagaki and Hatano, 2004; Keil, 1994) has established that young children develop a naïve understanding of biology throughout the preschool years. This understanding includes the ability to distinguish between living and nonliving things (R. Gelman, 1990; Gelman and Opfer, 2002; Inagaki and Hatano, 1996; Opfer and Siegler, 2004; Poulin-Dubois and Heroux, 1994; Rakison and Poulin-Dubois, 2001), knowledge of the insides of living things (Gelman and Wellman, 1991; Gottfried and Gelman, 2005), and an understanding of growth, digestion, and reproduction (Backscheider et al., 1993; Bernstein and Cowan, 1975; Hirschfeld, 1995; Keil, 1994; Rosengren et al., 1991).

What remains a topic of debate within the literature is the way in which children understand and explain biological phenomena. Although a number of different theories have been proposed, including essentialism (S.A. Gelman, 2003; Gelman et al., 1994; Waxman et al., 2007) and functional-teleology (Keil, 1992, 1994), the focus of the present study was on *vitalistic causality* (Hatano and Inagaki, 1994; Inagaki and Hatano, 1993, 1996). In a series of experiments, Inagaki and Hatano (1993) have shown that Japanese children, aged four to six years, explain the function of body parts as an exchange of 'life-force' or 'energy'. Within this age range, children begin to develop the understanding that body parts maintain human life, but do not have the biological knowledge to explain how; thus, they resort to vitalistic reasoning. For instance, in response to the question of why blood flows through our bodies, a child with a vitalistic view typically answers: 'because our heart sends out energy with blood that keeps us alive'. They believe that the functioning of the bodily organs is the goal of maintaining life, and life force is essential for them to work (Inagaki and Hatano, 2004). Inagaki and Hatano argued that this type of reasoning is evidence of an early biological understanding of life children have before they gain enough knowledge to provide biological explanations (i.e. blood carries oxygen to the body).

Although studies on vitalistic causality were originally based on data collected from Japanese children, American and Australian studies have supported the findings of Inagaki and Hatano (Jaakkola and Slaughter, 2002; Slaughter and Lyons, 2003; Slaughter et al., 1999). Jaakkola and Slaughter (2002) demonstrated that vitalistic reasoning about the human body was also evident in American children. The children explicitly referred to life as the purpose or goal of body functioning. In two experiments, children were asked a series of questions on the locations and functions of various organs and body parts. For example, they were asked, 'Where is your heart? What is your heart for? What would happen if someone had a heart that did not work?' Results revealed a developmental progression in children's references to 'life', 'staying alive', or 'not dying' in response to the questions. In total, 33 percent of four-year-olds, 92 percent of six-year-olds, and 100 percent of eight- and ten-year-olds used life as a causal-explanatory mechanism. In addition, children who used life in their responses were more likely than their peers to know about the specific function of vital organs. Jaakkola and Slaughter concluded that these children had begun to reason with a vitalistic causality.

Another study by Slaughter et al. (1999) investigated children's understanding of biological processes and their relationship to maintaining life or preventing death. Four- and five-year-olds were interviewed about the human body and the concept of death. Children were asked questions such as, 'Can you name something that can die? Once a person is dead, can anything bring them back to life again? Does a dead person need food, water, air, etc.?' Children were classified as Life Theorizers if they mentioned the importance of organs and body parts in maintaining life or avoiding death. Life Theorizers had a more sophisticated understanding of death than Non-Life Theorizers including the concepts that death was universal, irreversible, applicable only to living things, and involves the cessation of bodily functioning. In a subsequent study, Slaughter and Lyons (2003) devised a training study to examine whether Australian children adopt a vitalistic mode of construing when reasoning about the human body. After an initial interview to assess their knowledge of human body function and death, 40 preschoolers were given a single training session on vital body parts and processes (e.g. digestion). Not only did preschoolers in the training condition learn to adopt a vitalistic approach, but their understanding of human body function and death significantly improved as a result. In sum, the results of these studies suggested there is a reorganization of bodily understanding between the ages of four and six that marks the beginning of children's use of vitalism as a causal reasoning principle.

Although these studies examined the development of vitalism in young children's biological thinking as they age, there has not been a systemic examination of gender differences in this type of reasoning. Neither Jaakkola and Slaughter (2002) or Slaughter et al. (1999) looked at Life Theorizer status through the lens of gender and, although Slaughter and Lyons (2003) found an equal gender distribution between Life Theorizers and Non-Life Theorizers, they did not examine the body interview data for gender differences.

In the present study, we examined possible gender differences in the biological reasoning of North American preschoolers with particular focus on differences in reasoning about vitalistic causality. Preschoolers were administered a structured interview on the functions of body parts and organs for maintaining or preventing death. Our predictions were as follows: if young boys demonstrate a higher interest, and therefore achievement, in science than young girls, it is possible that boys and girls also differ in their use of vitalistic causality.

Method

Participants

The sample consisted of 100 North American participants distributed across two age groups: 56 four-year-olds with a mean age of 4.6 (SD = 3.3 months; range = 4.0–4.11; 26 boys, 30 girls) and 44 five-year-olds with a mean age of 5.6 (SD = 3.8 months; range = 5.0–6.2; 24 boys, 20 girls). Children were primarily Caucasian, from varied socioeconomic backgrounds, and proficient in English. Children were recruited from childcare centers in a large western Canadian city. Three additional participants were tested but were excluded from the final sample because they were not proficient in English (and thus did not understand the task instructions or questions).

Experimental task

The Body Interview (Slaughter et al., 1999) contained 13 questions on body parts and organs as well as two questions on bodily processes (eating food and breathing air). See Table 1 for a complete list of organs and bodily processes used in the interview. For each body part and organ, children

Table 1. Life-Theorizer list of organs and bodily processes

Organs/body parts	Organs/body parts	Bodily processes
Heart	Lungs	Eat food
Blood	Teeth	Breathe air
Eyes	Nerves	
Muscles	Bones	
Brain	Skin	
Tongue	Hands	
Stomach		

were asked two questions, 'What is/are X (e.g. heart, muscles, bones) for?' followed by, 'What would happen if someone didn't have a/an X?' For the bodily processes questions, children were asked, 'Why do we eat food/breathe air?' followed by, 'What happens when we eat food/to the air we breathe?'

Procedure

Each child was interviewed individually in a private room of the child care centre. The data were collected as part of two larger studies on the instruction of biological understanding. One researcher interviewed each child and a second researcher recorded the answers and videotaped the interview. After each interview, the preschoolers were given a sticker for participating.

Coding

Canonical organ function. Responses to the question 'What is an X for?' from the body interview were scored according to the criteria used by Jaakkola and Slaughter (2002). See Table 2 for a list of responses considered correct for function of body parts. Children were given a score of one for each body part for which they gave a correct, canonical function resulting in a total possible score of 13.

Table 2. Responses considered correct for function go body parts

Body part	Function
Blood	Transporting food and air; attaching germs
Bones	Structure and shape; protecting organs
Brain	Thinking; control of body
Eyes	Looking; seeing
Hands	Feeling; touching; acting on objects
Heart	Pumping blood
Lungs	Breathing; taking in air
Muscles	Movement; strength
Nerves	Sending messages; sensation
Skin	Protection; warmth
Stomach	Holding food; digestion
Teeth	Chewing; eating; biting
Tongue	Tasting; talking; eating

Concept of life. Preschoolers were given credit for using the concept of life based on their reasoning about body parts in the body interview following the procedure outlined in previous studies (Jaakkola and Slaughter, 2002; Slaughter and Lyons, 2003; Slaughter et al., 1999). A score of one was given for each body part in which the goal of maintaining life (or avoiding death) was mentioned. For example, in response for what would happen if you did not have a heart, a child might reply, 'You would die.' The children were also given a point if they appealed to maintaining life or preventing death for why we eat food and breathe air for a total possible score of 15.

Reliability

To assess inter-rater reliability, one researcher scored the body interview data and one-third of the responses were scored by a second researcher. Agreement between the two coders was calculated using Cohen's kappa. Inter-rater reliability was excellent with a kappa of 1.0 for life explanations and .87 for canonical organ function. Any disagreements were discussed and a consensus was reached.

Results

Two 2 (Age group) x 2 (Gender) univariate analysis of variances (ANOVAs) compared preschoolers' responses to the function of body organs and appeals to life. The mean organ function score and appeals to life by age and gender are presented in Table 3.

Function of body organ

A 2 (Age group) x 2 (Gender) ANOVA yielded a moderate effect of Age, $F(1, 96) = 14.28$, $p = .00$, η_p^2 (partial eta-squared) = .13, but not Gender, $F(1, 96)$ .39, $p = .54$, $\eta_p^2 = .00$ for correct function of body organs. The interaction between Gender and Age for mean correct body function was not significant, $F(1, 96) = 1.00$, $p = .32$, $\eta_p^2 = .01$. This analysis indicates that five-year-olds ($M = 5.80$, SD = 1.88) provided more correct function responses for the body parts than four-year-olds ($M = 4.30$, SD = 2.05). As children age, they are likely to have a greater concept of the role body parts play, and to increase in their knowledge of what parts of the body do.

Appeals to life

A 2 (Age group) x 2 (Gender) ANOVA yielded a significant moderate effect of Gender, $F(1, 96) = 6.07$, $p = .02$, $\eta_p^2 = .06$, but not Age, $F(1, 96) = 2.67$, $p = .12$, $\eta_p^2 = .03$ in appeals to life. This

Table 3. Mean organ function score and appeals to life by age and gender

	Four-year-olds		Five-year-olds	
	Girls (n = 30)	Boys (n = 26)	Girls (n = 20)	Boys (n = 24)
Function	4.23 (1.94)	4.38 (2.21)	6.15 (1.69)	5.50 (2.00)
Appeals to life/death	1.73 (2.21)	2.19 (2.50)	1.75 (1.55)	3.92 (3.75)

analysis indicates that boys (M = 3.02, SD = 3.25) were more likely than girls (M = 1.74, SD = 1.96) to make appeals to life for various body organs. The interaction between Gender and Age for mean appeals to life was not significant, $F(1, 96) = 2.57$, $p = .11$, $\eta_p^2 = .03$.

Discussion

The findings of the present study indicated that there was an increase in correct responses to the role of body parts as a function of age in our North American sample. This result is consistent with previous research documenting that preschoolers' knowledge of biological events increases between the ages of four and six years (Jaakkola and Slaughter, 2002; Slaughter and Lyons, 2003; Slaughter et al., 1999). We also found that boys were more likely than girls to conceptualize life as an important goal of body parts. Although boys and girls were equal in their knowledge about the function of organs and body parts, boys were more likely to resort to vitalistic reasoning when asked what would happen if someone did not have an organ/body part. That is, boys were more likely than girls to link the importance of organs, body parts, and bodily processes (eating and breathing) to sustaining life.

Recall that the use of vitalistic causality depends on children becoming aware that they are ignorant of the exact mechanism underlying what they see, so they use explanations that reflect vitalism. The reason for the early gender difference in children's conceptualization of life is not clear. Although research on gender differences in science at such a young age is sparse, there is evidence that boys may be more interested in certain science topics than girls. Tunnicliffe (1997) found that boys were more likely than girls to ask for factual details about babies and toddlers during class discussion. Therefore, one can extrapolate that the boys in our North American sample may have had more interest in the topic of 'life' and 'death' and, as a result, had more experience with the concepts. Boys, for instance, may have made the connection in a rudimentary way when studying living things, such as bugs and insects. Their knowledge may have been reinforced in a social context by adults who introduced the concept to them and are more likely to provide explanations to boys than girls (Crowley et al., 2001). This might also account for boys' preference for factual information over relational content and, further, result in greater interest in science content.

Another potential explanation for these differences is that boys and girls focus on different information due to variations related to gender identification (Eichstedt et al., 2002). The concepts of 'life' and 'death' may overlap with this behavior earlier for boys than girls. Simply stated, boys may develop a vitalistic reasoning earlier than girls due to the types of behavior they tend to engage in during play or the topics they choose to discuss with adults.

Future research needs to compare the interest North American boys and girls have in the topic of life to determine the extent to which interest is a mediating factor in vitalistic reasoning. Moreover, research is also needed to explore gender differences in other biology topics. If interest influences how well boys and girls understand science content, then it is possible their performance would differ depending on the area of biology being tested.

Our finding that gender differences emerge in biological thought as early as the preschool years has ramifications for how we approach science education for young North American girls and boys in the early school years. It is undoubtedly prudent for early childhood educators to become aware of the nature of the theories all children hold about biological phenomena and probe for misunderstanding or gaps in knowledge that interfere with learning. Understanding how children understand the natural world constitutes the first step in designing developmentally appropriate curriculum for them (Case, 1985). With this knowledge in hand, teachers and program developers are well positioned to determine where their students are on the developmental spectrum from naïve to expert understanding and then to design activities that are within each student's area of expertise (Case, 1985; Vygotsky, 1962). Such developmentally based, differentiated instruction has been shown to be successful with a range of learners, from gifted to learning challenged (Tomlinson, 1999).

The early gender differences that emerged in the present study also suggest that North American educators need to find a way to pique interest in topics that either gender may not naturally be drawn to. To illustrate, in one kindergarten classroom centers were developed that focused specifically on children's awareness of the function and purpose of body organs and processes (J. Kresowaty, personal communication, 15 July 2008). With the support of the school nurse, hands-on activities were developed that involved using a stethoscope to listen to one's own and classmates' heartbeat. Discussions, art activities, and trade book reading on the topic of the function and purpose of the heart rounded out the unit. Other ways to increase girls' interest might include focusing on the role science plays in our society (e.g. how important doctors and nurses are) or the individuals who have made significant contributions to science, especially including female figures.

Parents can also support their children's development by being aware of unintentional social expectations communicated to their children about traditional gender roles. During interactions with their children, they might ask themselves if they encourage boys to discuss science more than girls, if the conversations are different in terms of content and structure, and if there are differences in topics of interest. In addition, girls should be exposed to successful female scientists from a range of specializations so that success in science is not associated only with specific areas such as biology and the social sciences.

In summary, the findings of this study are a first step toward understanding how gender might impact North American preschoolers' understanding of biology. Although considerable research exists that demonstrated gender differences in the later grades, there is a paucity of work that targets young children. Because preschool is a period of rapid cognitive growth, it is imperative that early childhood educators understand the various theories children hold so that they can build on their foundational knowledge. Moreover, it is centrally important that researchers work toward understanding the mechanisms that underpin such gender differences and that educators work toward creating instructional contexts that support optimal development for both genders.

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