Children ‘Draw-and-Tell’ Their Knowledge of Genetics

Martha Driessnack, Agatha M. Gallo

The purpose of this study was to explore children’s early understanding of basic genetic/genomic concepts using an innovative, child-sensitive approach to data collection. Exploratory, qualitative study using art-based “Draw-and-Tell Conversation” interviews with children were used. Each conversational interview was guided by two drawing completion tasks and a semi-structured interview guide. Data were analyzed using qualitative content analysis. In this study, 27 children 7 to 10 years of age shared their understanding of basic genetic/genomic concepts in their drawings and conversations. Data were organized into four categories: 1) Inside the Body, 2) Under the Microscope, 3) It’s Genetic, and 4) In Our World. Using a child-sensitive approach to data collection, children revealed a range of understanding about basic genetic concepts, including DNA, disease causation, risk, and inheritance. Data suggest informal family conversations and media exposure inform children’s early understanding, highlighting the need to be aware of the sources and content of information available to children. Nurses play a central role in assessing children’s genetic/genomic knowledge. The Draw-and-Tell Conversation is a novel approach that can be used to support parents as they approach and discuss genetic concepts with their children.

The classic framework for understanding children’s health-related knowledge has been Piaget’s theory of cognitive development. However, over the past two decades, there has been growing dissatisfaction with Piaget’s deficit-based view of children (Greene & Hogan, 2005; Melton, 2005; Wink & Putney, 2002). Using Piaget, accounts of children’s health knowledge have been dominated by evidence of children’s cognitive immaturity and limited ability to understand health and illness concepts. While it is important not to refute the worth of these accounts, what has been challenged is the assumption that children’s misconceptions, confusion, and partial understanding of health and illness concepts are the inevitable consequence of cognitive immaturity, overcome only by advancement in chronological age. Eiser (1989) highlighted that the process children use to acquire knowledge, not their chronological age and corresponding stage of cognitive development, most significantly determines children’s understanding. In nursing, Holaday, LaMontagne, and Marceli (1994) suggested using Vygotsky as an alternative framework. Vygotsky’s competency-based view approaches children as early “theorists,” capable of forming complex mental structures that func-

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Authors’ Note: For this article, the term “genetic” will be used in place of “genetic/genomic.”

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The clear challenge for researchers and clinicians is to develop methods for assessing prior lay understanding in children, especially when most approaches to self-report, such as interviews, questionnaires, and surveys, are language-based. The integration of arts-based techniques in the process of data collection allows children to tap into their more sensory-based abilities first, providing them with the opportunity to organize their thoughts in familiar ways before they are asked to share them (Freeman & Mathison, 2009). It is for this reason that arts-based techniques are often referred to as a natural medium for children and are increasingly being integrated into research studies and clinical interventions (Driessnack & Furukawa, 2012).

The purpose of this study was to explore children’s early understanding of basic genetic concepts using an innovative, arts-based approach for data collection.

**Design and Methods**

This was an exploratory qualitative study (Saldana, 2011) informed by Vygotsky’s theory of cognitive development and a child-sensitive approach to interviewing children, the Draw-and-Tell Conversation (DTC). Each conversational interview was guided by two drawing completion tasks and a semi-structured interview guide.

The Draw-and-Tell Conversation

The DTC (Driessnack, 2006; 2009a) begins with a specific art directive that includes a drawing or drawing-completion task. The art directive reflects the study purpose, and along with the interview guide, helps to facilitate the conversation that follows. The DTC provides children with a transitional space where their thoughts can be externalized into concrete forms, and it has been shown to be more effective in bringing out the complexities of children’s experience than adult-centered approaches, such as directed interviews, surveys, and questionnaires (Brooks, 2004; Coad, 2007; Driessnack, 2005; Malchiodi, 1998).

**Sample**

The sample included 27 children, 7 to 10 years of age (see Table 1). Participants were selected using maximum variation sampling (Patton, 2002). Sources of variation included age, gender, socio-economic level, ethnicity/race. The children were equally distributed by age and gender. Just under half of the children (n = 12; 44%) were European-American, with the remaining 15 children from various ethnicity/race categories. The indirect measure of free/reduced school lunch eligibility was used to identify socio-economic level and ensure a cross-section of participants. All participants were recruited through a metropolitan YMCA in a large Midwest city.

**Data Collection/Analysis**

Approval was obtained through The University of Iowa Institutional Review Board and from the Midwest YMCA. Prior to data collection, parental permission was obtained, followed by child assent. Data collection was conducted with each child individually onsite at the YMCA and lasted no more than 25 minutes.

Each DTC began by asking children to draw the inside of their body using a provided body outline. When completed, the conversational interview began with the children talking about their drawings, followed by specific questions and probes from the interviewer using a prepared interview guide (see Figure 1). The second step was to have each child select two different “samples” from their body outline drawing, imagining that he or she was looking at each of the samples using a microscope, and then draw it using provided microscope drawing outlines (e.g., children might select samples from their brain and foot or from their heart and stomach). Once complete, the children were again asked to talk about their drawings with the interviewer following up with specific questions and probes. These two drawing completion tasks, along with an interview guide outlining the questions and probes, stimulated the children’s conversations about their bodies and basic genetic knowledge.

### Table 1. Demographic Characteristics of Child Participants

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<th>Age (in Years)</th>
<th>Male</th>
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Socioeconomic Status: Free lunch (9); Reduced lunch (10); No assistance (8); Ethnicity/Race: European-American (12); Hispanic (7); African-American (5); Mixed Race (2); Asian-American (1).

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The findings are organized into four primary categories: Inside the Body, Under the Microscope, It's Genetic, and In Our World.

Inside the Body

Children's drawings of the inside of their body using the body outline elicited a kaleidoscope of details. All of the children drew the brain, heart, stomach, bones, eyes, and mouth. Other named "organs" included the lungs, kidneys, intestines, and gall bladder. At times, the children also included additional details about different elements of the nervous system. As one 7-year-old described, "these are 'nerves'...connectors from the brain out to your whole body, your muscles, and your finger skin." Additional details were also provided for other organs, including one 8-year-old child who drew an elaborate, colored-coded arterial and venous system, explaining:

These are our "lifelines"...the "red" ones come out of the heart, which is here in the middle, and bring oxygen to our cells and muscles...and these, well, they are "blue" because their oxygen is used up, and they have to come back up here to get more.

In most instances, the addition of details included explanations about how individual organs connected to each other. These explanations contained fairly accurate interpretations.

However, there were some disconnects. For example, 9 children (33%) incorrectly connected their stomachs directly to their hearts. As one 10-year-old child explained (see Figure 2a):

This is your stomach...when it gets "backed up" with food, it goes to your heart and burns the inside of it...and then you get heart disease...and have heart attacks when you get older. But if you take your medicine, it won't burn, so then you won't have to worry about that [heart disease] later.

Under the Microscope

Children’s microscope drawings fell into one of two groups: 1) individualized miniature replicas of each sampled site, or 2) cellular drawings that were universal, not site-specific. In the first group, for example, if the sample was from the bone, the microscope drawing showed a miniature bone (see Figure 2c). When a second “sample” was taken from another site, the microscope drawing was a miniature replica of the new, rather than the former, site. In the second group, when a second “sample” was obtained, the child’s microscope drawing was identical to the first one. Further, the content was more cellular, with drawings varying from red blood or bacteria to more intricate drawings of DNA (see Figure 2b). As one 8-year-old child (see Figure 2b) shared:

This is how it looks...it is the same everywhere inside you. It will be the same blood here, or here...It looks red, but it has all these little cells that do different things, but it's basically red.

Another 9-year-old (see Figure 2b) explained:

This is DNA; it is in every cell...it has two strands that twist around, but they are staying connected by this ladder in the middle. So, it's the same here in this cell...you have your DNA deep inside...and it's the boss of everything.

Another 9-year-old child explained (see Figure 2d):

Now this is your DNA. It's normally not all lined up and easy for scientists...it looks like these scribbles here...but when you put a chemical drop on it under the microscope...it
Within the second group, numerous explanations suggested cellular views that depicted bacteria. As one 8-year-old child shared (see Figure 2e):

*It is a war zone. You have good bacteria and bad bacteria…it's really just one big battle. Most of the time the good bacteria should be in charge, but sometimes these guys win...you don't see this happening, but it does if you understand how it is inside...*

All of the children recognized the term DNA (deoxyribonucleic acid), yet none of the children recognized the term RNA (ribonucleic acid). Children did not connect proteins to DNA, reporting instead that our sole source of protein was from the outside in the form of food. For example, one 7-year-old child shared, “Proteins are the ‘building blocks’ of your body...that's why you have to eat meat every day.”
The children's understanding of DNA varied from specific descriptions, as noted in the earlier narratives, to added philosophical or forensic explanations, such as from this remarkably literate 7-year-old:

**DNA, well it's what makes us alive. I mean, you can still get your DNA after you are dead, but...If something was never alive in the first place, well, it would not have DNA...all living things are the same because they all have DNA.**

This 9-year-old shared a more forensic understanding of DNA:

**DNA is in your hair, your spit, and your fingerprints...so they can figure out who the dead person is or if you are the killer by your hair sample or prints, like on CSI.**

**It's Genetic**

The children's responses to the meaning of word “genetic” were sorted into three sub-categories: 1) You were born with it; 2) It's passed from one generation to another; and 3) There's something wrong.

In the sub-category, You were born with it, children's responses varied from everyday lay language, such as, “genetic means...it's in there for good,” to more scientific language, “genetic means it is in your DNA from birth.” In the sub-category, It's passed from one generation to another, the children's language was more consistent. As one 10-year-old child explained, “It means it's passed along generation to generation,” while an 8-year-old child explained, “It means it's in your family...a lot.” In the final sub-category, There's something wrong, children's responses again ranged from everyday language, such as "it means something is wrong with you," to more scientific language, as from this 8-year-old, “It means you are a mutant...cool.”

The majority (78%; n = 21) of the children shared they are able to figure out if something is genetic through their own assessment and/or observations. One 9-year-old said, “You just figure it out,” while a 10-year-old child explained, “You are living with it, I mean it's all around you, all the time, and you figure it's coming your way soon.” Children identified four types of genetic traits that run in a family: 1) physical traits (e.g., “big bones”), 2) abilities (e.g., “how smart you are”), 3) disease (e.g., “diabetes”), and 4) family beliefs/ traditions and/or recurrent behavioral phenomena (e.g., “bad luck” or “having babies when you are too young”).

When something was considered to be genetic, 10 (37%) children were somewhat deterministic about their abilities to change the outcome. As one 9-year-old child said, “If it's genetic, there's nothing you can do...” or as one 8-year-old shared, “You learn to make the most of it...I mean you try to work with it, but you can't change it.” However, the other 17 children (63%) proposed potential risk-reduction behaviors, including, “You need to do something healthy, like eat better...before it gets in too deep” [8-year-old], or “you better wash your hands a lot more” [9-year-old]. Among their proposed risk-reduction behaviors, there was a subset of suggestions that were more psychosocial in nature, including one nine-year-old who shared, “All I know is that you better marry someone way different,” and a 10-year-old who stated simply, “You just have to get out of the family as soon as you can.”

**In Our World**

Children's self-reported sources of their genetic information included family members and school, television, and/or computer programs. As one 8-year-old shared, “I heard about it once on Sponge Bob Square Pants.” One 10-year-old mentioned, “I have this science kit that can figure out your DNA, like on TV...like CSI.” Seven (26%) children named a specific family member as their source. None of the children identified health care providers. All 27 children referred to the Internet as a source. As one 9-year-old child explained, “If I need to know anything, I can get it off the Internet...it's pretty easy.”

As part of the conversational interview about genetic concepts, children were also specifically asked about their exposure to three contemporary childhood characters (Harry Potter, X-Men, Spiderman). These characters were selected because their accompanying stories have embedded broader understandings, including genetic discrimination and eugenics. As one 9-year-old child shared:

**There are some bad problems too, where the “pure-bloods” are trying to get rid of the “half-bloods,” lookin’ down on them...totally dissin’ them... just because their parents were Muggles...I mean, they want to get rid of them.**

Children also explained how Harry's powers would be passed along to his children by identifying the variable outcome if Harry married a wizard, while other children said they already knew the final outcome. “Well, he actually marries Ginny, so all their children are wizards, although they don't all get her red hair because Harry doesn't have it too.”

**X-Men.** The children primarily described X-Men as a group of male “mutants” who inherited the X-factor that gave them specific powers that surface during adolescence. Although the X-factor was the same for all X-Men, the powers were different for each person, which again points to some level of understanding about variable phenotypic expression. One 10-year old child said:
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They are mutants...they have the X in them, and it causes their power to come out, but it depends on things what their power is...I don't know what things, but it does depend.

The pattern of inheritance of the X-factor described by the children was similar to the inheritance of X-linked conditions. As one 10-year-old girl insightfully explained, “It is not a girl thing...it is only in the boys because they don't have a good X to protect them...you know, we have two.” When children were asked about the offspring of X-Men, their responses varied from no explanation at all to very specific ones, such as from this 9-year-old girl, “Have you seen them?...No one is gonna marry them,” and from a 9-year-old boy, “It's pretty complicated...I think it will get passed down...but only to the boy children.”

Spiderman. The children uniformly identified the origins of Peter Parker’s “Spiderman” powers as a spider bite. Some children went on to explain, “It was not a normal spider...normal spiders won't do this... this spider was part of a science experiment” [9-year-old]. Most children indicated that Spiderman’s children would be “normal.” As one 8-year-old said, “His children...they won't get any powers...they will just have a weird dad.” A smaller number of children were not as certain as to the outcome. As one child explained, “I'm not sure... I don't think so because it happened to him when he was older...” [8-year-old].

Discussion

The current study provided the opportunity to extend the use of the DTC into the exploration of genetic concepts with children. Using this child-sensitive, arts-based approach to data collection, children shared their emerging awareness of basic genetic concepts both in their drawings and conversations without hesitation. The children were immediately engaged in the process. Of particular note was the amount of data shared, as well as the attention to detail, breadth of understanding of genetic concepts, and accuracy of many of the children's interpretations. In short, children know a lot more than we think they do, at least about genetics. The notion that children often surprise parents and providers by knowing much more than we assume has been reported by others when efforts are taken to engage children in conversation (Gallo et al., 2005). The rich information provided by children in this study and the ease with which it was accessed may reflect the ability to engage children in conversation by using a more child-sensitive approach to data collection.

Vygotsky suggests that irrespective of how much, how complete, or how accurate it is, children's jobs are to make sense of their worlds on the basis of what information they have available to them (Mooney, 2000). In this study, the children's individual drawings and responses clearly illustrated they are trying to make sense of the world both around and inside them. Although their informational sources were not the primary focus of the study, the children were clearly familiar with contemporary media influences, including television programming, such as CSI. This insight not only reinforces literature about media exposure and its broad impact in children's lives, but it also highlights the need to assess children's expanding networks and information sources (Driessnack, 2009a; Roberts & Foehr, 2008). Familiar sources can also provide contemporary contextual opportunities to engage children and their parents in conversations about genetic concepts. For example, children's familiarity with the Harry Potter series can serve as an instructional vignette for explaining patterns of inheritance, carrier status, and variable phenotypic expression (Driessnack, 2009b).

The focus in this study was children's early understandings about genetic concepts as accessed through the use of the DTC. The identification of early understandings and misunderstandings about genetics can provide insight into children's contemporary influences and early thought processes. These insights can focus educational interventions so children's misunderstandings are addressed before this information becomes internalized and resistant to change. For example, many children connected their stomach and heart together, relaying explanations reflective of “heart burn.” While this explanation might easily be attributed to media influence, the early misunderstanding that preventing heartburn also eliminates one's risk for heart disease could confound the broader link between diet and heart disease.

In this study, the children's drawings and resultant conversations also revealed the presence of genetic determinism in even the youngest of participants. Equally interesting were the range of disease prevention efforts proposed by the children when confronted with genetic risk. The types of behaviors suggested by the children, which ranged from hand-washing to getting out of one's family altogether, have been reported as parallel explanations and notions in studies with adults (Condit et al., 2009; Dougherty, 2009; McClean & Shaw, 2005). This intergenerational presence of common concepts and related behaviors suggests children's social networks may not only provide the ecological context for developing childhood theories, but it may also be nurturing their continuance. This reinforces the need for family-based interventional efforts when educating parents or children about health and disease. The need for novel interventions that engage the public in socially and culturally appropriate ways increases in a world in which personalized medicine and individualized lifestyle recommendations are based on an individual's genetic profiles (Kosztolanyi, 2011).

Calls for improving genetic and health literacy continue and echo calls for the public's engagement in the process (Cunningham-Burley, 2006; Forrest et al., 2008; Kenner, Gallo, & Bryant, 2009). Engaging children and learning what they already know, and how they come to know it, is an essential place to start. This is especially important because it appears children are already assimilating familial and cultural frameworks about basic genetic concepts, including disease causation, risk, and inheritance. It is also important because today's children are the future users of genetic and health information as well as tomorrow's health care providers, educators, decision makers, and researchers. A list of clinical resources is included (see Figure 3).

Nurses have a long history of advocating for children's health education and well-being. To improve child health knowledge and literacy, the next logical step may well be one with a “back to the future” approach that redirects the research and clinical agenda to the importance of the developmental precursors of adult health knowledge and genetic literacy found in childhood. This study also adds to a
The University of Utah Genetic Science Learning Center has a wealth of resources and information aimed at bringing genetics, bioscience, and health alive, whether the audience is one child or an entire classroom. Additional tools and resources are provided on two companion Web sites:
http://learn.genetics.utah.edu
http://teach.genetics.utah.edu

The International Alliance of Patients' Organizations (IAPO) is a global alliance promoting patient-centered healthcare around the world.
http://www.patientsorganizations.org/index.php

The Human Genome Epidemiology Network (HuGENet™) promotes global collaboration on the relationship between human genomic variation and health and on the quality of genetic tests for screening and prevention.
http://www.cdc.gov/genomics/hugenet

References
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