

UC Berkeley

UC Berkeley Previously Published Works

Title

Changing Conceptual Change

Permalink

<https://escholarship.org/uc/item/17s224sb>

Journal

Human Development, 50(1)

ISSN

0018-716X

Author

diSessa, Andrea A

Publication Date

2007

DOI

10.1159/000097683

Copyright Information

This work is made available under the terms of a Creative Commons Attribution-NonCommercial-NoDerivatives License, available at <https://creativecommons.org/licenses/by-nc-nd/4.0/>

Peer reviewed

Changing Conceptual Change

9-3-06

**Andrea A. diSessa
Graduate School of Education
University of California
Berkeley, California 94720
USA**

E-Mail: adiSessa@soe.berkeley.edu

Phone: 510-642-4206

Fax: 510-642-3769

Key Words: Conceptual change, biology, vitalism, personification

Preprint of:

diSessa, A. A. (2007). Changing conceptual change. *Human Development*, 50(1), 39-46.

Abstract:

This article reviews Giyoo Hatano's ground-breaking theoretical, empirical, and methodological contributions to conceptual change research. In particular, his discovery of "vitalism" as part of children's legitimate and distinctive biology at early ages stands as a landmark. In addition, his work reinterpreted childhood "personification," changing it from an indicator of deficit intellect, to a creative and often insightful strategy for coming to understand biology.

1. Introduction

Among his many splendid contributions to cognitive science, Giyoo Hatano's research on conceptual change stands out. Two decades of work by him and his close collaborator, Kayoko Inagaki,¹ were cumulative, careful, and continuously innovating. I believe this work has left an indelible stamp on conceptual change research, and, in fact, deserves more recognition and influence even than it has had. Although our backgrounds and interests were very different in many respects, Giyoo and I found common ground in thinking about conceptual change. I wish here to honor Giyoo Hatano with a brief account of his work in this area.

Before details, I would like first to pick out some general characteristics of his work. These themes will re-appear and intertwine in later, more specific accounts of his research and scholarship. The best single source for Hatano's conceptual change work is the book he co-authored with Inagaki (Inagaki & Hatano, 2002), which I will often cite, implicitly and explicitly.

Broad and Balanced

Many researchers pick narrow paths for themselves. They "own" and advertise a particular perspective, concern, or methodology, which constitutes an easy handle for their status in the field. I have nothing against specialization, and certainly major personal contributions should identify researchers. Yet, I feel I was lucky to have learned very early in my career that the complex nature of the issues we attack means that the world, as it shows itself to us, dictates concerns, theories, and methodologies often much more than we might prefer. We must be reactive and go where the issues demand.

Giyoo wonderfully balanced cognitive and social perspectives. While championing social views of cognition, he did this precisely to display often missed contributions of the social world to conceptual development. It was not a polemical advocacy, but a basis for particular, important insights. His work on children who cared for goldfish at home, and how that influenced their naïve biology comes to mind (see Hatano & Inagaki, 1996). While an advocate of social

¹ For simplicity, I will not often remind readers that much of his work was deeply collaborative, nor, in particular, try to separate out his contributions from Inagaki's.

perspectives, he never pushed to what I take to be attention-grabbing absurdities of, for example, denying that the mind has anything much to do with thinking and learning.

On the other side, Giyoo was completely fluent with the most technical cognitivist research, whether on mental models or individualist learning-by-doing studies. In looking through some of his work in preparation for this essay, I was impressed at the level of discussion concerning “knowledge systems,” which even implicated virtual (computer) implementable models. For example, at the end of his book with Inagaki (Inagaki and Hatano, 2002) he discusses a model of conceptual change that involves propagation of “truth” value in a kind of network model of learning and knowing.

Giyoo perfectly balanced East and West. I believe he was by far the most influential researcher in bringing (Western) cognitive science to Japan. On the other hand, he championed and exploited the strengths and differences of Japanese thinking and culture without parlaying them into chauvinistic advocacy. His cross-cultural studies often made use of local-cultural differences, for example, the generally high status (spiritually) of plants in Japanese culture.

Methodologically Giyoo was also broad and balanced. Statistical studies almost always were enlivened and contextualized by interview data. Each study seemed an occasion for refinement of methods to suit the particular needs and context of that study.

Subtle and Careful

Giyoo’s work was always worth very careful reading as it showed great thoughtfulness in construction. Theoretically, he was meticulous. Fashionable terms often take on unreflective lives of their own; frequent use seems to bring immunity from critical consideration. In contrast, Giyoo always examined core terms. His studied consideration of the definitions of “naïve theory,” of the problematics of often taken-for-granted terms, like “domain” or “constraint,” were exemplary. When he stated results, he always expressed uncertainties, “level of conviction,” and remaining issues. I have always thought that it should be a law in cognitive studies that researchers should express uncertainties and even the ways in which their claims are likely false or limited, along with positive claims. Giyoo was exemplary in this respect.

Conceptual change, in Hatano’s view, was irreducibly complex. I will later expose just a little of the particular complexities that we must thank him for showing us.

A “Continuist” at Heart

Of the themes I list, a continuist orientation—the deep belief in the value of children’s ideas, and a cultivated sense for them and their importance in the story of conceptual change—may be the most “stylistic.” That is, “respect for children’s ideas” does not sound scientific. On the other hand, I believe there are critically important facts of the matter underlying this orientation, which have been difficult for the field to learn. This is true both theoretically and empirically. Hatano and Inagaki begin their book by stating that Piaget’s frequent characterizations of young children as incompetent stimulated their work on conceptual change in biology, aiming to show not only that children’s thinking is often much more legitimate and serious, and less often fanciful, but, in

addition, that their thinking is a strong platform for further development than many, including Piaget, expected. For Piaget, the process of personification, projecting ideas about humans into the non-human realm, for example, was simply a sign of immaturity and egocentrism. For Hatano, personification was a wonderful use of strong experiential knowledge to hypothesize things about unknown domains.

In my own area of conceptual change in physics, for a decade and more into conceptual change studies, the by far most prominent view of prior conceptions was that they were simply misconceptions (Smith, diSessa, & Roschelle, 1992). Not only were prior conceptions considered odd and unproductive ideas in their own right, but they required confronting and replacing. Only very slowly has the continuist orientation been advanced, and it is still—I think to our great detriment—not generally embraced.

2. Substantial Contributions

In this section and the next, I elaborate and concretized the themes above, while briefly discussing specific contributions Hatano made to the conceptual change literature. I have selected vitalism and personification as examples.

Vitalism

Early conceptual change work on biology focused substantially on the lack of distinctly biological thinking until quite late (about 10 years of age), and also its relation to or derivation from other domains, like psychology (Carey, 1985). A huge literature has come to show that children are sensitive to biological characteristics of the world much earlier (age 5 is a benchmark), and they make distinctly biological inferences as well. For example, one can “will” many things about one’s self, such as motion and attention. However, some things like eye color or the fact of breathing cannot be changed in this way. Inagaki and Hatano (1993), among others, showed that children understand this long before age 10. Indeed, they begin to sense the difference between characteristics that are socially acquired in a family, as opposed to those still-roughly understood biological continuities among family members.

Hatano and Inagaki were among the leaders in this extended accomplishment. However, a distinct contribution of theirs is the claim that children as early as 5 formulate a theory-like framework for thinking about some biological phenomena. This is *vitalism*. (For a brief review, consult Inagaki & Hatano, 2004.) Vitalism starts with and prototypically concerns humans. However, importantly, it then spreads in application to animals and plants. The core of this framework is that living things’ intake of food and water is essentially responsible for their vitality and energy. Eating and drinking carry a vital force into the body, and, in some cases, children also show belief that internal parts of the body have a role in distributing the vital force. Furthermore, growth and the ability to fend off illness and recover from wounds or sickness stem also from intake of vital force.

The idea of vitalism, in my view, is extraordinarily important both theoretically and empirically. In the first instance, much of the research noting that children are sensitive to biological

attributes and that they make distinctly biological inferences relies on an adult or scientific sense of “what is in the biological domain.” That is, *we* classify certain characteristics as biological and think of certain inferences in the same way. But, in what sense is that real biological thinking, in terms of the children’s own ways of construing the world? Perhaps what children are showing us is a plethora of very particular and context-bound judgments and reasoning patterns that do not go together in any reasonable way for children—only for us! Some might say, “no (integrated) domain, no ‘theory’.”

However, vitalism is established not by our classification of inferences as biological, but by a distinct style of reasoning that we find in children, which is based on a particular set of ideas. We can argue endlessly about whether a particular inference made by children is biological (by scientific standards), but establishing a fabric of reasoning in children puts such questions in much more productive terms. This *is* a child biology, and its developmental relation to adult and scientific biology (or psychology) can then be discovered by empirical and theoretical study.

Vitalism is what I call an ontological innovation (diSessa & Cobb, 2004), a new explanatory construct, distinct from common-sense or other easy sources of ideas. Hatano and Inagaki had to create this idea by filling in gaps in data with the idea’s fabric of sensibility. I believe such creations are the essence of the deepest science, as opposed to even the most convincing and unusual empirical result, *per se*.

I have a personal reason for considering vitalism an intriguing and important discovery. I believe that conservation, for example, Piagetian conservation of mass or volume, is one of the most central and generative principles in human development. I believe children generalize, specialize, and, broadly, make very many positive uses of conservation. For example, in physics, students invent the idea of an impetus passed from a cue ball to its object, or from a hand to a thrown ball as a mechanical version of conservation, similar to vital force. In this respect, like personification, conservation is a huge resource, not a deficit or transient idea.² Hatano also notes that vitalism is a kind of balance theory of health (ala Ayurvedic medicine), which connects to a similar richness and importance of physical intuitions of balance.

I have to note that I believe Hatano would vigorously oppose my speculative connection of vitalism and physical causality. He strongly maintained the autonomy of biology from other domains. However, I am certain that he would also be much interested in engaging the point, as, in fact, we did on several occasions. Stimulated, in part, by his perspective and data, my current work pursues this issue of domain specificity. In particular, we are looking at ways in which children see very different situations as alike. High school students look at an abstract computer simulation where a red shape is “nudged” by a blue one; at first, the red shape returns to its initial position, but after enough nudging, it moves gently away. Students say this is like a ball pushed up, then over a hill. They say it is like a breakup between a couple and also like a sumo wrestler giving up after being pushed out of the ring. In a different case, students say temperature equilibration is driven by one object’s “freaking out” (getting overly excited) over a temperature

² This is not the place for elaboration or argument, but see diSessa (in press) for a pointer to “flow” as potentially core in understanding physics. For a contrasting view of conservation as a misconception (inappropriately carrying the idea of material flow into physics), see Chi (1992).

difference. Are these just metaphors, or (I would say) students' detecting domain-transcending causal patterns?

The concept of vitalism grew out of Hatano's continuist instincts, and careful consideration of children's ideas in their own terms. Inagaki reminded me (personal communication)—and it sounds just right—that vitalism also might have been influenced by Hatano's Japanese heritage of endogenous science. See, also, Hatano & Inagaki (1987). However, it also took methodological care and innovation to build good support for the idea, some of which I describe in the next main section.

Personification

Hatano's rehabilitation of what was taken by Piaget to be childhood animism or egocentrism lay in recognizing powerful positive value in personification. In the first instance, in the best continuist tradition, he noted that it is completely sensible and likely to be productive for children to be inclined to take areas of strong knowledge, such as about themselves, and see how much of that knowledge is productive when applied to new contexts. He argued that animism seeds or can contribute to the beginnings of the idea of life. He also suggested and demonstrated empirically that untoward projection of human-centric ideas occurs mainly where children's knowledge of the target domain or phenomenon is so weak as not to allow rejection of personifying hypotheses (Inagaki & Hatano, 1991).

Personifying and, more generally, analogical projection (using ideas from well-know domains at least as hypotheses in thinking about less well-know domains) continue to be used in adults (see the synthesis and references in chapter 7 of Inagaki & Hatano, 2002). In addition, adults continue to use vitalistic reasoning, although more mechanistic biological thinking becomes preferred (Inagaki & Hatano, 1993). Consider this report from the television nightly news (August 16, 2006): "MRSA is a staph infection so sophisticated that it outwits antibiotics."

Adult personification and analogical projection is doubly interesting. First, it tends to validate Hatano's unusually positive view of these strategies in thinking, which were dismissed as primitive by Piaget and ignored by many researchers searching for the roots of distinctly biological thinking. It is quite likely that in adults such strategies are often productive, and seldom "in error" or "primitive" in a negative sense. As important, the discovery and empirical validation of adult personification provides evidence of multiple strands of conceptualization. Adults can think about bodily mechanisms in biological issues, but they may also fall back on "simpler" strategies in cases where either their knowledge of the particular biology is limited, or the stakes are low (such as a report on the evening news). Conceptual change is more nuanced, as Hatano taught us, than "concept B succeeds concept A."

3. Methodology

Hatano's methods were also broad, balanced, nuanced and careful, showing respect for and sensitivity to "early" ideas. His book on naïve biology with Inagaki (Inagaki & Hatano, 2002) several times mentions "child-appropriate questions," and in almost all of his work, we see

careful concern for phrasing and setting of interview questions, and also persistent criticism and improvement of items based on experience. I already mentioned that his cross-cultural studies and studies depending on culture-specific characteristics (such as goldfish raising children) complemented studies that would be classified as “cognitive” rather than socio-cultural. He often used adults as controls, and in order to provide perspective on children’s thinking, as illustrated by the finding that adults also personify.

I would like to use brief, specific examples from his studies of vitalism and personification to illustrate characteristics of his methodologies. With regard to vitalism, Hatano realized that child competence may be context specific and fragile. But this means only that our methods of investigation need to be more sensitive, not that the competences do not exist. For example, at early stages, knowledge from a stronger domain, such as psychology, might encroach on a weaker one, such as biology. In addition, nascent ideas might not be easily activated.

Hatano and Inagaki developed two methods of improving sensitivity for detecting vitalistic reasoning. First, they prompted students with vitalistic (or other) explanations when posing questions for inductive projection. The standard paradigm for inductive projection imputes some new and unknown characteristic to a member of a category. In Carey’s early work (Carey, 1985), an animal such as a bee is said to have golgi. Then, one tests whether subjects are likely to attribute this characteristic to another member of the category. If the subject “has” the category, he/she is likely to project that the new member also has the new characteristic. Inagaki & Hatano (1996) improved the method by cuing vitalism with a vitalist explanation of *why* the anchor creature (in this case, human beings) has the attributed property. Sure enough, vitalism shows up earlier and more clearly in children’s projection of characteristics from humans to animals and plants.

The second improvement in sensitivity is more common, but still it was used to excellent effect by Hatano. In Inagaki & Hatano (1993), subjects were asked to choose from vitalist and other kinds of explanations rather than being asked to generate or articulate them. The method reveals preference for vitalistic explanations in cases where spontaneous explanations reveal little.

With respect to personification and analogical projection, Inagaki and Hatano used a simple but effective “finger print” for the distinction between categorical and analogical inductive projection. If one takes a series of exemplars that are successively (analogically) more different from an anchor, then projection, if it is analogical, will show a gradual decrease. For example, people are known to have a property (say, “be happy,” or “have a heart”); then what will subjects say about this property for rabbits, pigeons, fish, grasshoppers, tulips, trees, or stones? If they project analogically, the frequency of responses will gradually decrease. If, in contrast, they use category membership as the criterion for projection, then a discontinuity can be expected somewhere along the line. In adults, the discontinuity will usually occur at the boundary between animals and plants, or between living and non-living things. Typical of their care, Inagaki and Hatano protected against the possibility that averaging the location of different discontinuities across different subjects might smooth the frequency curve and hence make categorical projection look like analogical. Again, consult Inagaki & Hatano (2002) for a review.

4. Personal Reflections

There are no particular reasons that scientific excellence should go together with many personal characteristics. Many great scientists have been unattractive as human beings. In Giyoo's case, he was a stunningly generous person, modest, but also direct, when it served scientific purposes. When reviewing work in the field, I found him meticulous about attributions and more than fair in discussing others' work. He was steadfast in acknowledging his collaborators, even though his extraordinarily high public visibility would make it easy, without any effort on his part, to be given credit that others' deserved. Instead, he worked constantly to display and credit the contributions of his colleagues, both personal colleagues and others in the field.

My personal connection to him came rather late in my career, which is not surprising since I work mainly in technology and physics instruction. And yet, from my own selfish perspective, I found it remarkably productive to talk ideas over with him. He is among a small handful of researchers I have known who I felt always engaged out of genuine interest in figuring things out. He was singularly interested in mutual inquiry, stretching his own boundaries, and he was singularly disinterested in pushing his own ideas because they were his, or for the purpose of "winning." In Giyoo's case, I believe his personal characteristics were, indeed, the roots of many of the excellent properties of his science. Those characteristics also generated wide and deep affection for him.

At the risk of stereotyping, I felt he combined the best of Japanese culture—in particular modesty and respect for others—with elements of "combative" Western scholarship. There is a scientific point to respect and care for others' ideas; but there is also a point to drawing lines and pitching an intellectual battle. Excellence is in knowing when each is appropriate. His reviews of the literature are a sea of respect punctuated by moments of focused and carefully articulated disagreement. In my case, he publicly gave ground on the issue of the meaning of "naïve theories." At the same time, he made equally clear that my position on the existence of domain-independent causal inferencing seemed absurd and counter to basic and long-established developmental data concerning the autonomy of domains. I will miss the collaboration we were planning, and also his critiques and ideas; my own work will be slower and poorer for it. At the same time, all of us should celebrate Giyoo Hatano and his accomplishments. We can honor him by carrying his work forward.

References

- Chi, M. T. H. (1992). Conceptual change across ontological categories: Examples from learning and discovery in science. In F. Giere (Ed.), *Cognitive models of science: Minnesota studies in the philosophy of science* (pp. 129-160). Minneapolis: University of Minnesota Press.
- diSessa, A. A. (in press). A bird's eye view of "pieces" vs. "coherence" controversy. In S. Vosniadou (Ed.), *Handbook of conceptual change research*. Mahwah, NJ: Lawrence Erlbaum Associates.

- diSessa, A. A., & Cobb, P. (2004). Ontological innovation and the role of theory in design experiments. *Journal of the Learning Sciences*, 13(1), 77-103.
- Hatano, G., & Inagaki, K. (1987). Everyday biology and school biology: How do they interact? *Quarterly Newsletter of the Laboratory of Comparative Human Cognition*, 9(4), 120-128.
- Hatano, G., & Inagaki, K. (1996). Cognitive and cultural factors in the acquisition of intuitive biology. In D. Olson & N. Torrance (Eds.), *Handbook of education and human development* (pp. 683-708). Oxford, UK: Blackwell.
- Inagaki, K., & Hatano, G. (1992). Constrained person analogy in young children's biological inference. *Cognitive Development*, 6, 219-231.
- Inagaki, K., & Hatano, G. (1993). Young children's understanding of the mind-body distinction. *Child Development*, 64, 1534-1549.
- Inagaki, K., & Hatano, G. (1996). Young children's recognition of commonalities between animals and plants. *Child Development*, 67, 2823-2840.
- Inagaki, K., & Hatano, G. (2002). *Young children's naïve thinking about the biological world*. New York: Psychology Press.
- Inagaki, K., & Hatano, G. (2004). Vitalistic causality in young children's naïve biology. *Trends in Cognitive Sciences*, 8(4), 356-362.
- Smith, J. P., diSessa, A. A., & Roschelle, J. (1993). Misconceptions reconceived: A Constructivist analysis of knowledge in transition. *Journal of the Learning Sciences*, 3(2), 115-163.