

Saxe, G. B. (1999). Cognition, development, and cultural practices. In E. Turiel (Ed.), Culture and Development. New Directions in Child Psychology. SF: Jossey-Bass.

Cognition, Development, and Cultural Practices

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In this chapter, I sketch a research approach for gaining insight into relations between culture and cognition, with a focus keyed to the overarching theme of this volume -- the interplay between cognitive development and culture change.

Treatments of culture change and cognitive development are often linked to different disciplines, analyses of cognitive development belonging to psychology and analyses of culture and culture change linked to sociology and cultural anthropology. Like others who have broken with this disciplinary tradition, I argue that a systematic analysis of either culture change or cognitive development requires that they be understood relative to one another in a single integrative treatment.¹ A core thesis is that a wide range of cognitive developments take form in and depend upon cultural practices and that new developments in culture (culture change) involve the cognitive constructions of individuals.

SOME PRELIMINARIES

The approach I outline is *cultural* insofar as the collective practices are elevated as a principal target for analysis. Practices are

conceptualized broadly as recurrent socially organized activities that permeate daily life. Practices may be as diverse as playing games, working in particular professions, or participating in any of a diverse set of social institutions (school, religion, or politics). Regardless of the practice, the approach is based on the assumption that there is a reflexive relation between individual activities and practices.

Individuals' activities are constitutive of practices and at the same time practices give form and social meaning to individuals' activities.

The approach is also *developmental*. A core assumption is that novel cognitive developments emerge in individuals' efforts to structure and accomplish goals in practices. The focus is on three levels of analysis, each of which concern the interplay between cultural forms, such as number systems, and cognitive functions, the purposes for which forms are used as individuals structure and accomplish practice-linked goals. The analyses concern processes of (1) microgenesis, or changes that occur as individuals transform cultural forms into cognitive means for representing and accomplishing goals in practices, (2) ontogenesis, or shifting relations between individuals' uses of particular forms and functions in their activities over development in practices, and (3) sociogenesis, or changes that occur in cultural forms as individuals' representational and strategic accomplishments become valued by multiple members of a community and spread to serve variant functions in individuals' goal directed activities.

Readers familiar with formulations of cognitive development will find that the cultural-developmental approach sketched here is marked

by a confluence of Piagetian and Vygotskian ideas. Key Piagetian constructs of epigenesis (that new structures of knowledge have their roots in prior structures) and construction (that individuals are active agents in epigenetic change) are central to the treatment of development (Piaget, 1970). At the same time, Piaget's focus on universals does not well afford a differentiated treatment of history and culture in analyses of cognitive development, a principal focus here. In this regard, the approach shows similarities with Vygotsky's focus on mediation as a key target in an analysis of the intrinsic relations between individual and social history in a treatment of development (Vygotsky, 1978, 1986).

THE CHANGING PRACTICE OF ECONOMIC EXCHANGE IN THE OKSAPMIN

In sketching the framework, I draw on one of my prior studies on arithmetic in a remote group in Papua New Guinea -- the Oksapmin of the West Sepik Province (Saxe, 1982). I target the practice of economic exchange as it is conducted by adults. Though the Oksapmin live a style of life quite removed from the Western, the example presents a remarkable instance in which the dynamics of culture change and development stand out in particularly clear relief. My focus is on the emerging arithmetic used by the Oksapmin as it is linked to ongoing shifts in the practice of economic exchange.

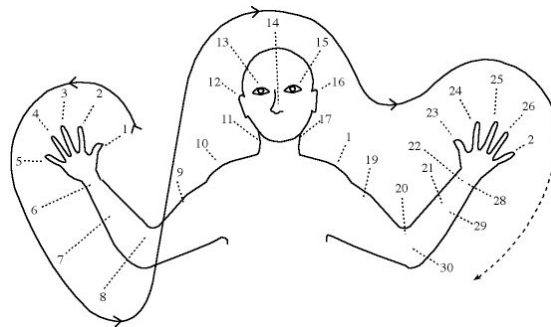
The Oksapmin Setting and Traditional Practices Involving Number

The Oksapmin people live in a remote highlands area. The only means of access is by single engine aircraft and travel by foot. For subsistence, Oksapmin people use slash-and-burn methods to cultivate taro and sweet potato, use bows and arrows to hunt for small game,

and keep pigs. Western contact was first established with the Oksapmin by the Australian 1938-1940 Hagen-Sepik patrol, although it was not until the 1950s that the Oksapmin were contacted by additional patrols. A government patrol post and a mission station were established in the Oksapmin area in the early 1960s.

The standard Oksapmin number system differs markedly from the Western base-ten system, as do the systems of other Papua New Guinea groups (see Lancy, 1978). To count as Oksapmin do, one begins with the thumb on one hand and enumerates 27 places around the upper periphery of the body, ending on the little finger of the opposite hand. If one needs to count further, one can continue back up to the wrist of the second hand and progress back upward on the body (see Figure 1).

Figure 1. The Oksapmin body part counting system



Oksapmin Practices of Economic Exchange

Contact with the West has led to shifts in the everyday practices with which Oksapmin are engaged including practices involving economic exchange and number. In traditional practices, Oksapmin used the body system to count valuables (e.g., pigs), to denote the ordinal position of an element in a series of elements (e.g., the ordinal position

of a hamlet in a series of hamlets on a path), or in basic measurement operations (as a means of measuring and representing the length of string bags, a common cultural artifact). Procedures for computation are not used in traditional life; however, there are some analogs of a computational process. For instance, in traditional economic exchanges, Oksapmin traded goods directly in one-for-one or one-for-many exchanges (bows for leaves of salt, axes for bows). In general, such analogs lack a representational solution procedure in which an answer can be determined in the absence of the objects.

The brief history of Western currency in the Oksapmin community is noteworthy, since it has relevance to understanding the shifting practice of economic exchange and the way Oksapmin come to structure and accomplish numerical goals in economic transactions. Western currency entered the Oksapmin community through a number of routes. Australian shillings and pounds (20 shillings = 1 pound) were brought by early missionaries and patrol officers to the region, in about 1961. In 1966, the Australian dollar was instituted (100 cents = 1 dollar), and in 1975, before the country became independent, Papua New Guinea issued its own currency in the form of kina and toea (200 toea = one 2-kina note). Beginning in the 1960s, some Oksapmin men were flown out of the area to earn about 200 kina (the equivalent of about \$300 in purchasing value) for 2-year stints of labor on copra and tea plantations. These men often returned to the Oksapmin community; some built tiny trade stores and bought bags of rice and cans of fish to sell to people in their hamlets. The first trade store was started in 1972, and by 1980 there were more than 100 stores in the subdistrict. These stores are the contexts in which currency is

exchanged most frequently within the Oksapmin community. Missionaries and government officers continue to contribute to the local supply of currency through the purchase of vegetables or through trading currency for labor (such as the carrying of goods). Many Oksapmin people, particularly individuals beyond their 20s, translate kina and toea (current national currency) into pounds and shillings (the first currency system). On this basis, people call one 10-toea coin, one shilling (a 20-toea coin is called two shillings and one 2-kina note, one pound).

ANALYZING DEVELOPMENT IN OKSAPMIN ARITHMETIC:

RELATIONS BETWEEN FORM AND FUNCTION

I reasoned that economic transactions in such sites as tradestores led individuals to create numerical goals, and that these goals differ from those that mark traditional economic practices. For instance, in the tradestore, customer and owner pose arithmetical problems to one another. The customer presents items to be purchased for currency while the store owner evaluates the amount of those items and considers payment in currency for those items. To understand the way changes in the practices in which individuals engage are related to form-function shifts in individuals' efforts to achieve these goals, I observed and interviewed people with varying levels of participation in the money economy. In the interviews, I was concerned with learning about individuals' use of the body system form in problems that emerged in such contexts and the way use varied with increasing participation in such currency-linked exchanges.

The fruits of the observations and interviews lead to the identification of the three interrelated levels of developmental analysis noted above -- microgenesis, ontogenesis, and sociogenesis. In each case, cognition is understood as a process undergoing transformation as cultural forms, like the Oksapmin number system, become vehicles for serving new functions in currency-based economic practices.

Microgenesis

Whether we observe Oksapmins' use of their number system or individuals' use of a number system in any human community, we find that the meaning of cultural forms are not fixed. For example, in everyday Oksapmin practices, body parts are only sometimes used to signify numerical relations. At other times, pointing to body parts simply refers to parts of the body. Even when body parts are used as numerical signifiers, numerical meanings are not predetermined, but take form in activity. For example, the same body part may refer to different numbers since sometimes individuals count from right to left and at other times from left to right. Further, body parts are sometimes used to refer to ordinal numbers and at other times to cardinal numbers. Thus, cultural forms like the body system are schematized to serve different functions as they are used in activities. This schematization involves a process of microgenesis in which the body part form is transformed into a means for accomplishing goals in practices.

Numerical Reference in Oksapmin

Werner and Kaplan (1962) proposed a model of microgenesis that can be extended to the analysis of numerical reference in

Oksapmin. The model provides a means of understanding how referential meaning and semiotic flexibility is possible in cognitive activities (e.g., how, at one moment, the individual can use the nose to mean the number fourteen and in the next moment use the nose to mean the body part that was the source of a sneeze.) As used here, the model consists of three aspects. These involve a schematization of (1) a representational vehicle, such as a number or other system of reference, (2) a representational object, such as the quantity of objects in a set, and (3) a semantic mapping between vehicle and object. These activities were assumed to occur co-extensively. Here, we consider the problem of numerical reference in Oksapmin.

Schematizing a vehicle for numerical reference. If cultural forms like body parts have no inherent numerical meaning, how do they become symbolic vehicles that take on numerical meaning? Werner & Kaplan point out that forms (such as body parts) have many “latent” features that may afford or support a wide range of cognitive functions. For instance, fingers are elongated and the elbow is hard and pointed. Such latent features are brought to the foreground in activity as they are deployed to serve particular functions -- the fingers and thumb may be used to serve prehensile functions and the elbow may be used to jab. The same body parts also have latent features such that can be brought to the fore to serve numerical functions in convenient ways: body parts can be parsed and ordered as a stable sequence and organized in a pattern (up one side of the body and down the other). These latent feature also constrain numerical functions in particular ways. For example, one can only count to relatively small numbers using body parts. Such latent

features mean that while body parts have no intrinsic numerical function, they can be schematized in such a fashion that they serve numerical functions.

Schematizing an object of numerical reference. Just as body parts are not inherently numerical, elements in the world that are the target of numerical representations (such as Oksapmin pigs) have no inherent numerical meaning. However, like the Oksapmin body system, objects have latent features that could be used to support quantitative activity. To be treated numerically, objects must be schematized as discrete entities that are countable. For instance, objects like pigs can be treated one by one and conceptualized as a countable set.

Schematizing relations between vehicle and object. Finally, to use body parts to represent objects numerically requires not only that a potential vehicle (body parts) and a potential object of representation (pigs, shells, coins) be schematized as conceptual entities with numerical properties. In addition, a relation between body parts and target entities must be created coextensively, such that each body part denotes a potential sum of objects (the forearm may be used to refer to the totality of seven pigs) or a potential position in an enumeration (the forearm may be used to denote the seventh pig); indeed, without a schematization of a one-to-one correspondence between vehicle and object, the vehicle does not provide a means of representing the object numerically. Thus, inherent in the microgenetic act is a schematization of a correspondence between the latent

qualities of the vehicle and object such that one can come to stand for the other.

An example of the microgenesis of an arithmetical strategy linked to economic exchange with currency. Consider a traditional adult who participates little in the money economy as he attempts to solve the following problem:

“You have 6 shillings (1 shilling = 1 coin),” as the informant gestured around the body to the appropriate body part and to the coins. “A friend gives you 8 shillings” (gesturing from the thumb to the inner elbow). “How many do you have altogether?”

As depicted in Figure 2, to accomplish the problem, the individual enumerates body parts beginning with the thumb (1) and ending at the wrist (6) to represent six coins (the first term of the problem). For the second term (8), the individual continues with his count, not creating a means of keeping track of the addition of 8 on to 6, thus stopping at an inappropriate body part (the ear on the other side (16)). The failure to keep track makes sense when we consider that in traditional practices, arithmetic with non-present objects was virtually nonexistent. Thus, when confronted with the novel arithmetical task, the individual treats the activity as if it were a count of present objects, in which keeping track does not emerge as a problem with which to be dealt.

Figure 2. A global enumeration procedure used to solve the problem $6+9=?$

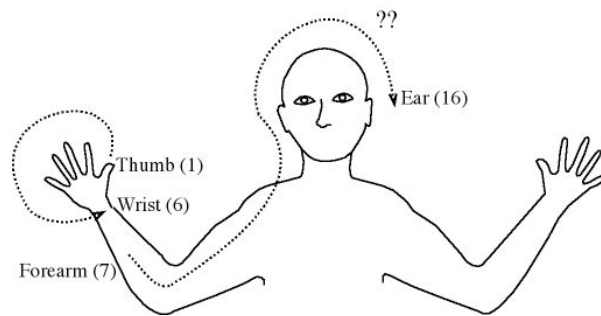
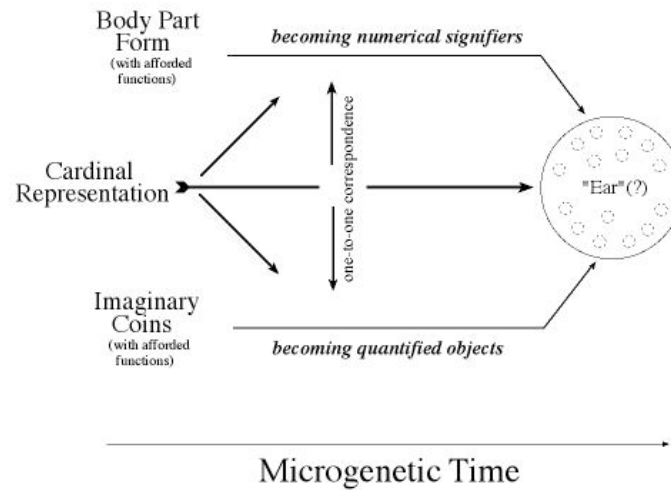


Figure 3 contains a general depiction of the microgenetic process. The figure shows the threefold schematization involved in the count of $6 + 8$ coins. The individual begins with the intent to produce a cardinal representation -- a numerical function afforded by the body system. The individual brings to bear his knowledge of the body system, a cultural form to serve a numerical function -- the representation of a cardinal value. The function is realized in an effort to accomplish the goal of representing numerically the first term of the problem. In this representational act, the individual structures imaginary one-to-one correspondence relations between vehicle and object of reference such that the body parts become a vehicle for representing coins. In this process, the generic form of body parts become parsed into ordered numerical symbols, and the imaginary coins are co-extensively parsed into a group of elements to be enumerated. In the end, the product of the activity is the wrist, the symbolic expression referring to six coins. To add the additional coins, the individual continues the flow of the microgenetic process of structuring a representational solution to the arithmetical problem by

schematizing imaginary coins from the forearm (7), though the schematization is not adequate to produce an accurate solution.

Figure 3. The microgenesis of a global enumeration procedure.



In this sketch of microgenesis, individuals structure cultural forms like the body system into means for accomplishing representational and strategic goals. This dynamic process allows for the flexibility of forms to serve different functions in activity, in that the same forms may be structured into means for accomplishing different ends. Such flexibility may be fundamental for individuals' construction of novel cognitive developments over the course of ontogenetic change, an issue addressed next.

Ontogenesis

To gain insight into developmental shifts in the way individuals approached and accomplished mathematical problems over time, I interviewed 80 individuals who varied in their levels of participation with the money economy. These included men who had owned a trade store for at least 2 years; men who had returned from a period of work at a

plantation but did not own a trade store; young adults who had not been to a plantation (and therefore had little experience with currency); and older adults who had not been to a plantation and who therefore had only peripheral experience with the money economy. I reasoned that an analysis of these individuals' strategies (microgenetic constructions) would provide insight into the way engagement in the practice of economic exchange supports the structuration of arithmetical goals leading to the creation of new schematization and functions of the body system in Oksapmin collective practices. Specifically, I expected that with greater experience in the money economy, individuals would increasingly create new kinds of microgenetic constructions that reflect more sophisticated schematization of correspondence operations in accomplishing arithmetical problems.

The double-enumeration strategy depicted in Figure 4 appears to be an outgrowth of the global enumeration procedure used by the traditional adult described in the earlier example. With the double enumeration strategy, individuals created a more differentiated schematization of a problem solution. To solve the same problem ($6+8$ coins), an individual begins at the first term of the problem (wrist [6]). As the individual adds the second term (elbow [8]), a record is kept by establishing physical correspondences with a sub-series of body parts used to represent the second term (thumb [1] to inner elbow [8]). Thus, the individual establishes correspondences between the thumb (1) and the forearm (7), the first finger (2) and the inner elbow (8), and so on until the individual reaches the correspondence between the inner elbow (8) and the nose (14). As a result, unlike the earlier global

strategy, the individual typically achieves the accurate answer, nose (14).

Figure 4. The double enumeration procedure.

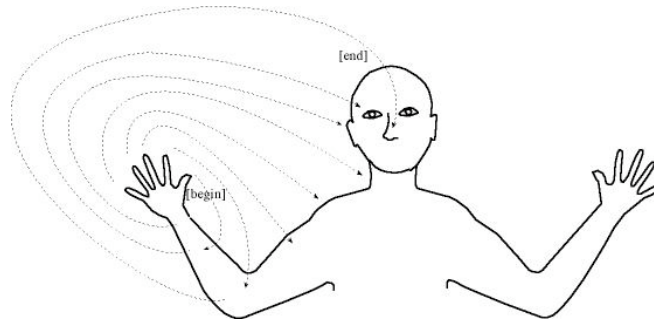
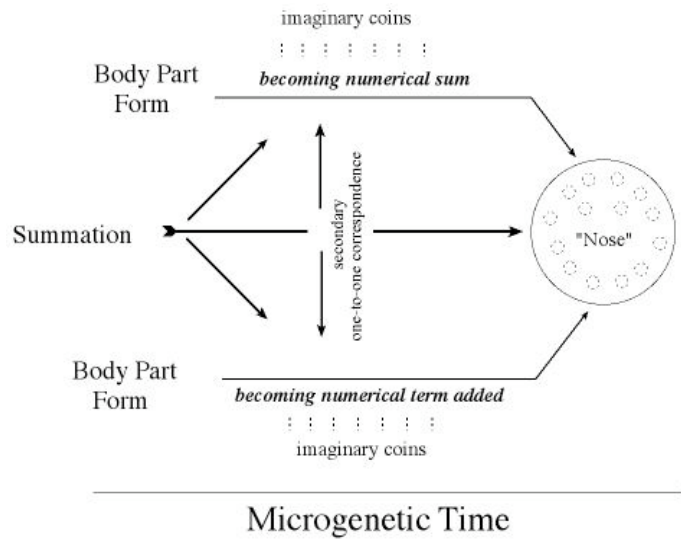


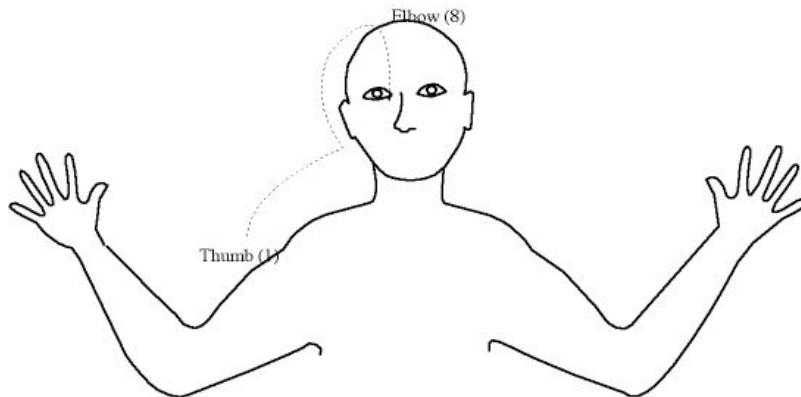
Figure 5 contains a depiction of the microgenesis of the double enumeration strategy. The figure highlights both the continuity and discontinuity with the prior global enumeration approach. Now one-to-one correspondences (continuity) are used to structure secondary correspondences (discontinuity) as individuals use a subset of body parts (thumb [1] to elbow [8]) to keep track of the addition (forearm [7] to nose [14]). In this process, one-to-one correspondence links to coins are implicit.

Figure 5. The microgenesis of a double enumeration procedure.



A further development is the body-part substitution strategy (depicted in Figure 6). This schematization is similar to the double-enumeration procedure, with one major exception. Rather than establishing physical one-to-one correspondence between two series of body parts, one series is strictly verbal and the other physical. As a consequence, the individual often produces calculations at a quicker pace. Thus, to add $6 + 8$, an individual may recite the series, thumb (1) to inner elbow (8) as he or she points to the series forearm (7) to nose (14). Noteworthy here is that the use of the terms for body parts now violate a linguistic convention in the Oksapmin language. Body parts are called by the names of other body parts in this strategy to serve the function of keeping track.

Figure 6. The body substitution procedure.



Finally, the halved-body procedure (depicted in Figure 7) is the most complex strategy observed. In this procedure, rather than using a sub-series of the body-part sequence to keep track of a progressive summation of coins, an individual uses each half of the body as a separate register for numerical values. To accomplish this, an individual organizes each half of the body around a focal point such as the shoulder (10). Each arm is then used as an independent register to add or subtract coins. For instance, to add $6 + 8$ coins (Figure 7), an individual would “put” eight on one arm (inner elbow) and six on the other (wrist). The addition would be accomplished by a simple transfer of the 6th (wrist) and 5th (little finger) body parts from the first arm to the 9th (biceps) and 10th (shoulder) body parts of the second arm. Thus, the solution would be 1 kina and 40 toea (shoulder [10] and ring finger [4]).

Figure 7. The halved-body procedure.

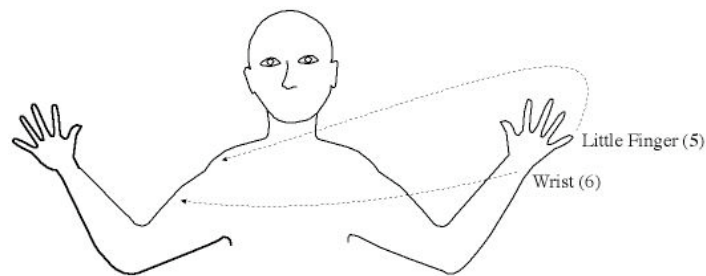
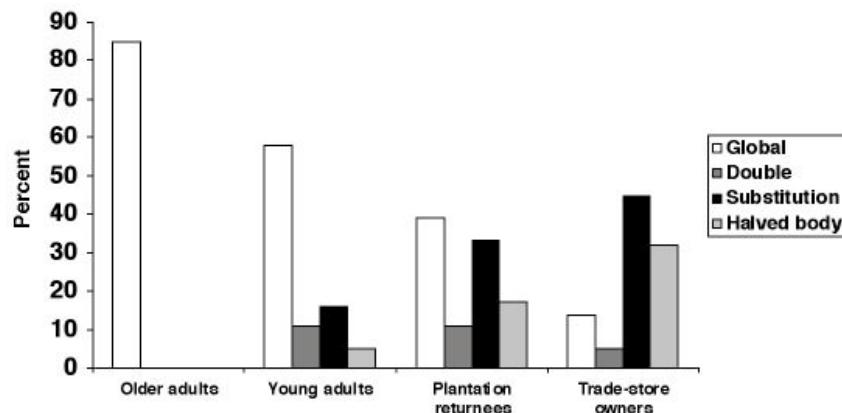


Figure 8 contains a frequency distribution of individuals' strategy use for an addition problem as a function of population group.² The trend is clear. With greater experience in the money economy, individuals increasingly used strategies that reflect developmentally more sophisticated correspondence operations. Indeed, the vast majority of traditional adults used the global enumeration strategy. With increasing participation in the money economy, individuals used strategies that show new patterns of schematization reflecting more sophisticated correspondence operations.

Figure 8. Percent distribution of individuals' solutions to $6+8=?$ or $6+7=?$ coin problems as a function of population group.



In sum, with greater participation in the money economy, body parts are deployed to serve new functions. Those Oksapmin people with

only minimal participation in the new economy first attempt to extend the body-counting form to accomplish new arithmetical tasks that emerge in economic transactions. This direct extension from enumerative functions in traditional activities to the new kinds of numerical problems is not adequate to accomplish arithmetical solutions, and it is not even clear that Oksapmin with little experience treated the task as one that involves the cognitive function of arithmetic. Oksapmin with greater experience in the money economy make a labored effort to restructure their prior global counting strategy in such a way that one term is added on to the other (the "double enumeration strategy"), creating a new type of body-part to body-part correspondence operation in order to keep track of the addition or subtraction of elements. At more advanced levels in the developmental sequence, we see the body-part-counting form progressively specialized into more sophisticated cognitive forms that serve distinctly arithmetical functions. Now, individuals, rather than establishing physical correspondences between body parts as they do previously, efficiently use the name of one body part to refer to another in a "body substitution strategy." Cognitive forms that are distinctively specialized to serve arithmetical and not enumerative functions are more frequently displayed by trade store owners who have the most experience with problems of arithmetic that emerge in economic transactions with currency. In their strategies, some trade store owners incorporate a base-10 system linked to the currency as an aid in computation.

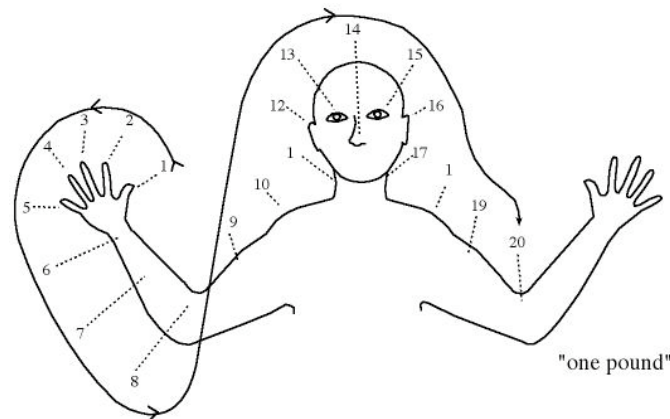
Sociogenesis

Up to this point, I have only alluded to the collective aspects of practices of economic exchange and the emergence of collective forms of representation and problem solving. In collective activities, like exchanges at Oksapmin trade stores, individuals are engaged with microgenetic constructions in communications about quantity and in accomplishing quantity related problems. Such occasions provide opportunities for reciprocally appropriating at least superficial features of one another's constructions. In such appropriations, new forms are born as particular representations become valued and institutionalized as regularized ways of representing and accomplishing problems linked to collective practices. The process of diffusion and institutionalization of individuals' microgenetic constructions into the activities of others constitutes a "sociogenesis" of knowledge.

One likely product of such a sociogenetic process is a newly emerging structure of the Oksapmin body counting system. In their fieldwork, Moylan and Guilford (personal communication) noted that many individuals who had considerable experience with the money economy were using a hybrid structure of the Oksapmin body system in their quantitative representations of currency, a development that I found in my own interviews with people with greater experience with economic exchange. The adaptation is one that incorporates the base structure of the early Australian currency system into the indigenous system (depicted in Figure 9). With the adapted system, rather than using all 27 body parts in an enumeration, an individual counts shillings up to the inner elbow on the other side of the body (20) and calls it one round, or one pound (reflecting the organization of the first Australian currency system). If the individual needs to continue the count, he or

she begins again at the thumb [1] of the first hand (rather than progressing on to the wrist [21]). Similarly, an individual may count 2-kina notes and thus count 40 kina (20 2-kina notes = 40 kina) as one round.

Figure 9. The “hybrid” Oksapmin number system.



The adapted system, then, has a structure that reflects the base structure of the early Australian currency system but nevertheless is an outgrowth of the standard indigenous system. Those Oksapmin who use this system use it flexibly. There are many ways of expressing the same value, either through combinations of the traditional and the adapted system or through using only one system.

Of course, there are different possible ways of accounting for the emergence of such representational forms in the social history of the Oksapmin community, and diffusion is only one possibility. It may be that the novel collective form of representation (as well as the more sophisticated arithmetical strategies) were the products of independent invention and not diffusion. The failings of the indigenous system when dealing with the emerging problems of economic exchange with great numbers associated with currency would support this view,

as many individuals were dealing with problems of representing great values under the constraints of Oksapmin body part numeration. While independent invention may certainly play a role in the construction of new representational forms, the press for communication between individuals certainly points to the importance of diffusion and institutionalization as core sociogenetic processes in accounts of the interplay between culture and development.

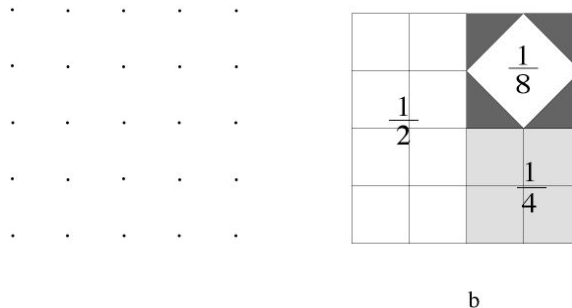
A FURTHER APPLICATION OF THE FRAMEWORK

The recent history of arithmetic in the Oksapmin community presents a case in which the interplay between microgenetic, ontogenetic, and sociogenetic processes are remarkably apparent in everyday practices. The account of development sketched here can serve not only as a useful starting point for understanding the interplay between cultural practices and developmental processes in entire societies like the Okspamin, but also in very small scale communities, such as classrooms in today's schools. To conclude, I illustrate with observations of an upper elementary mathematics classroom made as a part of a larger research project (Gearhart & Saxe, 1997; Saxe & Gearhart, 1997).

The teacher, Ms. Snow, was working in her fourth grade classroom with a mathematics curriculum unit on fractions. The unit supported students' mathematical inquiry and joint work. A core mathematical concept targeted in the unit was fractions are not defined by the appearance (e.g., a semicircle as "one-half" or a quarter of a circle as "one fourth"); rather, a fraction is defined by a relation between parts and wholes (e.g., a whole partitioned into four

equivalent parts creates four fourths (regardless of their shape) and the four fourths are equivalent to the whole). In one of the early activities supported by the unit, students were working at their desks with copies of a square composed of dots defining 16 cells (see Figure 10a). The teacher asked the students to show many different ways of creating “one-half” using the larger square. Later, problems of creating many ways to show $1/4$, $1/8$, and then $1/16$ were also introduced. In the final activity, children were asked to create and show squares depicting different fractions that were later to be assembled in a class quilt (one student’s drawing is depicted in Figure 10b).

Figure 10. (a) Sixteen cell-worksheet presented to students. (b) A child’s creation of fractional parts using the 16-cell worksheet.



Consider how analyses of microgenesis, ontogenesis, and sociogenesis sketched in the Oksapmin case applies to developing understandings of fractions in Ms. Snow’s classroom.

Microgenesis. For children to create mathematical representations with fraction words (forms) in the partitioning activity, the words must undergo a microgenesis (just as did Oksapmin’s use of body parts to represent cardinal number). Like the

Oksapmin case, the microgenesis involves a three-fold schematization of a representational vehicle (in this case, fraction words), a representational object (in this case, part-whole relations between cells and the entire square), and a schematization between vehicle and object such that the vehicle (fraction word) comes to stand for the object (relations between parts and wholes). Thus, a child might shade squares, conceptualizing “one-fourth” as a representational vehicle to stand for the relation between parts (four squares) and whole (16 squares).

Ontogenesis. Just as in the Oksapmin case in which there was evidence of form-function shifts in over individual development in the accomplishment of numerical problems, in observations and interviews with children in Ms. Snow’s class, we find that children’s schematizing activities shift over ontogenesis. Indeed, less mathematically sophisticated children create representational meanings with fraction words that differed qualitatively from more sophisticated children. For example, less sophisticated children tend to schematize fraction words as a brand of whole number words and the conceptual object of fractions as “pieces” not as relations between parts and wholes. Such children use “one-fourth” to refer to a particular kind of piece (e.g., a quartered circle) or a particular number of pieces (e.g., four pieces). With increasing participation in partitioning activities, we see a form-function shift. Children begin to differentiate and coordinate part-whole relations and begin to use fraction terms to serve the function of representing relations between parts and wholes.

Sociogenesis. Finally, we also observed various sociogenetic processes in Ms. Snow's classroom involving the production of new means of accomplishing problems and the spread of these means through the classroom such that they become normative procedures, analogous to aspects of sociogenesis in Oksapmin. Consider one such case. In their collaborative work, some children had developed an understanding of fractions as relations between parts and wholes. They penciled 8 cells in different parts of the square to represent one half (eight of 16 cells), four cells to represent one-fourth (four of 16 cells), and 2 cells to represent one-eighth (two of 16 cells); subsequently, they abbreviated their analysis of parts and wholes, such that they made use of the number of pieces that would be equivalent to each fractional part, as they produced different squares. The procedure of counting pieces to create specific fractions was imitated by others, and spread through the classroom. For many 8, 4, and 2 cells became synonymous with the terms "one-half," "one-fourth," and "one-eighth," respectively. Appreciating that the counting strategy was becoming a classroom norm, Ms. Snow administered an assessment to her class that depicted two squares, one with 16 and the other with 24 cells, both of which had 8 cells grayed. She wrote on the problem sheet, "Both squares have 8 colored squares, but one shows $1/2$ and the other shows $1/3$. Explain why." She found many children that were stumped and targeted those children for additional help, an effort to re-direct the process of sociogenesis.

CONCLUDING REMARK

In this paper, I have sketched ways of (a) understanding cognitive development that highlight its cultural roots as well as (b) understanding culture change that highlight its roots in individual development. In the account, processes of microgenesis, ontogenesis, and sociogenesis play off of one another in collective cultural practices. In microgenesis, individuals create schematizations that build on prior representational and strategic constructions (ontogenesis). In turn, these schematizations may become appropriated by others, becoming seeds for the spread of new collective forms of representation or procedures for problem solving in a community (sociogenesis). With the sociogenesis of cultural forms, individuals gain access to new forms for microgenetic schematization which become the basis for new ways of engaging in practices and the germs for subsequent ontogenetic shifts in knowledge. Such an account may not only reveal the interplay between cultural and developmental processes over the social history of traditional groups, it may also provide a frame for understanding the dynamics of cognitive development in collective practices closer to home.

References

- Cole, M. *Cultural Psychology: A Once And Future Discipline*.
Cambridge, MA: Harvard University Press, 1997.
- Cole, M. and Scribner, S. *Culture and thought*. NY: John Wiley & Sons,
1974.
- Gearhart, M., Saxe, G. B. Ching, C. C., Nasir, N., Bennett, T., Rhine, S.,
Sloan, T. *When can educational reforms make a difference?
Opportunities to learn fractions in elementary mathematics
classrooms*. Berkeley, CA: University of California, Berkeley,
1997.
- Greenfield, P. M. (in press). use paper in this volume.
- Luria, A. R. *Cognitive Development: Its Cultural And Social
Foundations*. Cambridge, MA: Harvard University Press, 1976.
- Piaget, J. Piaget's theory. In P. H. Mussen (Ed.) *Carmichael's Manual
Of Child Psychology* (p. 703-732). NY: John Wiley & Sons, Inc.,
1970.
- Saxe, G. B. Developing Forms Of Arithmetic Operations Among The
Oksapmin Of Papua New Guinea. *Developmental Psychology*, 1982,
18(4), 583-594.
- Saxe, G. B. *Culture And Cognitive Development: Studies In
Mathematical Understanding*. Hillsdale, NJ: Erlbaum, 1991.
- Saxe, G. B. Studying Cognitive Development In Sociocultural Context.”
In D. Jessor , A. Colby, & R. Shewder (Eds.) *Ethnographic
Approaches To The Study Of Human Development* (pp. 275-303).
Chicago: University of Chicago Press, 1996.

- Saxe, G. B. Gearhart, M., & Seltzer, M. Relations between Classroom Practices and Students' Developing Mathematical Understandings. Berkeley, CA: University of California, Berkeley, 1997.
- Scribner, S. Vygotsky's Uses Of History. In J. V. Wertsch (ed.), *Culture, Communication And Cognition: Vygotskian Perspectives*. New York: Cambridge University Press, 1985.
- Scribner, S. & Cole, M. *The Psychology Of Literacy*. Cambridge, MA: Harvard University Press, 1981.
- Vygotsky, L. *Mind In Society* (eds., M. Cole, V. John-Steiner, S. Scribner, & E. Souberman). Cambridge, MA: Harvard University Press, 1978.
- Vygotsky, L. In A. Kozulin (Ed.), *Thought And Language*. Cambridge, MA: MIT Press, 1986.
- Werner, H., & Kaplan, B. *Symbol Formation*. New York: Wiley, 1962.
- Wertsch, J. *Voices Of The Mind*. Cambridge: Harvard University Press, 1991.

Endnotes

¹ Other authors who make similar arguments include Cole (1997), Greenfield (this volume???), Luria (1976), Scribner (1985), and Wertsch (1991).

² Due to design considerations described in a prior article (Saxe, 1982), about one half of the individuals in each population group solved $6+8=?$ and the other half solved $6+7=?$. The the bar chart contains the pooled strategies for these two problems.