
Making Change in Oksapmin Tradestores: A Study of Shifting Practices of Quantification Under Conditions of Rapid Shift towards a Cash Economy

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Abstract

We report two studies about shifting practices of quantification in tradestores in Oksapmin communities (Papua New Guinea). In Study 1, we enlisted 7 local tradestore clerks to collect information about customers' language practices of quantification, age cohort, schooling level, and cost of purchase. Analyses of 305 exchanges revealed that older cohorts tended to use indigenous practices and extensions of the indigenous language. Younger cohorts – particularly those with some schooling -- tended to use practices that involved Melanesian Pidgin. In Study 2, we analyze interviews with 9 tradestore clerks who described typical purchase transactions with customers from different age cohorts/schooling levels. Analyses of interviews revealed that elders tended to structure multi-item purchases into sequential transactions and use extensions of indigenous approaches to quantification. Schooled adults tended to purchase multiple items in a single transaction and use Pidgin quantifiers. We argue that tradestores today sustain multiple practices of quantification but also support change towards the exclusive use of Melanesian Pidgin.

Human communities have used a diversity of practices for quantifying their physical and social worlds. Many of these practices are documented through archeological records – the Ancient Sumerians used cuneiform tablets for book keeping records (Damerow, 1996), the Mayans used their place value system to keep calendar records of births and deaths (Closs, 1986), and the Incas used the knotted quipu to keep records for gold mining and personal information (Ascher & Ascher, 1981).

Though these practices may be stable over many generations, they are also subject to innovation and change over the social histories of communities (Crump, 1990; Menninger, 1969). For example, in medieval Europe the confluence of economic forces and local conditions of mercantile transactions led to the shift from Roman Numerals and counting boards to Hindu-Arabic arithmetic notational conventions and arithmetical algorithms (Swetz, 1987).

In today's world, perhaps the geographical location of greatest diversity and change in systems of quantification is in Papua New Guinea, with groups that use over 700 different natural languages and whose numeration systems vary widely (Lancy, 1983; Lean, 1992; Moylan, 1982; Wassmann & Dasen, 1994). As indigenous groups have had increasing contact with Western mathematical systems, indigenous systems are giving way to practices of quantification inherent in Melanesian Pidgin in which expressions for number are similar to English (Pidgin is one of the country's official languages). There is remarkably little systematic documentation of processes of change and forces that support change in quantitative practices. In this article, our purpose is to report two studies that capture some aspects of the dynamics of change. Our focus is on Oksapmin communities that occupy remote valleys in the Sandaun Province of Papua New Guinea.

The Oksapmin are a cultural group that today number about 18,000, occupying two valleys in a mountainous region in the Western part of the Sandaun Province, Papua New Guinea (see Weeks (1981) for a compendium of essays about the area). Traditional sources of subsistence that are still a major part of Oksapmin life today include local gardening for root crops (taro and sweet potato), keeping pigs, and hunting small mammals with bow and arrow (Moylan, 1981). There are no roads to the area and the only access is by small plane to dirt landing strips, followed by a hike of up to 4 hours to reach small hamlets.

Social Processes Supporting New Practices of Quantification in Oksapmin Communities

In pre-contact times (prior to 1940), Oksapmin used a 27-body part count system (Moylan, 1982; Saxe, 1981). 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 (see Figure 1). To indicate a particular number, one points to the appropriate body part and says the body part name. For example, to indicate the number 12, one points to the ear which is the 12th body part and says the word for ear, "nata". To count past the 27th body part, one continues up to the wrist, forearm, and on up and around the body. There is no distinction between the name for the 21st body part and the 29th body part; both are called "tan besa" or "other forearm". Thus, context is crucial for an understanding of the numerical referent for any number in the Oksapmin counting system.

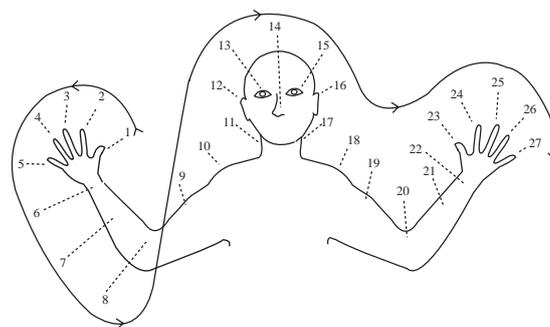


Figure 1. The Oksapmin 27-body part counting system. Body parts in order of occurrence: (1) *tip^{na}*, (2) *tipnarip*, (3) *bum rip*, (4) *h^{tdip}*, (5) *h^{th^{ta}}*, (6) *dopa*, (7) *besa*, (8) *kir*, (9) *tow^t*, (10) *kata*, (11) *gwer*, (12) *nata*, (13) *kina*, (14) *aruma*, (15) *tan-kina*, (16) *tan-nata*, (17) *tan-gwer*, (18) *tan-kata*, (19) *tan-tow^t*, (20) *tan-kir*, (21) *tan-besa*, (22) *tan-dopa*, (23) *tan-tip^{na}*, (24) *tan-tipnarip*, (25) *tan-bum rip*, (26) *tan-h^{tdip}*, (27) *tan-h^{th^{ta}}*.

Several interdependent factors have supported change in quantitative practices. We focus on two – schooling and economic exchange. Below, we briefly sketch how these processes have come to penetrate Oksapmin daily life and in particular, the representation of quantity.

Economic exchanges and the use of Western currencies

It is likely that early patrols and missionaries introduced Western currency to the region some time after the time of contact. During the mid-1960s through the 1970s, men were recruited from the Oksapmin region to work in far off plantations for money. Typically, the men would stay for 2 years at a time before returning to Oksapmin. Upon returning, some opened small tradestores where they sold bags of rice and tins of fish to members of their hamlets. People congregated at the tradestores, stopping to share news and stories when they bought supplies (Guilford, 1981). In a study conducted in 1980, Saxe (1982) documented emerging arithmetical practices associated with participation in the newly emerging money economy linked to stores. Tradestore clerks and their more frequent customers began using the 27-body part system in novel ways in order to accomplish the novel and complex forms of arithmetical problems.

During the 1980s, the multinational Ok Tedi gold/copper mine became operational. The mine and Tabubil, the remote town that supports the mine, are about a 40 minute “bush” plane flight away, or approximately 100 kilometers over rugged terrain. The mine brought about increasing commercial activity in the Oksapmin region. Some Oksapmin found work at the mine, sending currency back to family in Oksapmin communities. Others remained in or returned to Oksapmin communities, becoming brokers or opening tradestores. The demand for vegetables to feed the mine-workers increased vegetable exports dramatically, so that by 2001, almost all Oksapmin families grew extra vegetables for export.

The growing participation with a cash economy in Oksapmin co-occurred with changing system of currency. The first Western currency to enter Oksapmin was Australian pounds and shillings, with 20 shillings to a pound. In 1966, Australia started using dollars and cents, but the terms ‘faun’ (from ‘pound’) and ‘siling’ (from ‘shilling’) had taken hold in Oksapmin language practices and use of these terms persisted. In 1975 a newly independent Papua New Guinea introduced its own currency based on a decimal system: 100 toea is equal to 1 kina. Many people engaged with economic exchange made use of the familiar pound/shilling currency in referring to the new currency, calling a 10 toea coin a ‘siling’ and preserved the 20-to-1 relation between pounds and shillings by calling the K2 note ‘wan faun’. Adaptations of the traditional counting system were linked to the structure of the shilling-pound Australian currency system. To count using adapted systems, one enumerates shillings from the thumb (1) to the elbow (20), a point that became equivalent to one pound (“wan faun”). To count further, typically one returns to the thumb (1) on the first hand (“wan faun, wan siling”), though other approaches are used as well (Saxe, 1982).

Schooling

Schooling is another factor that has influenced practices of quantification used in Oksapmin. The first community or “bush” school in Oksapmin opened in the 1970s, though the 1962 mission functioned to teach the Bible in Oksapmin communities. Since 1962, the number of schools has multiplied and the number of students has greatly increased. Schooling in Oksapmin was officially in English, though some Pidgin was also used. Basic skills in academic subjects are emphasized. Although the amount of schooling varies widely between individuals, most young people in Oksapmin today have completed at least a few years of schooling. Middle-aged adults are much less likely to have gone to school, and the elders in the community have not had access to school. In 1980, Saxe found some evidence that children in schools were using their indigenous body part counting system to help them solve problems in school (Saxe, 1985). In a follow-up study conducted in 2001 (Saxe & Esmonde, in preparation), we found that very few children used indigenous counting strategies to solve school mathematics problems, a fact that may well reflect shifting uses and knowledge of the body part system among today’s Oksapmin youth.

Tradestores as Sites for Practices of Quantification in Public Activity

As a result of the rapid social changes, people in the Oksapmin area use a remarkable

heterogeneity of mathematical practices. Many Oksapmin use Pidgin count words and the body system side by side as alternative forms of representation. Today's tradestores are one principal site where this heterogeneity is visible and in which practices that are favored by different segments of Oksapmin society come into contact. In our efforts to understand the shifting practices of quantification in Oksapmin communities, we chose tradestores in Bak (one of the two Oksapmin valleys) as a principal site for study of practices of quantification.

Tradestores in Bak Valley

A rough map of the Oksapmin area and the principal path that runs through the Tekin and Bak valleys is contained in Figure 2, as are local tradestore locations. The path does not support motorized vehicles – all transport of commodities is by foot. The tradestores depicted in the figure became principal sites for our work.

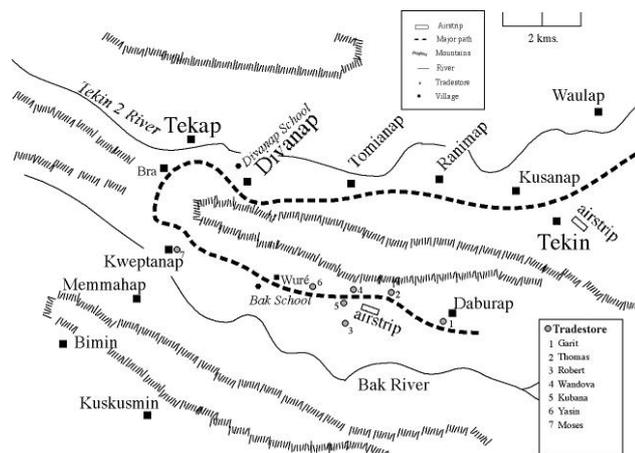


Figure 2. Map showing trail from Tekin to Daburap and store locations in Bak valley.

Stores are made of materials indigenous to the community, save the roof, which is sometimes made of imported metal. Three typical stores are pictured in Figure 3. Tradestores in Oksapmin vary in the number of commodities that they contain and the amount of business that they support. The stores that are engaged with the most transactions are adjacent to the airstrip and vegetable market.



Figure 3. Tradestores in Oksapmin, 2001.

Inside the store, as captured in Figure 4, a storeowner or clerk stands behind a counter on which transactions are made. The commodities for sale are displayed behind the counter, and often (but

not always) prices are posted with written numerals. Prices are always rounded to the nearest unit of 10 toea.



Figure 4. Interior of Oksapmin tradestores, 2001.

STUDY 1

Our aim in this study was to gather information on the use of quantitative language in stores. In field observations, we noted that to represent quantity, people sometimes used Oksapmin language (specialized language and/or body parts), Pidgin numbers, or a mixture of the two. To systematically sample quantitative language use in stores, we documented some features of practices that individuals used in transactions in several different tradestores. We focused our data collection to capture trajectories of shifting practices of quantification over generations, and to examine the role of schooling in trajectories of change.

Methods

Participants

Participants included both store clerks and customers. We describe each group below.

Store clerks. Nine individuals who worked in one of seven tradestores located in Bak valley. Participants varied in age from adolescents to late thirties. Most of our sample consisted of storeowners who worked as clerks in their own stores.

In our recruitment procedures, we approached clerks from each store in Bak Valley, asking whether they would participate in our work. We explained that our purpose was to understand economic transactions that occurred in stores where people made or considered making purchases. We explained that we wanted the clerk to help us by recording information about the transactions occurring in their stores. We indicated that we would pay the clerk for his/her efforts.

Customers. Our tally of clerk records revealed more than 300 transactions occurred in the time allotted in data collection. These transactions were unequally distributed over population groups. Of the total transactions, we found that Elders, Older Adults, Younger Adults, and Youth participated in 15, 65, 102, and 123 transactions, respectively.

Procedures

Transaction recording form and its use. We presented each clerk with a form contained in Appendix A. The form contained 10 columns and 8 rows. Each row was used to record information about a single purchase. Each column was used to document information related to that purchase. In presenting the chart, we reviewed each column, explaining the meaning of each category and the values that were to be entered under each category. Further, we explained that each row was to represent a single transaction. If a customer requested an item, paid for the item and then requested and paid for a second item, the exchanges were to be recorded as two transactions.

Of import for the present analysis were the following columns on the transaction recording form:

- (1) Name of customer [filled in];
- (2) Age of customer [circle one of three well-known individuals in the community that span in age from young adult to community elder; two additional categories were also included, child and school age individual];
- (3) Grade completed in school [circle no school, Grade 1-5, Grade 6 or above];
- (4) Language used for number [Oksapmin, Pidgin, Mixture of Oksapmin and Pidgin];
- (5) The number of items purchased [circle: 0, 1, 2, 3, 4, 5, 6+];
- (6) The amount of money that the customer offered for the goods [enter amount];
- (7) The amount of money that the item(s) cost [enter amount].

Once we reviewed the chart with the clerk, we then engaged in a mock transaction in which the clerk used the form to record a transaction with our Oksapmin research assistant. The clerk made a mock purchase and the clerk filled out a row under our supervision. We answered questions as they emerged and we repeated the process, if necessary, to clarify the recording task. We visited stores during the time that individuals were using the forms, observing how the forms were being used and checking whether clerks had any problems with the forms. Most had few problems.

Debriefing. We retrieved the transaction record forms shortly after the clerks finished using them (the late afternoon or the next morning). We checked over the forms with the clerks individually, asking for clarification of questionable entries as a check of how faithful the participant was to our procedures. We made some changes in entries in collaboration with the participant on questionable entries. On one occasion, we discarded a day's entries and asked the participant to repeat the day's efforts.

Whenever possible, we selected three records from each of the clerk's diary of records for a follow-up debriefing interview. One record involved a transaction with a community elder, another with a middle-aged adult with schooling, and another with a middle-aged adult without schooling. Sometimes no individual from a targeted group was present in a clerk's record sheets. For groups that were represented, we tried to select a transaction for the interview that had recently occurred. We avoided interviewing participants about transactions that occurred many hours earlier (except in the small tradestores that had very few customers).

Once targeting selected transactions on the diary record sheets, we elicited narratives from the clerk about the structure of the exchange. The interview was designed to elicit a 'blow-by-blow' description of the transaction. "After entering your store, what did s/he do first? (Did they say anything to you? What?) What did you do? What did you say? What would he/she do next?..." This style of turn-taking elicitation continued until the exchange was completed. We were particularly attuned to the following issues that occur in transactions: (Consider Items, Consider Prices, Select Items, Pay for Items, Break Denomination, Exact Change, Receive Change, Credit).

Results

Transactions and Amounts Tendered

The number of total recorded transactions varied across stores. The greatest number of transactions at a single store was 104 and the least was 2. For purposes of analysis, we pooled all transactions across stores, regarding them all as occurring in Bak valley and displaying common properties. To determine an overall sense of the amount of cash and goods exchanged across transactions, we computed amounts paid for items, number of items in a purchase, and whether change was tendered across all of the recorded transactions. Costs of items for purchases varied from 0 to K36.¹ The median purchase was K1.50. The number of items purchased also varied from no items to more than 6 items. The median number of items purchased was 1. Finally, for 45% of the transactions change was tendered; for the transactions in which change was not tendered either the customer produced exact change, or, on a few occasions, the customer bought goods on 'credit'.

Language Practices of Quantification in Purchases

To analyze quantitative language use in transactions by cohort and schooling, we made use of three codes for the language used for quantitative representations. The codes were drawn directly from the diary record sheets. These included, "Indigenous Only", "Pidgin Only", and "Mixed." It is unusual for Oksapmin speakers to use Pidgin when speaking to other native Oksapmin speakers, except for quantification. We will provide example narratives from our debriefing interviews with clerks to exemplify language use for number in the stores.

"Indigenous only" indicated that a customer only used expressions for quantity based upon indigenous quantification methods. Items included in this category include references to body parts used in the conventional body system, references to small values in the 5-number system for conversational numbers, and references to currency units using traditional language. (For example, the 50-toea coin is termed a "gangasi", meaning the pointed one, referring to its cornered points. A K2 note may be referred to as "haben," meaning "leaf of tree.") We report below two transactions described by tradestore clerks in which customers only used indigenous practices of quantification.

Clerk: KUB, Customer: STE (Unschooling Adult). STE entered the store, asking for a bag of rice and a can of tinned mackerel. He already knew the prices of these items, because he is a frequent customer at the store. (Prices are posted beside each item.) The total cost of the items was K7.20, but neither KUB nor STE said the values aloud. STE handed KUB a K10 note, and told KUB that he expected "haben tansi kir hai" back in change [K2.80, literal translation: 'leaf of tree (K2) and elbow (8 10-toea coins)']. KUB gave STE his change, which he did not count but put directly in his pocket.

Clerk: ROB, Customer: HAN (Elder). Two days earlier, HAN had come into the store and asked for noodles. At that time ROB told him the price. On the day of the study, HAN returned and asked for a package of noodles, handing ROB a K5 note. ROB gave him back K4, without counting it out. ROB explained that HAN probably remembered the price of noodles from his previous visit to the store. HAN returned a few minutes later, asking for the price of a cooking dish, and ROB told him in the indigenous language, "imah kak-si, wan faun tana" [K22, literal translation: 'pig head (K20), one pound (the equivalent of K2)']. The phrase 'pig head' refers to the K20 bill, which has a picture of a pig's head on it, while 'one pound' refers to K2.] HAN turned to his wife, who was standing next to him, and asked in Oksapmin language for K2. She handed him a K2 note. After examining the cooking dish, HAN went back outside. A few minutes later, he re-entered the store, having decided to buy the dish. He put a K20 note and a K2 note on the counter. ROB took the money without comment and handed HAN the dish.

"Pidgin only" referred to quantitative language use that was only in Melanesian Pidgin. The

Pidgin numbering system closely resembles English.

Clerk: RUT, Customer: SPA (Unschooling Adult). SPA entered the store and asked the price of a Coca-Cola (Note: in this store, prices are posted beside each item.) RUT answered in Pidgin, saying “tu kina, tuwenti toea” [K2.20]. SPA then asked for the price of a packet of biscuits. RUT again answered in Pidgin, saying, “wan kina, forti toea” [K1.40]. SPA gave RUT two K2 notes, then asked her for the total cost of the two items. RUT again answered in Pidgin, saying “tri kina, sexti toea” [K3.60]. She took the two bills, told him that his change was “forti toea” [40t], and returned his change. SPA put the change in his pocket without counting it. Notice that SPA never used any number words in either language, and spoke only in Oksapmin language. RUT spoke primarily in Oksapmin language, only using Pidgin for the number words.

Clerk: NIC, Customer: MER (Schooled Adult). MER came into the store and asked for the price of a packet of rice. (In this store, prices are not posted). NIC told MER the price in Pidgin: “fo kina, eiti toea” [K4.80]. MER asked to buy three packages of rice but did not ask for the total cost. He gave NIC a K20 note. Neither man said the total cost of the 3 packets of rice. When NIC gave the change to the customer, they both counted it out together. (The clerk may have used a calculator to compute change.)

Finally, “Mixed use” was defined as the use of both Pidgin and indigenous methods of quantification in the transactions.

Clerk: THO, Customer: ERI (Schooled Adult). ERI entered the store and said that he wanted to buy “tupela batteries” [2 batteries]. ERI did not ask for the price and presumably read it from the sign beside the batteries. ERI said the total cost himself in Pidgin, as “faiv kina, forti toea” [K5.40]. Then ERI counted out the correct change, listing the coins and bills in Oksapmin language: “haben tan tita, haben tan tita, temsi tan tita, gamen tan tita, gamen tan tita” [K5.40, literal translation: ‘flat leaf of tree (K2), flat leaf of tree (K2), flat one with hole (K1), married flat one (20t), married flat one (20t)’]. Once ERI had counted out the correct amount, ERI handed all the money to the owner, who put it away.

These narratives illustrate that the tradestore transactions are collective accomplishments, as the customer and the clerk each accommodate to the communicative moves of the other. In this give and take, particular choices are made in the language that is used for number in the interactions. On some occasions the customer appears to play a leading role in language choices in the interactions. For example, when STE (customer) uses Oksapmin to tell KUB (clerk) how much change he should receive, STE appears to take the lead. On other occasions, the clerk appears to determine the language used for number. When SPA (customer) asks RUT (clerk) for prices of Coca Cola and a packet of biscuits (in Oksapmin), the clerk (RUT) answers in Pidgin, telling SPA his change. The clerk’s use of Pidgin anticipates the customer’s fluency in Pidgin numeration. Clerks and customers know one another well in Oksapmin communities and are generally knowledgeable of one another’s language and arithmetical fluencies in Pidgin and Oksapmin.

In order to document generational shifts in quantitative language use and relations with schooling, we partitioned records into both age cohort and levels of schooling. Age Cohort consisted of 4 levels. These included Youth, Younger Adult, Older Adult, and Elder. Schooling included three levels, including No school, Grade 1-5, and Grade 6 and beyond. We then analyzed the transaction records as a function of language use by cohort and level of schooling. The results of this analysis are contained in Figure 5.²

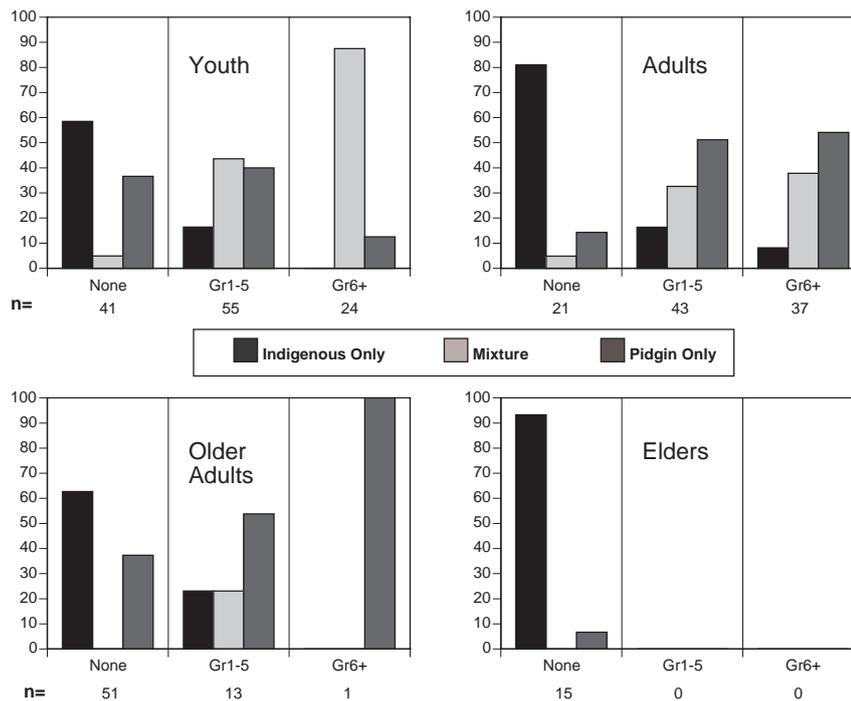


Figure 5. Percent distribution for language of quantification as a function of age cohort and schooling level.

Inspection of Figure 5 reveals several features of linguistic practices of quantification in Oksapmin tradestores. Perhaps most striking is the diversity of quantitative language use. Both indigenous practices of quantification and practices associated with Melanesian Pidgin are well represented in store transactions, though frequency of these practices differs by cohort and level of schooling. In the populations that have had no access to schooling, there is predominant use of only indigenous methods of quantification. Indeed for the “No School” categories, all age cohorts make use of “Oksapmin Only” as the principal category, whether Youth (58%), the Younger Adults (81%), Older Adults (63%), or Elders (93%). With participation in a Grade 1-5 level of education, we find a shift to use of Pidgin, though all populations retain some level of “Indigenous Only” language use. With Grade 6+, “Indigenous Only” is no longer present among the Youth, and less than 10% of the transactions made use of “indigenous only” in the Younger Adults with Grade 6+.

In the Grade 6+ transactions, the difference between Youth and Younger Adults is noteworthy. Many of the adults have visited or lived in Tabubil, a mining town where many Oksapmin have sought gainful employment. It may well be that engaged in economic exchange in the town, which is a melting pot for many different indigenous groups that do not speak Oksapmin, is a press for using a common system of quantification, Melanesian Pidgin.

Summary

These findings show a remarkable heterogeneity in practices of quantification in Oksapmin tradestores. Indigenous practices and practices linked to Pidgin exist side by side, though the trajectory of change is towards exclusive use of Pidgin, with schooling associated with increased use of practices of quantification involving Pidgin.

STUDY 2

Our findings from the prior study revealed that individuals used a diversity of practices of quantification within stores. The practices reflect both elders' efforts to stretch indigenous practices of quantification to the relatively novel problems that occurred in stores as well as the use by schooled individuals of new practices of quantification associated with Melanesian Pidgin. Notable in our informal observations and discussions was the fact that clerks had developed considerable knowledge about the nature and organization of transactions with customers from different age cohorts. The purpose of the present study was to draw upon the expertise of the clerks to help us understand ongoing shifts in practices of quantification in the Oksapmin community as well as the role of clerks in brokering these shifting practices. To this end, we engaged study participants in an interview in which we asked them about prototypical transactions with two types of customers: elders and schooled adults. These two types of customers presented different profiles in their practices of quantification in our diary records. We asked about typical transactions with which these customers engaged under two common conditions – one in which customers had exact change available for a purchase and one in which they only had a single larger denomination.

Methods

Participants and Location

The nine tradestore clerks who participated in the previous study were interviewed for the present study. Each interview was conducted in the clerks' respective stores.

Procedure

In an interview, we presented store clerks with four scenarios. Each involved a customer who arrived at the store and purchased the same two items. In the scenarios, the customer had either a K5 note or notes and coins adding up to K5. The focus of the interview was on how the purchase was accomplished (e.g., language used, how payment and return of change was accomplished), depending on the cohort of the customer (community elder or adult with schooling) and whether or not the customer had exact change for his or her purchase. We describe the structure of the interview below.

We conducted all interviews at the clerks' stores. To integrate our procedures with clerks' everyday experience with customers, we chose to use two items in each particular store that together: a) cost more than K4; b) cost less than K5; and c) could be paid for with exact change from the amount of money laid out in the multi-denomination condition. Throughout the interview, we assumed each of the customers wanted to buy these same two items.

We counterbalanced the order of the scenarios: for one half of the interviews, we began with the scenario involving the elder, and for the other half, we began with the scenario involving the schooled adult. In both scenario types, the story involving the "exact change NOT possible" condition was followed by the "exact change possible" condition. In all, we used four stories. The first two involved the transactions in which the customers' production of exact change was not possible, and the second two involved transactions in which exact change was possible. In all interviews, we brought coins and notes to represent the money that the fictional customer brought to the store.

Story 1: Exact change NOT possible (single denomination [K5 bill]), community ELDER. We used the following line of questioning for this condition.

“Suppose an elderly person came to your store, and s/he had this amount of money.”

We would then place one K5 note in front of the participant. We asked the participant to suppose that the elderly customer wanted to buy the two items we had selected.

We then asked,

“what does the elderly person do first when they enter your store? ... Do they say anything to you? ... What?... What do you do? ... What do you say? ... What would he/she do next? ...”

This line of questioning is repeated with appropriate probes until a narrative of the exchange is completed..

Story 2: Exact change NOT possible (single denomination [K5 bill], schooled ADULT. The same procedure is used as that for the community elder, single denomination condition. However, “schooled adult” is substituted for a “community elder”.

Story 3: Exact change possible (multi-denominations), community ELDER. The same procedure is used as that for the community elder single denominations condition. However, in this case we lay out one K2 note (K2), six 10t coins (K0.60), two 20t coins (K0.40), two 50t coins (K1), and one K1 coin (K1) to represent the money carried by the community elder. The total of the money laid out is K5.

Story 4: Exact change possible (multi-denominations), schooled ADULT. The same procedure is used as that for the community elder, multi-denomination procedure. However, “schooled adult” is substituted for a “community elder”.

Results

Language used for number

In all the interviews, we asked participants what language the customer of the targeted cohort would typically use to express numbers: Oksapmin language, Pidgin, or both. All participants but one stated that they expect elderly customers to use only Oksapmin language, regardless of whether or not they had a single denomination (K5) or multiple denominations adding up to K5. (The one clerk who stated that he expected elders to use Pidgin was a young high school student who said he didn't know how to express numbers and prices in Oksapmin language. In order to communicate with this clerk, the elderly customers would have to use Pidgin.)

The clerks' judgments about language use for schooled adults also did not depend on the currency condition. Whether or not customers had exact change for their purchases, tradestore clerks expected their schooled adult customers to use predominantly Pidgin, or a mix of Pidgin and Oksapmin language.

Structure of Transactions

In the interview narratives we found that clerks reported two ways in which individuals accomplished a purchase, organizations reflected in our analysis of diary records from Study 1: (a) Individuals purchased both items in a single transaction; (b) individuals purchased items sequentially, first purchasing one item and then purchasing another.

Frequencies of reported payment structures are reported in Figure 6. These results are presented as a function of customer type and currency condition. For the schooled adult customer in both currency conditions, all of the clerks (9 of 9) described “both items at once” transaction structures. In contrast, for the Elders transaction type varied over currency condition. All clerks reported transactions of the “one item at a time” type in the “exact change possible” condition. However, in the “exact change NOT possible” condition, reports were less consistent. Some clerks reported “item by item” purchases, many reported “both items at once” purchases, and one narrative description was unclear.

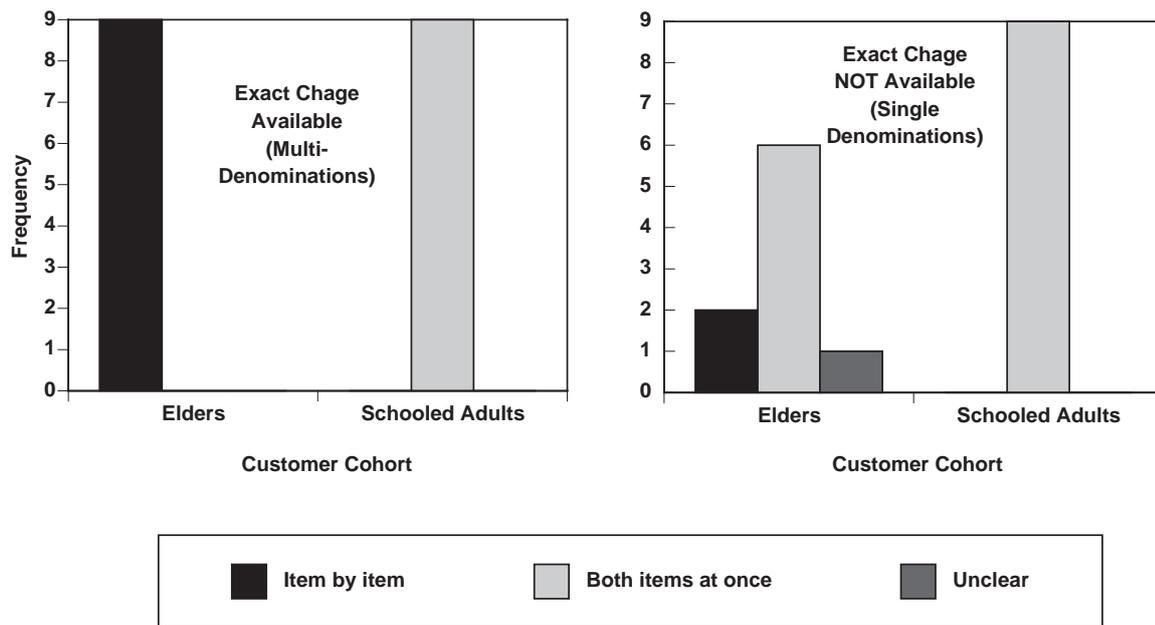


Figure 6. Frequencies of payment structures reported by clerks as a function of currency condition and customer cohort

In sum, when exact change is not available, all customers are more likely to buy both items in a single transaction. However, when exact change is available, schooled adults are likely to purchase both items at once, whereas community elders are likely to purchase items one at a time. It is noteworthy that Study 1 indicated that only 7% of the purchases of 2 items or more were of the sequential variety.

Approaches to Quantifying Payment and Change

Another focus of the interview was on the mathematical computations involved in making payments and determining change. In a single transaction, customers and clerks need to take into account the prices of each item, the total cost for multiple items, and the change paid to the customer. Do tradestore clerks typically perform all the mathematical work involved in a transaction, or do their customers solve some of these problems? Do these behaviors differ between the two cohorts we discussed? We will discuss the two currency conditions separately, as the mathematical problems involved are distinct. Data for the Schooled Adults and Unschooled Elders across the two currency conditions are presented in Figure 7.

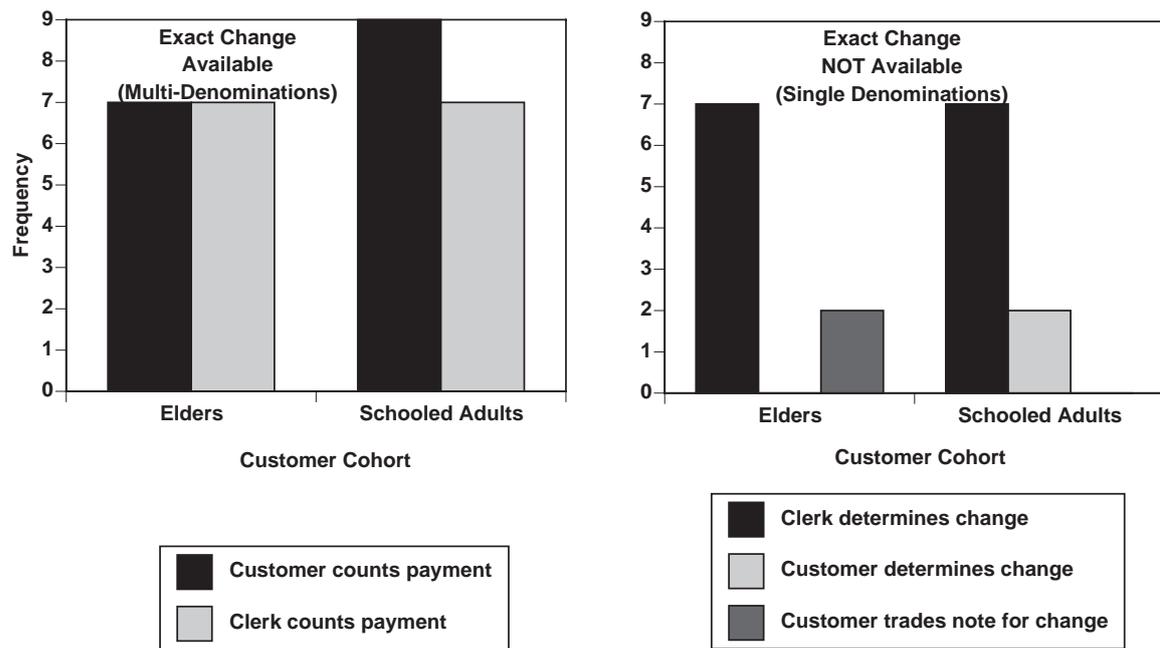


Figure 7. Frequencies of payment and change types reported by clerks as a function of currency condition and customer cohort

Exact change possible. When exact change is available for the purchase, we found that clerks reported that both customer cohorts did some of the mathematical work in the purchases. All of the clerks reported that schooled adults typically count their payment before presenting it. Seven of 9 participants reported that elders would typically count out their payment. Referring to both customer cohorts, 7 of 9 clerks reported that they themselves would typically count the payment. (Participants often reported that both clerk and customer would typically count the payment.)

Exact change NOT possible. When customers do not have exact change they have a number of choices. Customers can either ask for change, or simply pay with the K5 note – these choices lead to different kinds of mathematical problems. If customers exchange a note for change, they create the equivalent of the ‘exact change possible’ condition. Two of 9 participants reported that community elders often ask for change when they enter a store. In contrast, according to clerk reports, schooled adults never ask for change for their bill before making a payment.

When a customer pays for items with a single K5 note, they must receive change. Clerks reported that they would be most likely to do the mathematical work of determining change. For both elderly and schooled adult customers, 7 of 9 participants reported that the clerk would determine the change. The remaining study participants reported that the schooled adult customers would most likely determine the amount of change for themselves, whereas, as noted previously, the elderly customers would most likely have exchanged their bill in order to pay with exact change.

Limitations with the Interview Data

Our interviews posed challenges to clerks. Clerks were asked to abstract from a multitude of exchanges and report a particular pattern focusing on particular population groups. Clearly, there is considerable room for distortion in their accounts. We attempted to mitigate the methodological problems in several ways. We selected for our interview tasks commodities actually found in each of the clerks’ stores, and we made use of tasks that were typical, linked to the kinds of exchanges observed in everyday transactions. Finally, our interviews supported our documentation in Study

1 – that customer-clerk transactions emerged differently for customers of different cohorts in predictable ways.

General Discussion

Tradestores are one of varied sites in which arithmetical problems emerge in Oksapmin communities, problems for which traditional practices of quantification are ill suited. In our effort to understand shifting practices, we focused our analysis on tradestore exchanges of individuals of different age cohorts and with different levels of schooling. Our data sources were varied. They included our own preliminary observations of store transactions, the development of diary methods that supported clerks' documentation of language for number used in store transactions, and interviews with clerks about how prototypical transactions unfold with customers of different population cohorts.

It is also noteworthy that we did not use particular methods. We did not code direct observations of transactions. Though our initial observations were helpful in framing our study, such direct observations were not a viable approach for covering multiple stores; further, we also believed that our presence might lead transactions to differ from the typical. Thus, in our first study, our diary records with regular and careful follow-up became an attractive alternative. In our second study, we interviewed only clerks about their transactions with customers. We did not interview customers about their interactions with clerks, though such data would have been a useful source to corroborate our findings of cohort differences.

Our analyses in Study 1 revealed that community elders and many individuals from younger cohorts with limited schooling extended indigenous practices to represent and accomplish problems in stores, and thereby rendered those problems tractable. These extensions were quite varied.

Often extensions included the use of ordinary language to represent large numerical values and specific denominational units of currency. We found varied examples of these extensions in our observations, informal discussions, and narratives produced by clerks. 'Ganga-si' in the Oksapmin language means 'pointed' and in the context of currency use it has come to mean 50-toea. The '50-toea' meaning of 'ganga-si' is linked to the unique characteristics of the 50-toea coin, which is shaped as a hexagon with pointed corners. "Gamun-tan" literally means married (gamun) and flat (tan). In the context of currency use the expression refers to the 20-toea coin – deriving from a marriage between two 10-toea coins that are flat.³ Coins and bills contain images of animals. Indigenous words for cassowary, butterfly, 'cascas' not only index these animals, but have become conventional indices for standard coin and bill denominations themselves.

Perhaps the most complex set of extensions are those linked to the body system itself. In prior work, Moylan (1982) and Saxe (1982) described the attenuation of the body system to 20 as opposed to 27-body parts, an abbreviation that was linked to the counting of shillings to the value of a pound (20 shillings was equivalent to 1 pound). Many people today treat body parts as shillings. Today the 10-toea coin has become the shilling equivalent. Body part expressions like "wrist," the sixth position on the body, are taken to mean six "silings" or ten toea coins, the equivalent of 60 toea.

Of course, the practices that we observed were not limited to extensions of traditional forms, but included the use of Melanesian Pidgin and written notation. Written notation is used extensively in the larger stores, with most commodities marked with paper tags taped to the shelves on which they are displayed. The use of Pidgin supports and is supported by the written notational system for number.

Young cohorts, particularly those who attended school, used practices involving Pidgin

extensively. Pidgin expressions present new methods of quantification, ones organized with multi-unit or base-structure principles analogous to the structure of currency systems. Some Pidgin forms have become so interwoven with everyday practice that they are barely distinguishable from the Oksapmin language. Thus, 'siling' and 'faun' derive from the English words "shilling" and "pound," but they are so commonplace in Oksapmin vernacular that it is unclear whether they are treated as a part of the indigenous language or Melanesian Pidgin.

Our analyses in both Studies 1 and 2 revealed that both customers and clerks orchestrate multiple resources, making efforts to engineer interactions in order to accomplish coherent solutions to emerging problems.⁴ Clerks especially showed remarkable flexibility and were able to support their customers regardless of quantification practices used. In this process, clerks became brokers for diverse members of the Oksapmin community to support the purchase of goods. Indeed, in our interviews with store clerks and in our observations in stores, we found that when purchasing multiple commodities, elders as customers (according to clerks) would re-structure the organization of a computation, purchasing items one by one, and in this process influence the clerks' activities in accomplishing the transaction. At the same time, clerks supported these exchanges, sometimes perhaps anticipating them and sometimes simply following customers' requests. We also found that customers and clerks used currency as a resource, determining the amount left after a single purchase and then considering the possibility of another purchase. Clerks made use of such displays by sometimes taking the appropriate amount for a purchase and sometimes taking an overpayment and returning change. Many clerks posted written prices in their stores so that literate customers could determine prices without clerk assistance. Some literate customers made use of the posted prices and performed the calculations themselves. Thus, in an important sense, exchanges at stores were collective accomplishments of both customers and store clerks as they made use of one another, physical artifacts, and different languages of representation as resources to support transactions.

Even though the store context supported diverse practices of quantification, clerks' language of preference for quantification was Pidgin, at least in the store context. In the larger stores, prices were posted in Hindu-Arabic numerals, the commodities sold were labeled with written script, typically English. Multiple clerks now use calculators to compute change and to support record keeping. When a customer (especially younger cohorts with some schooling) asked for a price in the Oksapmin language, the typical response in used numbers in Pidgin, not Oksapmin. By valuing Pidgin but supporting indigenous representations for quantity, stores serve as an arena of contact between diverse practices as well as a site of social change in practices of quantification.

References

- Ascher, M., & Ascher, R. (1981). *Code of the quipu : a study in media, mathematics, and culture*. Ann Arbor: University of Michigan Press.
- Closs, M. P. (1986). *Native American mathematics*. Austin: University of Texas Press.
- Crump, T. (1990). *The anthropology of numbers*. Cambridge ; New York: Cambridge University Press.
- Damerow, P. (1996). *Abstraction and representation: Essays on the cultural evolution of thinking*. Dordrecht: Kluwer Academic Publishers.
- Guilford, V. Oksapmin trade stores [microform]. S.l.: s.n.
- Lancy, D. (1983). *Cross-cultural Studies in Cognition and Mathematics*. New York: Academic Press.
- Lean, G. A. (1992). *Counting systems of Papua New Guinea and Oceania Glendon Angove Lean*. Unpublished Thesis Ph D --Papua New Guinea University of Technology 1992.
- Menninger, K. (1969). *Number words and number symbols; a cultural history of numbers*. Cambridge, Mass.: M.I.T. Press.
- Moylan, T. (1981). History of Oksapmin area. In S. Weeks (Ed.), *Oksapmin: Development and Change* (Vol. E.R.U. Occasional Paper No. 7). Port Moresby: University of Technology, Papua New Guinea.
- Moylan, T. (1982). *The Oksapmin Counting System*. Paper presented at the 1982 Meeting of the Northeastern Anthropological Association.
- Saxe, G. B. (1981). Body parts as numerals: A developmental analysis of numeration among the Oksapmin in Papua New Guinea. *Child Development*, 52(1), 306-316.
- Saxe, G. B. (1982). Developing forms of arithmetical thought among the Oksapmin of Papua New Guinea. *Developmental Psychology*, 18(4), 583-594.
- Saxe, G. B. (1985). Effects of schooling on arithmetical understandings: Studies with Oksapmin children in Papua New Guinea. *Journal of Educational Psychology*, 77(5), 503-513.
- Swetz, F. (1987). *Capitalism and arithmetic : The new math of the 15th century, including the full text of the Treviso arithmetic of 1478, translated by David Eugene Smith*. La Salle, Ill.: Open Court.
- Wassmann, J., & Dasen, P. R. (1994). Yupno number system and counting. *Journal of Cross-Cultural Psychology*, 25(1), 78-94.
- Weeks, S. G. (1981). *Oksapmin, development and change*. Port Moresby: Educational Research Unit University of Papua New Guinea.

Appendix A

Time	Man or Meri	Kostama	Krismas	Skul (completed)	Tok Usim Kaudim	Senis Note?	Amas samting	Kostama Paid	Em i kostim hamas?
AM	Man		Sel	No School	Tok Ples	Yes	0 1 2		
PM	Meri		Dikitet Henry Skul Age Pikinini	Grade 1-5 Grade 6+	Tok Pisin Both	No	3 4 5 6 or moa		
AM	Man		Sel	No School	Tok Ples	Yes	0 1 2		
PM	Meri		Dikitet Henry Skul Age Pikinini	Grade 1-5 Grade 6+	Tok Pisin Both	No	3 4 5 6 or moa		
AM	Man		Sel	No School	Tok Ples	Yes	0 1 2		
PM	Meri		Dikitet Henry Skul Age Pikinini	Grade 1-5 Grade 6+	Tok Pisin Both	No	3 4 5 6 or moa		
AM	Man		Sel	No School	Tok Ples	Yes	0 1 2		
PM	Meri		Dikitet Henry Skul Age Pikinini	Grade 1-5 Grade 6+	Tok Pisin Both	No	3 4 5 6 or moa		
AM	Man		Sel	No School	Tok Ples	Yes	0 1 2		
PM	Meri		Dikitet Henry Skul Age Pikinini	Grade 1-5 Grade 6+	Tok Pisin Both	No	3 4 5 6 or moa		
AM	Man		Sel	No School	Tok Ples	Yes	0 1 2		
PM	Meri		Dikitet Henry Skul Age Pikinini	Grade 1-5 Grade 6+	Tok Pisin Both	No	3 4 5 6 or moa		

Endnotes

¹ Store clerks included occasions in which customers did not make a purchase but (1) asked about item prices, (2) asked for change, (3) paid credit due.

² Note that if a single customer engaged in multiple transactions in a short period of time, each transaction would be recorded separately even though such sequential transactions might be regarded as a single purchase. We noted that 7% of the purchases that included 2 or more items were sequential transactions. In our data records, 8 individuals made two successive purchases and one individual made three successive purchases. For most of the sequential transactions, customers used “Indigenous Only” (68%). Further, most had no schooling (56%) or little schooling (44%). Of the customers who purchased more than one item, 4 were elders, 31 were Older Adults, 51 were Adults, and 35 were Youth. Of this group, 25% of the Elders, 10% of the Older Adults, 8% of the Adults, and 3% of the Youth made sequential purchases.

³ The use of the 10-toea coin derives from a period prior to independence when the shilling and pound were currency units, and the 10-toea coin became equated with the shilling.

⁴ Consider a particularly telling case of a clerk that one of our informants told us about. He described a storeowner (who was no longer alive at the time of our study) who would only sell to customers who came with 10-toea coins. The clerk thereby avoided arithmetical computations that emerged when making change. While this anecdote must be taken as such, we find it consistent with our observations in tradestores today.

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