

Active Language in the Collaborative Development of Cooking Skill

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Abstract

It is crucial to approach a cognitive account of development with an accurate picture of the parent-child system in hand, otherwise one will tend to underestimate the richness of support and dynamics of that system and so will tend to overestimate the complexity of the learning processes of the child. In order to understand the developmental functions of collaborative action and its accompanying linguistic activity we examine the verbal and physical activity in parent-child cooking. We present an analysis of the physical collaborative structure of a baking soda measurement task from 36 parent-child dyads in three (child) age groups: 3, 4, and 5-years old, and a qualitative analysis of some phenomena of active language in this setting. Active language is discussed in terms of its function in providing clues to lexical semantics, to the structure of the task, and to contextual cues and non-obvious aspects of the situation.

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The Resource of Active Language

Cognitive development is largely concerned with how children operate in the complex physical and social world, and how their basic ontologies and cognitive skills, such as planning, analogy, and problem-solving, arise. Many developmental theories consider language, action, thought, and the physical setting as interacting phenomena – each serving to organize the others. In these theories the physically and socially embedded activity of parent-child dyads (and, later, of other social systems) is a crucial locus of learning (cf. Bruner, 1983; Kaye, 1982; Rogoff, 1990; Vygotsky, 1978). However, there is less agreement upon the methods and theories by which psychologists can study and understand parent-child systems, in part because this requires studying a system with complex long-term dynamics that cannot be confined to the laboratory.

We think it crucial to approach a cognitive account of development with an accurate picture of the parent-child system in hand, otherwise one will tend to underestimate the richness of support and dynamics of that system and so will tend to overestimate the complexity of the learning processes of the child. One can view the early strategy choice work of Siegler & Shrager (1984) and VanLehn's (1987) work on procedure induction as examples of both the advantages of utilizing an accurate analysis of the learner's social and physical environment, and as examples of the limitations imposed by our still shallow understanding of that environment. Siegler and Shrager modeled the dynamics of subtraction skill acquisition and the pattern of use of strategies by simulating the strategies observed in children and, more

importantly, by presenting problems to the simulation in accord with the frequency with which problems were presented to children by their parents (as observed by Hamman and Siegler). VanLehn's simulation was given ordered sequences of worked examples of long subtraction problems from which it learned a general subtraction procedure. Although both of these models rely upon time-extended activity of the child in executing strategies or in reading the worked examples, the child's *interaction* with the parent or teacher, or with the task context was not considered. Nor was there consideration given to the linguistic context that one would expect to infuse such settings. The present work contributes to efforts at developmental modeling by offering a description of parent-child collaborative work that includes their interaction physically and communicatively.

One can describe the embedded parent-child system in terms of resources that are available to the child. In making use of, or by influence of a complex of resources, a relatively simple learner can develop complex modes of activity. The frequency of problems given the simulation by Siegler and Shrager is a resource of practice guidance, and the sequence of examples seen by VanLehn's simulation is an resource of induction examples. Here we examine another sort of resource: the verbal correlates of collaborative activity. We want to understand the learning function of the utterances that accompany collaborative work. We shall refer to this as the social resource of "active language."

Collaborative Cooking

The study of active language requires simultaneous analysis of activity and of the language functions that takes place during that activity. Shrager, Callanan, and Holloway (1991) videotaped 38 roughly upper-middle-class parent-child pairs baking muffins in their home kitchens from a recipe in a children's cookbook. The children occupied three age groups; mean ages 2;11, 3;9, and 4;11. One step of this recipe calls for one-and-one-quarter teaspoons of baking soda to be added to the dry materials being collected in a bowl. The recipe book comes with a set of colored plastic measuring spoons, whose colors are coded to measures by the pictures in the recipe book. In the case of the baking soda, a picture

of a box of baking soda is shown with a red and a blue spoon next to it; the red spoon is 1/4-teaspoon and the blue spoon is 1-teaspoon.

Analysis of Physical Collaboration

Shrager, et al. studied the baking soda segment from each tape. The time taken for this step varied widely, ranging from 10 to 238 seconds, but there was no age difference between these durations (mean=70.7, stdev=23.8 at 3-years, 81.5, 50.7 at 4-years, and 81.6, 31.9 at 5-years; $F(2,33)=0.34, p > .7$). The baking soda task was divided into six steps: each of the two spoons has three substeps: filling the spoon with baking soda, optionally leveling the spoon (if it is too full, or adding more if there is too little), and dumping the baking soda into a receptacle. Each of these steps was coded according to who *physically* carried out the step: the parent, the child, both, or the step was excluded or uncodable (p, c, b, or e/x), leading to a six-part code such as: PBC/CBC (the parent fills the first spoon, they jointly level it and the child dumps it into the bowl; the child fills the second spoon, they again jointly level it, and the child again dumps it). We would expect to find a number of different sorts of organizations of collaboration: the child might passively watch the parent doing the activity; the parent might support the child's doing parts of the task; the parent might demonstrate with the first spoon and then give the second to the child; the parent might explain what to do and the child do it; etc. When analyzed without the E and X codes there was a significant interaction between age (3, 4, 5) and contributor (p, b, c) only for the first spoon leveling step ($\chi^2(4) = 10.08, p < .05$). These effects reveal that whereas the leveling activities for the first spoon are apparently being taken up by the child, this is not the case for the first spoon's filling, nor for the steps in the second spoon. (Dumping is generally carried out by the child throughout ages and spoons.) The cross-step effects (fill-level-dump by parent-both-child) are significant at 3- (spoon 1: $\chi^2(4) = 21.08, p < .001$; spoon 2: 9.52, $p < .05$) and 4-years (24.37, $p < .001$; 12.11, $p < .02$), but not at 5. The effects demonstrate that whereas there is a difference between who is carrying out the activity (parent vs. child) in the first two age groups, there is no difference in the oldest group (5-year olds). That is, a "division of labor" is eventually reached wherein the

child is a full collaborator, in the sense that we do not find the tasks differentially distributed to either parent or child. (More detail can be found in Shrager, Callanan, & Holloway, 1991.)

Qualitative Analysis of Active Language

The second step in our method is to analyze the functions of the utterances that occur in this setting, leading eventually to a joint analysis that should enable us to study the relationships between the language and the development of the collaborative activity. As a first attempt to capture these details we present a qualitative analysis of the active language of three subjects in the baking soda step. In the next section we discuss the possible functions of the active language observed here, and in the conclusion we ask how this analysis can inform cognitive theories of development.

Let us examine one dyad from each age group: Colin (2;9) and his mother, Cindy¹, took about 85 seconds to complete the task, and their collaborative structure was coded as: "PPC/CBC" (the parent filled and leveled the first spoon and the child dumped it into the bowl, the child filled the second spoon, they both leveled it, and the child again dumped it); Sarah (3;7) and Sue took about 60 seconds, and were coded as: "PPC/CCC"; Jennifer (4;10), her mother, Joan, (and Jennifer's sister, Amy) took about 98 seconds, and were coded as: "BBC/CCC".² The activity of each of these parent-child pairs, the children about a year apart, is in some ways very similar: one can see from the given collaboration codes that in each the parent helps the child out more with the first spoon than with the second, but also that the older children are able to accomplish the activity by themselves, whereas Colin's mother helps him with the leveling of the second spoon. Our summary data suggests that this distribution of collaboration is typical.

We will focus here upon the way in which the parents introduce the procedure for leveling the material in the spoons, and how they guide the child through this procedure. We will see that in

these cases the parents of younger children seem to combine both physical and verbal guidance while parents of older children rely on verbal guidance more than upon physical guidance. Eventually, for the oldest children, parents are able to simply explain and demonstrate the activity, leaving the child completely unmonitored. Older children become more articulately and physically skilled in the task, as well as in their engagement with their parents, for instance replying to guidance and inquiry and taking initiative by greater degrees. Thus the structure of the interaction between parent and child differs in significant ways.

Colin's mother, Cindy, guides him physically through the leveling activity on the second spoon:

At the point in the second spoon where it is filled with baking soda, and as Colin moves to dump the material into the big bowl, Cindy says: "We only want..." and as Colin pulls out the spoon, apparently going to dump it into the bowl, Cindy says: "Woop woop woop woop..." and takes the spoon handle in her right hand just below the point at which Colin is holding it. She says: "We're gonna do one more thing before we put it in there, okay? We're gonna scrape it. Scrape it." While saying this she is guiding the spoon back into the box (with Colin still holding it) and then she changes grip so that she is holding his hand rather than the spoon itself and says: "Scrape the top so it comes real flat....just like that...see?" They draw the spoon out of the box, scraping it along the top of the box so the baking soda level in the spoon becomes (real) flat. Cindy says, more loudly and brightly: "Okay?" and releases Colin's hand near the bowl. He moves the spoon fully over the bowl and dumps the material in as she backs away. She says: "Then we won't get too much [in]."

Sarah's mother, Sue, verbally guides Sarah through the procedure with the second spoon:

Sue takes back the spoons and picks out the blue one and hands it to Sarah. Sue holds the box, turning it toward Sarah saying: "Okay stick it in there" which Sarah does. Sue goes on: "and fill it up". Sarah digs around. Sue touches Sarah's hand briefly in

¹These are, of course, not their real names.

²A complete transcript of Jennifer and Joan's (and Amy's) baking soda segment is included as an appendix. [Square brackets indicate utterances that were difficult to transcribe, and so are questionable.]

gentle direction: "That's it." Sarah continues to dig around. Sue takes Sarah's hand, gently guiding it, saying "Turn it around." Sue releases Sarah's hand: "and then scrape it off [unintelligible]" which Sarah also does. Sue says: "Oh, you didn't fill it all the way." and moves apparently to take Sarah's hand but switches to pointing to the material in the spoon. Sarah digs back into the box of baking soda and this time, without further conversation or guidance, completes the operation including scraping and dumping the material into the bowl.

Jennifer, the oldest child, is able to complete the leveling activity on the first spoon with verbal guidance and physical guidance and is then able to conduct the entire activity on her own with the second spoon (see Appendix). She also seems to be engaged with her mother's directive verbalizations, answering "yeah" to her mother's question: "See how it makes it flat?", whereas Sarah and Colin do not reply to their parents' directives and Colin seems to require physical guidance. (Whereas Jennifer's mother eventually physically guided her activity as well in the first spoon, Jennifer had simply got the notion of scraping the spoon backwards - scraping it upside-down on the box top instead of rightside up.)

It is worth noting a closely related example of differential language use in the way that the parents indicate which spoons are to be used in the activity. Cindy selects the spoons for Colin and does not indicate the color or label. Sue selects the spoons for Sarah but also indicates the colors as the selection method. Joan selects the first spoon for Jennifer, indicating both the color and label. Jennifer selects the second spoon by herself, the appropriate color having been indicated by Joan (see Appendix).

Functions of Active Language

We have seen in these examples that the parents' physical guidance of the child's activity seems to decrease whereas the parent-child connection through verbal communication seems to increase. What learning functions are served by active language in enabling this change? The observed changes presumably entail (at least) improvements in the child's domain specific skill as

well as changes in the child's ability to engage with the parent in a verbally-mediated interaction. How might active language serve as a *resource for learning* about this task, as well as about how to collaborate? Some potential learning functions include:

Object and action labels: What is being manipulated, as well as the action taking place, is spoken about continuously, making explicit reference available to the child in both understanding and in production (e.g., in order to ask questions).

Sequencing of expectations (procedure organization): In part of its role in mediating joint attention, the language provides sequencing information for the child. What is to come next is often mentioned before the action takes place. Thus, if one learns a verbal narrative, and a set of action labels (as above), one can reproduce the action sequence. (See Bruner, 1983, for an excellent discussion of closely related functions of joint active language in game playing.)

Task structuring articulations (and activities): Various common ways of speaking, intonation, and repeated activities cue the beginnings and ends of action units, and the goal-structure of the task. Utterances such as: "Okay" ... "So" ... "What are we gonna do now?"

Explication of non-obvious aspects and focusing on relevant aspects: Explanations articulate non-obvious or cross-situational aspects of the setting (e.g., causal relations), and can guide attention to relevant aspects from among the many features in a complex situation. Some such aspects include the conditions that indicate when it is appropriate to carry out an action, and explicit task goals, and the purposes of actions with respect to those goals.

Interaction facilitating articulations (and activities): In addition to learning about the task itself, the child learns ways of operating in this domain which facilitate the collaboration. For instance, some of the task structuring articulations, such as saying "Okay" at various points, are picked up and used by the child, and elicit guidance from the parent, as when the child says "Okay" but it is not the end of the activity (to the parent). Ways of asking for instruction refinements (e.g., "Where?" and "What?") are also important facilitators of the collaboration, and come to be

used by children with cooking-specific content.

A given utterance and action context may serve a number of functions. Consider, again, Cindy's introduction of the leveling procedure to Colin, quoted above. As she is guiding Colin through the procedure, Cindy says: "We're gonna do one more thing before we put it in there, okay? We're gonna scrape it. Scrape it...Scrape the top so it comes real flat....just like that...see?...Okay?...Then we won't get too much [in]." This series of utterances, combined with the details of the action (see above) potentially provide: a name for the procedure ("scrape"), a focus for the procedure (the spoon they are holding, called "it"), the relevant conditions and local purposes of scraping ("so it becomes real flat") as well as the purpose with respect to the task goals ("then we won't get too much in"). Further, the structure of the active language is so timed that it brackets the procedure itself (The interruptions of "Woop, woop..." through "Okay?").³

Interestingly, all of the aspects of cooking available in active language – the names of things, the task goal and structure, causal structure, conditions and purposes, etc – are *interpretations* of the activity. In engaging the child in cooking activity, the parent is simultaneously engaging the child in *active interpretation about the activity*. Thus, the process of learning about cooking involves the child in learning to become a *culturally appropriate interpreter*.

We are presently working to develop coding schemes, like the collaboration coding scheme of Shrager, et al, (described above) through which we can test hypotheses about the these functions in the observed developmental changes.

Discussion

The collaborative work settings in which the child participates are extremely rich in resources for the local support of action as well as for learning. Although models such as those of Siegler & Shrager and VanLehn take some account of the structure of the child's context, they have barely grasped the nature of the parent-child sys-

³Intonations are very relevant in this argument, as in all of the above, but we cannot delve into this topic in the present limited space.

tem – a system characterized by close dynamically managed interaction, and including a richly woven system of active language. One promising approach to understanding collaborative development adopts the metaphor of the child-as-apprentice (e.g., Kaye, 1982; Rogoff, 1990) in contrast to the Piagetian view of the child-as-scientist. Substantiating the apprenticeship metaphor requires theoretical frameworks that focus on the mutual dynamics of the learner and the context of change (e.g., Agre & Shrager, 1990; Lerner and his coworkers, see Lerner, 1986; Kaye, 1982, Rogoff, 1990), as well as a modeling technology that integrates individual mechanisms of cognition (e.g., learning), attentional and perceptual mechanisms, and the collaborative mechanisms of jointly managed attention, negotiated guidance, etc. There is already some movement on this direction with the theories of Bruner (1983), Callanan (1991), and Rosenthal & Zimmerman (1978), and the models of Kaye (1982). With details of collaboration such as those described here in hand, we will be in a better position to build process models in which the developmental work is appropriately apportioned among the three areas of cognition, perception, and collaboration.

References

- Agre, P. & Shrager, J. (1990) Routine evolution as the microgenetic basis of skill acquisition. In the proceedings of the 12th annual meeting of the Cognitive Science Society (August, 1990). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Bruner, J. (1983). *Child's talk*. New York: W.W. Norton & Co.
- Callanan, M. A. (1991). Parent-child collaboration in young children's understanding of category hierarchies. In J. Byrnes & S. Gelman (Eds.), *Perspectives on Language and Thought: Interrelations in Development*. NY: Cambridge University Press.
- Kaye, K. (1982). *The mental and social life of babies; How parents create persons*. The University of Chicago Press.
- Lerner, R.M. (1986). *Concepts and theories of human development*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Rogoff, B. (1990). *Apprenticeship in thinking*. Oxford University Press.

Rosenthal, T.L. & Zimmerman, B.J. (1978). *Social learning and cognition*. New York: Academic Press.

Shrager, J., Callanan, M. & Holloway, A. (1991). The dynamics of collaboration in the development of complex activity. Presented at the Semi-Annual meeting of the Society for Research in Child Development. Seattle, April 1991.

Siegler, R.S. & Shrager, J. (1984). Strategy choice in addition and subtraction: How do children know what to do? In C. Sophian (Ed.), *Origins of Cognitive Skills*. Hillsdale, NJ: Lawrence Erlbaum Associates.

VanLehn, K. Learning one subprocedure per lesson. *Artificial Intelligence*, 31(1), 1-40.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Jennifer (4;10), Joan (and Amy)

There is a younger child (Amy) standing between Jennifer and Joan. Joan picks up the spoons and reads the recipe: "Okay, for the baking soda we need to put one and a quarter teaspoons." She sorts through the spoons. Jennifer reaches for the baking soda, which is in a plastic baggie. Joan selects the blue and red spoons and shows them to Jennifer: "So here's the one." Pointing to the blue spoon's label: "See the one?" Jennifer: "Uh huh" Pointing to the red spoon's label Joan says: "And that's a quarter...one fourth" Joan begins to open the baggie: "So you put a blue one and a red one." As she says "blue" and "red" she touches the blue and red spoons respectively. She opens the baggie, saying: "of this is here...let's see if we can...okay it's opened up..." Jennifer and Amy watch Joan's activity. Joan continues: "And the way you do that..." Jennifer reaches for the blue spoon that Joan is beginning to put into the box while holding it with her other hand. Joan: "...remember how you level off the spoon?" She gives the spoon to Jennifer who digs into the box. Joan continues to hold the box with her left hand: "With this one we don't use a knife, you can just kind of rub it against the top of

the box." Joan gestures a scraping motion with her free right hand near the box top. Jennifer does the appropriate leveling action, withdrawing the spoon. They inspect the spoon contents. Joan: "Up, let's see, get it all the way full." Jennifer repeats the operation, digging in for baking soda and scraping the spoon along the top of the box, while Joan continues to steady the box. Joan says "That-a-girl" as Jennifer withdraws the spoon. Joan says: "Okay and kind of scrape it..." Jennifer turns the spoon *upside down* on the box top and scrapes it backward, dumping the baking soda back into the box. Joan takes Jennifer's hand with the spoon: "Okay. I'll show you." They dig in together. As they do the activity together, Joan says: "You kind-a...put it in...and you fill it up...and then you kind of rub it against the top here." They dig in again: "Get it nice and full. Rub it against the top. See how it makes it flat?" Jennifer replies: "Yeah." Joan: "That makes it exactly right." Joan releases Jennifer's hand and the child dumps the material into the bowl. Joan says: "Okay." Jennifer begins to refill the blue spoon. Joan says: "Now we need a quarter, which is the red one." and touches the red spoon, which has been dangling in front of Amy, the younger child. Jennifer stops filling the blue spoon and begins to switch to the red one. Amy has meanwhile grabbed the dangling spoons. Jennifer makes a frustrated plea: "Amy!" for her to release them as she (Jennifer) pulls them away. Joan picks up Amy and puts her aside on the floor saying: "Okay. You know what? I'll get her her own spoons." Joan walks out of the scene. Meanwhile, Jennifer has filled and scraped the red spoonful of baking soda and holds it out to show (apparently no one as Joan has walked off camera), smiling and saying: "I got a [tiny]." She laughs and moves to dump the baking soda into the bowl but stops and says over her shoulder to about where Joan has gone: "I got it, mom." Joan calls from the hallway: "Okay. Did you get it..." and looks into the room at Jennifer who is holding the full spoon out toward the mother. Joan says: "...that-a-girl" and Jennifer turns back to the bowl to dump in the baking soda, Joan continues: "why don't you put the...that right in there..." Jennifer dumps the soda into the bowl.