Oral Financial Numeracy

A Hypothesis and Exploratory Test

I'd like to be able to calculate with a pen.
► Ms. Yan Pouen, Cambodian rice and cashew farmer

The sharp limits of our short-term memory explain the constant drive towards a compact notation for large numbers.
► Stanislas Dehaene, The Number Sense

My Oral Village

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Abstract

The goal of this study was to assess the capabilities and incentives of illiterate villagers to safely and confidently engage in formal savings or payment transactions in a digital or conventional interface. The study provides support for the proposition that illiteracy is a major cognitive transaction cost with the potential to disable the development of formal financial markets among millions of oral users.

Villages in the developing world face deep financial exclusion. They are oral cultures, where financial behavior is shaped by oral institutions and incentives. In this exploratory field study, involving a test of selected financial numeracy skills of 80 oral adults in Tanzania and Cambodia, combined with supplementary qualitative evidence from markets and focus groups, the evidence suggests that cash is used as a medium of exchange, but not as a store of value. Ability to decode place value and arithmetic zero is low, but ability to decode and manipulate numeric values with the support of physical cash notes and coins is relatively much higher. The paper also presents the results of tests of a simple human-centred design solution that presents financial information to illiterate users in a format that is more closely aligned with the needs of oral users.

Consistent with Ong's analysis of oral culture, we find evidence of relative deficits in several skills which are essential to financial inclusion: including decoding multi-digit number strings, saving and planning for the future in cash, and using calendars to manage household resources. The ability to decode arithmetic notation is lower than might be expected from demonstrated oral numeracy skills. However, we also find evidence of oral strengths that offer cognitive scaffolding for learning key skills, including ability to count large numbers with the support of physical cash notes, widespread ability to read and write individual numerals, facility with mnemonic priming, and willingness to risk using a pen in the testing environment (even after years of non-use).

Oral strengths offer cognitive scaffolding for learning new skills and should be levered in future, in smartphones and financial inclusion more widely.

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I am deeply grateful to the many participants in this study who dared to 'pick up a pen' and who are not afraid to show the world that their capabilities count. May your dream of a path out of poverty come true for you, and those you love.

Errors and omissions are mine alone.

Glossary

Financial inclusion

In 2010 the G20 created the Global Partnership for Financial Inclusion (GPFI), and summarized the rationale for, and expected impact of, achieving financial inclusion as follows.

> Universal financial inclusion requires bringing the 2.5 billion people (or about half the working age population) currently excluded, into the formal financial system. Financial Inclusion, with its full spectrum of financial services, helps build domestic savings, bolster household, domestic and financial sector resilience, and stimulate business and entrepreneurial activity. The cumulative effect of widespread exclusion is increasing inequality, economic distortions and slower growth and development. (GPFI, 2014, p. 3)

The GPFI expects to measure financial inclusion on three dimensions.

> Financial inclusion is measured in three dimensions: (i) access to financial services; (ii) usage of financial services; and (iii) the quality of the products and the service delivery. Both supply-side and demand-side data is included to form a comprehensive view. (GPFI, 2013)

Informal finance

Financial services not delivered within the framework of national legal systems, but legitimized instead by tradition or the absence of effectively functioning, regulated financial markets. Due to the ongoing fusion of traditional and modern systems in many nations, the distinction between and informal and formal resembles a spectrum. The Asian Development explains that

> … [a]t one end is the informal sector, with lenders and sub-markets characterized by highly personalized transactions, and at the other the formal sector in which the scale of operations of individual lenders is much larger, transactions are usually arms-length, and loan terms more standardized. Moreover, it is useful to apply the term semi-formal to the grey area in the middle segment of the continuum, as it consists of [providers] who do not clearly fall within either sector. (Ghate et al., 1992, p. 7)

Orality

Orality refers to the modes of thinking, speaking and managing information in social contexts in which most people cannot read or write, or prefer not to. Orality encompasses not just speech but a wide range of activities from pictures and numerals to memory, music and dance. Oral institutions, behaviors, capabilities and practices are most visible in rural communities, but can also be found in urban areas.

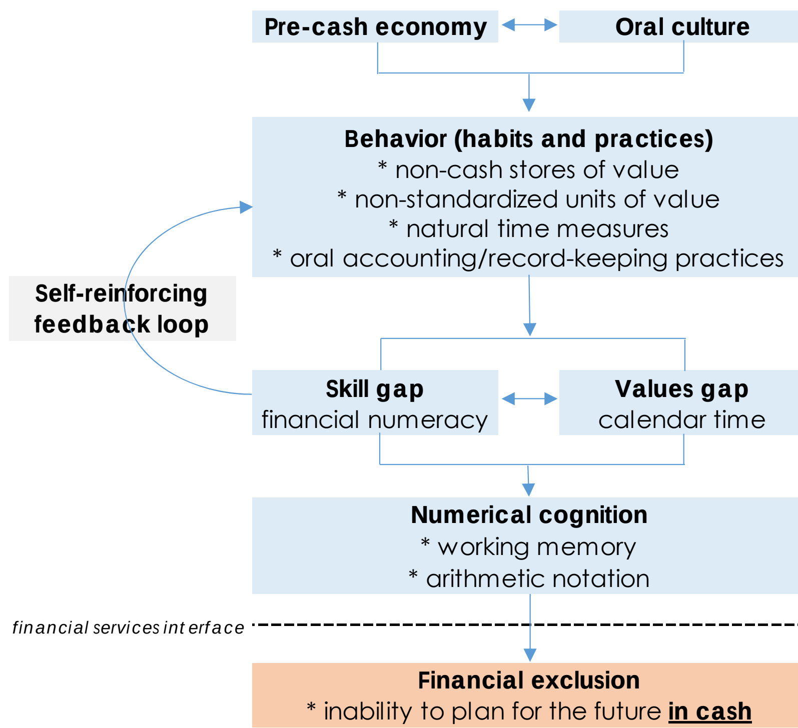
In his key work <u>Orality and Literacy</u> Walter Ong (2002, p. 6) distinguishes between:

- *primary orality* ("the orality of cultures untouched by literacy"),
- *residual orality* (the orality of cultures where literacy is not yet common or fully integrated into national institutions), and
- *secondary orality* (the orality that has reasserted itself in the modern world, through oral technologies like TV, the podcast or social media).

Introduction

In the past four decades there has been a strong push to achieve universal financial inclusion, and while there are still an estimated 2.5 billion excluded adults, the rapid diffusion of mobile phones is again raising hopes that this goal can be achieved quickly – perhaps as early as 2025. But about a billion of this excluded population cannot read or write, and live in 'oral' communities where most of their relatives and neighbours can't, either. Achieving financial inclusion for oral populations, even in a world with a smartphone in every adult pocket, is a distinctive, neglected and highly salient information-design challenge.

DIAGRAM 1
Hypothesized variables driving oral financial exclusion



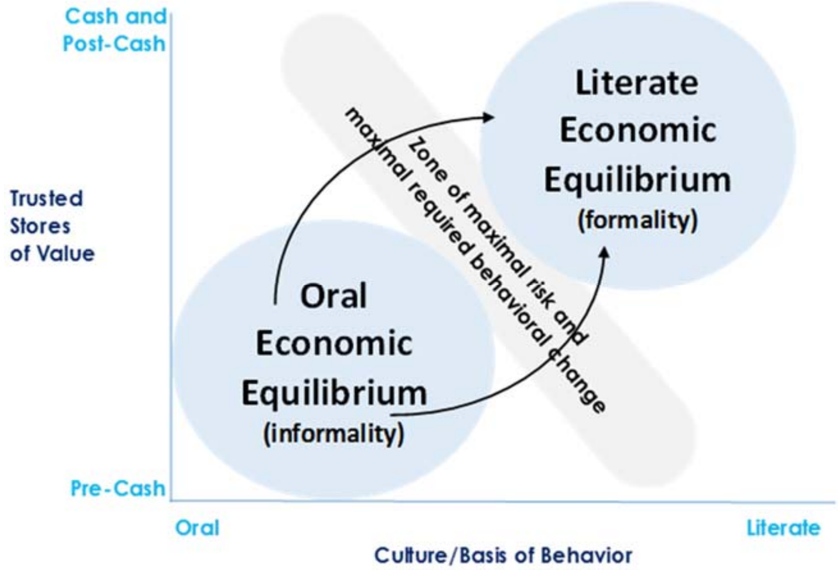
This paper presents a theory about oral financial inclusion and a simple empirical test. The **theory** is summarized in **DIAGRAM 1**. The transition from oral to literate culture, and the transition from a pre-cash to a monetized economy are dynamic human and cultural adaptation processes – independent of one another but overlapping. Both depend on a somewhat broad diffusion of new human capabilities, habits and practices. Financial numeracy involves a cluster of capabilities that are integral to both transitions.

The **hypothesis** is that oral adults are effectively stranded outside the modern world, in a self-reinforcing oral equilibrium. As mobile financial services close the much more widely discussed 'access' gap, a practical usability gap, largely related to financial numeracy, looms as an increasingly visible and important residual barrier. Overcoming this gap is a challenge in human-centred design.

Both oral cultures and pre-cash economies are characterised by legacy institutions, practices and habits that depend on legacy configurations of cognitive capabilities (see **DIAGRAM 2**). To successfully transition into the modern cash economy requires regular or frequent cash flows, and *a mental shift* towards active utilization of cash not just as a medium of exchange, but also as a store of value. It is virtually impossible to affect the cognitive transition without basic financial numeracy skills that unschooled and illiterate individuals may neither possess, nor easily acquire. Equally important, the habits, practices and institutions of the pre-cash economy and oral culture offer a safe zone where survival and traditional livelihoods are possible even without such capabilities. This reduces the practical incentive to acquire modern skills. In practice, it is usually youth who break out, migrating from rural to urban areas where they may live in deep poverty for years before they actualize the cognitive transition.

These dynamics affect a large population. National census data estimates that over 750 m adults were illiterate in 2015, of whom over 64% were women. Global illiteracy has dropped only 14% since 1990, and a dismal 4% in the 15 years since 2000 (EFA/UNESCO, pp. 13-14). Census data is based on self-disclosure at the doorstep, where vulnerability and fear of social stigma can trigger inflated self-assessments. Direct functional literacy assessments by UNESCO suggest that the true figure today is very close to 1 billion (EFA/UNESCO, pp. 140 ff).

DIAGRAM 2
Hypothesized oral equilibrium



The **test** in this study focuses on financial numeracy. I hypothesize that six skills are required to engage in very basic use of financial services as they are currently presented to poor people (see **TABLE 1**). I also hypothesize broadly similar, context-specific configurations of numeracy skills that will be referred to as **oral financial numeracy (OFN)**. OFN may be quite different from configurations of numeracy skills in literate communities. The differences may reflect not just capabilities but also **priorities and incentives**, which are driven by the values of oral culture. For example, traditional oral stores of value (such as livestock, jewelry and land) are viewed as more reliable than money, and depend for their value on oral measures of time (such as seasonality, lifecycles and discrete, memorable events). These views can result in a perception that the calendar, on which the modern concept of time-value of money depends, is both irrelevant to economic life, and a distraction from it.

TABLE 1:
Financial Numeracy Prerequisites to Formal Financial Services Use

1	**Numeral recognition**	Ability to recognize or decode the numerals 0-9.
2	**Positional notation (place value), including the role of zero**	Ability to decode a numeral string, such as '3,070', including the positional meaning of the numeral '7' and the meanings of each zero.
3	**Tabular syntax**	Ability to navigate the left-right/top-bottom syntax of rows and columns, and process related tabular rules.
4	**The four basic operations**	Ability to add, subtract, multiple and divide.
5	**Approximation**	Ability to extract personally-relevant meaning from larger, more complex numbers and from situations with many numbers.
6	**Calendar time**	Awareness of the purposes of a calendar, and ability to use it strategically to advance personal and household finance goals.

In a structured study of 20 illiterate savers and borrowers, conducted at the rural SafeSave replication in Hrishipara, Bangladesh, I observed that they did not *expect* to be able to decode their passbooks, which were their only transaction records (Matthews, 2014, pp. 29-30). They faced two basic problems: together decisively disempowering. The first was **tabular syntax**, which disabled passbook navigation. There were many cells on each page. Users lacked confidence in the left-right/bottom-top aggregation protocols of the tables, and the only navigational guidance was text headings above each column, which they could not read. In addition, most **could not decode multi-digit numeral strings** (e.g. '1,075') so that they couldn't learn by trial and error (as a literate person might) by decoding the number and matching it to the expected transaction amount.

To address this issue, the field test included an exploratory test of a passbook design that seeks to overcome the challenges faced under OFN, through the use of oral information management (OIM) tools (Matthews, 2014). OIM is a human-centred practice that places the principle of usability at the core of financial services design (Jordan, 1998; Norman, 2013; Lidwell et al., 2003). Instead of directly teaching tabular syntax, the OIM approach builds confidence in passbook navigation by employing carefully designed cues, such as memorable pictures. Recurrent practice in navigation can gradually build confidence and skill, building a cognitive scaffold on which understanding of tabular syntax can take shape.

Literature Review

There are a few studies that bear directly on numeracy capabilities in residually-oral societies, such as most villages in the developing-world (e.g. Saxe and Esmond, 2012; Zaslavsky, 1999; Nunes et al., 1993; Lancy 1983). A much larger number, particularly in the field of numerical cognition, offer indirect insights (e.g. Zebian and Ansari, 2012; Dehaene, 2011; Nuerk et al., 2011: Abadzi, 2006; Pica et al., 2004; Gordon, 2004). However, the field of oral numeracy - whether focused on financial inclusion, economic inclusion on more broadly on oral adaptation to modern life - lacks a focal point. The scope of the human challenge merits one.

Oral Culture and the Pre-Cash Economy

Walter J. Ong refers to 'orality' as the modes of thinking, speaking and managing information in societies where technologies of literacy (especially writing and print) are unfamiliar to most people (Ong, 2002). The scope of orality extends beyond speech to encompass any method of managing information consistent with oral resources and capabilities. Oral cultures have co-existed beside literate ones for centuries or millennia, and Ong argues that they may devalue or distrust text due to the ways in which records have been, and continue to be, falsified by self-serving literates (Ong, 2002, p. 95).

Text is one of the most powerful tools humans have developed to remember the past and to plan for or control the future (Ong, 1967, p. 91; see also McLuhan 1962). For individuals, acquisition of literacy is vital for long-term adaptation to the modern world. But short-term survival and adaptation imperatives can undermine the incentives acquire literacy skills, because **oral cultures are substantially pre-cash economies**. Oral households make their livelihoods mostly outside the cash economy, and enter it warily. They adopt cash as a medium of exchange more easily and quickly than they adopt it as a store of value (Matthews, 2014, pp. 17-22).

This cultural reluctance to adopt cash as store of value is driven by forces that extend well beyond the relative absence of account-based options in rural areas. Pre-cash stores of value (like animals, building materials, reciprocal commitments or precious metals) have supported the survival and adaptation of oral communities for thousands of years. Traditional oral practices rely on various **non-standardized units of value and time**, such as number of livestock, seasons and body-based measurements,[1] rather than on literate measures such as clocks and calendars. (Matthews, 2009, pp. 24-44). Pre-cash stores of value support household risk management: animals can be eaten, but cash can't. They also facilitate prudent household savings behavior: cows and building materials can't be spent on candy, cigarettes or alcohol, but cash can. Managing pre-cash stores of value demands extremely minimal **financial numeracy** skills -- again, in sharp contrast to managing cash-based stores of value.

Arithmetic Notation and Oral Number

How is an oral number different from its written analog? Why might this matter for financial inclusion? In recent centuries arithmetic notation has attained an almost 'universal convergence' across cultures, based on general use of base-10 notation and a place-value system utilizing a formal zero. This convergence has taken place "mainly because place-value coding is the best available notation" – however, "no such convergence is found for oral numeration" (Dehaene, 2011, p. 88).

[1] The English tradition includes the acre (the area of land a man can plough in a day with a yoke of oxen), the foot and the yard (a man's stride), the cubit (length of a man's forearm) etc. These vary with the size of the man who measures.

The arbitrary shapes of written Indo-Arabic numerals seem as counter-intuitive as the arbitrary shapes of the letters of the alphabet, and took even longer for humans to invent. Is it not easier for the user if one symbol (e.g. V) unpacks multiple values (e.g. IV, V, VI, VII and VIII)? History teaches otherwise, and literate innovation finally followed oral precedent (which always had unrelated words for '4', '5' and '6').

> A particular homage should be paid to a unique innovation in the Indian notation, one that was lacking in all other place-value systems: the selection of ten arbitrary digits whose shapes are unrelated to the numerical quantities they represent. (Dehaene, 2011, p. 87)

Indian and Mayan mathematicians appear to have independently invented the arithmetic zero in the first millennium, and from there it slowly spread around the globe. This 'literate' zero is formal and precise: an integer between +1 and -1. Its meaning cannot be captured by the oral concept of 'nothing', or easily appreciated in a world for which negative numbers are an irrelevant distraction.

Zero cemented the place value system by making arithmetic meaning, especially in larger numbers, very transparent to literate individuals. For example, which of these numbers can be analyzed and used in a calculation more quickly, and more easily: "two thousand, seven hundred and five" or "2,705"? So deeply is the Indo-Arabic number system ingrained in literate consciousness, that we are apt to forget that place value, like the arbitrary shapes of the numerals themselves, is a ***code***.[2] It follows that a person with limited schooling may have trouble learning it.

Furthermore, the literate zero does little to challenge traditional oral life, because it rarely applies to numbers that matter in a pre-monetized village. Zeros that appear in small numbers (1-2 digits) and at the ***end*** of longer numeral strings are easily integrated into oral numeric practice. The difficulties only begin when the zero creeps to the left in a longer string: for example, "305" or "4,020". The longer the numeral string, and the further to the left the literate zero appears, the more problematic it becomes for an unschooled person.

Using a modern arithmetic notation system literate individuals can work with far more numeric content, more flexibly, at one time. Arithmetic notation also permits organization of numeric content in space, a characteristic used to simplify processes like addition, comparison and estimation.

In spite of its utility modern arithmetic notation exhibits cognitive barriers to entry. In a 1987 study, Nunes and her colleagues presented 16 third-graders in Recife, Brazil ('working class children' in 'areas with street markets') with a series of 30 arithmetic problems (Nunes et al., 1993, pp. 28-48). Through close observation and subsequent debriefing, the algorithms the children used to arrive at solutions were analyzed. All the problems were within their personal experiences (such as purchasing an item or making change) and they had already learned written procedures at school. They were free to solve the problems orally or in writing. Most preferred the oral mode. Controlling for this preference and the difficulty of the problems, oral calculations were also more accurate.

These children could use the arithmetic algorithms they needed in both oral and written modes. But they avoided writing because they made more errors in it – and larger ones (e.g., in placing decimal points, or carrying). The study notes two reasons for this (Nunes et al, pp. 45-6)

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[2] In 2012 a microfinance practitioner insisted to me that since every rickshaw driver in his city could dial out on a mobile phone, they could input a cash amount into it as well. The future of his institution hung in this assumption, but it was so deep he had missed it.

1. "[O]ral and written procedures differ in the direction of calculation: The written algorithm is performed working from units to tens to hundreds, whereas the oral procedure follows the direction hundreds to tens to units." When working with hundreds an error in the hundreds is likely to be immediately evident, and can consequently be corrected. An error in the units may be invisible, but it consequences will carry upwards in the hundreds. Identifying the error, and correcting it, may then prove much more difficult.
2. During calculations "oral procedures preserve the relative values; written procedures set them aside". That is, during oral calculations the child continues to think of "two *hundred*"; in writing calculations there is simply a '2' in the third location from the right that could inadvertently be moved or mingled with a number to the left or right of it.

Walter Ong argued in 1982 that oral individuals are wary of text, because they are vulnerable to literates who manipulate it. Nunes and her colleagues extend this thesis by observing that semi-literate children may avoid the risk of written calculations because, in the high-stakes situations in which they need to use arithmetic, oral calculations do a far better job of facilitating retention of arithmetic meaning.

Numerical Cognition

The extensive literature on numerical cognition flourishes at the crossroads between cognitive psychology, pedagogy and neuroscience. While OFN has not been directly researched, there are studies on two related forms of numerical cognition: that of pre-school children, and that referred to by Ong as 'primary orality' – oral culture untouched by writing.

Learning and Working Memory

Financial transactions are conducted quickly, often under time pressure. Among oral populations this can cause great strain to cognitive systems in the brain, and particularly to working memory.

While the relative contributions of cognition, context and culture remain a topic of intense debate, a basic map of the cognitive drivers has been drafted. There is an 'innate' numeracy component that is universal in humans, who also bring differential cognitive assets to learning: especially working memory, attentional control, and inhibitory control (Nisbett 2009, p. 7). Effective use of this 'fluid intelligence' leads to the transfer of useful facts and processes to long-term (semantic) memory, where they can be applied to solving new problems. These semantic resources also reduce the strain of real-time problem solving on working memory by providing conceptual structures, practical shortcuts, and other tools.

Working memory has been shown to play an important role in simple arithmetic calculations (Baddeley and Hitch, 1974, DeStefano and LeFevre, 2004). It is a very limited resource. Memory traces decay within a few seconds, unless refreshed through rehearsal (Towse et al., 2000). Working memory is affected not just by the complexity of the task, but by cultural factors such as the length and complexity of number words in the user's language (Baddeley et al., 1975). From a cognitive perspective 'learning' is a process of isolating and storing meaningful facts and patterns in long-term memory, for future use.

Numbers become increasingly abstract as they become larger (Holloway and Ansari, 2016, p. 547). While a number like '5' is easily visualized, it is rare to retrieve sensory experience unique to '55', much less '555'. The larger the number the more strain is placed on working memory. "The sharp limits of our short-term memory" Dehaene argues "explain the constant drive towards a compact notation for large numbers" as found in modern arithmetic notation (Dehaene, 2011, p. 103). Schooled individuals have access to numerous tools that economize on working memory in cash and financial transactions, from fluency with Indo-Arabic numerals and place value to working familiarity with written calculation algorithms, calculators, calendars and percentages.

Oral working memory is further strained by the need, in many contexts, to conduct cash or financial transactions in a second language. Home languages are often not school languages, and it is difficult to learn abstractions in a second language, especially during a short tenure at school. Yet in performing calculations, bilingual adults show "a strong preference for the language in which they first learned math skills" (Abadzi, 2006 p. 60).

Within this framework, there are three variables generally thought to predict math performance over the long term that are critical to OFN:

- an innate 'approximate number sense' (ANS),
- development of a linear 'mental number line', and
- ability to connect the 'triple code' of concrete, oral and notational numeracy (Abadzi, 2015, slide 38).

Approximate Number Sense

'Approximate number sense' (ANS) is an 'innate' component of human numeracy: a universal human endowment, independent of culture or schooling. Studies of numeracy in primary oral settings have sought to identify the components of ANS, and include those among the Mundurukú (Pica, Lemer, Izard, Dehaene, 2004) and Pirahã (Gordon, 2004) of Amazonian Brazil. Evidence is emerging from these and related studies that humans have significant innate capabilities for assessing the relative numbers of things in an environment, and features like distance, speed, volume or time.

The ANS draws on two sources.

First, humans directly and accurately perceive numbers up to three without counting or estimating, as we might perceive colour or contour (Dehaene, 2011, pp. 53-58, 80). We can directly perceive larger numbers in familiar contexts, such as the five that turns up on a dice-roll. This ability is referred to as 'subitizing'.

Second, humans estimate larger numbers quite well – when they are not symbolically encoded. The very isolated Mundurukú in the Amazon have no words for numbers above five. However, when researchers show them paired clusters of dots on a computer screen, and asked them to assess which cluster in each pair has more dots, they prove able to "perform approximate additions and comparisons of large numbers at about the same level as educated French controls." They frequently err on mental calculations as simple as 5-3 however, because they approximate even small sums. (Dehaene, 2011, p. 262).

Related studies suggest a neurocognitive 'start-up kit' that may include, in addition to ANS, a 'ratio processing system' (RPS). For example, the Mundurukú demonstrate an intuitive sense of halving (McCrink et al., 2012, Vallentin and Neider, 2008).

The Mental Number Line

Extensive research by Dehaene and colleagues has found that adult humans engage in an 'automatic and unconscious' visualization of positive numbers on a 'mental number line' suspended visually in space (Dehaene, 2011, p. 75).

This powerful abstraction, also believed to be innate, facilitates the visualization and manipulation of symbolic number. Because humans struggle to visualize vast distances, the mental number line appears to compress automatically among large numbers (Dehaene, 2011, p. 65). Among children, this compression may be affected by 'break points' that reflect children's knowledge gaps. Familiar numbers, at least when small, trigger accurate spatial representations, but unfamiliar numbers don't (Nuerk et. al., 2011, p. 13).

Little is currently known about the mental number line of illiterate adults. However, a recent study compared literate and illiterate migrant workers in Lebanon (Zebian and Ansari, 2012). Evidence shows that the farther the numerical distance between two paired digits, the more quickly humans, whether schooled or not, can identify the larger one. Accuracy was similar between literates and illiterates, in both tests. These findings reinforce the view that an infinite linear number line – among the most abstract of human inventions – is deeply rooted in a concrete experience of physical space shared by all humans. Literacy has an impact however: literate individuals responded 30-50% faster in both symbolic and non-symbolic conditions (Zebian and Ansari, 2012, p. 100).

Why would fluency with written symbols accelerate *non-symbolic* single-digit numeric processing? Schooling, verbal numeric language and local monetization levels may all be relevant. Research to untangle and assess these inter-related effects would be useful.

The Triple Code

The influential 'triple code' model integrates cognitive and neural observations on number processing (Dehaene, 1992; Dehaene and Cohen, 1995).

- Number is sensed in the environment: three people are seen walking past.
- Number is spoken by oral individuals (and among literate individuals may also be read syllabically): "three".
- Number is coded in arithmetic (non-syllabic) notation: "3".

The numeracy skills of oral individuals more closely approximate a 'double code'. Oral financial numeracy is symbolic (the spoken word 'three' is a symbol) but features little or no dependence on written *notation*. This has important implications for working memory, which is processed through two sub-systems: a 'phonological loop' that manages sounds, and a 'visuospatial sketchpad' that handles images (Baddeley and Hitch, 1974). Once numeral recognition and mapping of symbolic images onto magnitude are fully internalized in long-term memory, working memory can use verbal and visual representations of number to reinforce each other.

Idiosyncrasies in spoken language have been found to sap working memory. In a study of cognitive processing of multi-digit numerals, Nuerk and colleagues note that place value has been neglected in the literature on numerical cognition. In a number of studies of literate European adults, they delineate 16 errors, including 3 involved with 'transcoding' between oral and written numbers. For example, the German oral '27' is spoken 'seven and twenty' and is often written '72' (Nuerk et. al., 2011, p. 9). A potentially large source of transcoding errors, and cognitive strain, in oral financial numeracy is the limited transparency of the arithmetic zero in spoken numbers, especially as those numbers get larger.

Monetization

Cash economies and financial systems require users to process *large* numbers with precision, in contexts where a mistake can be very costly. Out of 191 currencies tracked by Oanda, a currency exchange firm, on March 2, 2016 there were 75 trading at more than 100 units to $1 US, including 33 trading at more than 1,000 units to $1 US, and 11 at more than 10,000 units to $1 US.

Most of these are among the world's poorest nations, where literacy levels are lowest.[3] Oral adults in these contexts must calculate in 3-5 digits to buy even the most basic household items.

While exact calculations are not supported by the approximate number sense, some precision is achieved in pre-cash economies through traditional methods like one-to-one correspondence. Geoffrey Saxe has conducted field studies among the Oksapmin three times between 1978-2001, observing rapid monetization from a very early stage. The Oksapmin are an ethno-linguistic group in Papua New Guinea that experienced first contact with the outside world in 1938.

Traditionally an Oksapmin would subtract 5-3 using the traditional body-counting system: subtracting 3 units from the little finger of his right hand, which is denoted '5', to reach his right index finger, which is denoted '2' (Saxe and Esmonde, 2012, loc 1459-1502). An early adaptation to currency involved mental internalization of calculations: "[t]he turning of externally oriented correspondences inward to create internal body-part to body-part correspondences", which supported confident manipulation of numbers into the hundreds. (Saxe and Esmonde, 2012, loc 6131).

In a 2001 study of 'trade stores' among the Oksapmin, Saxe and Esmonde studied the practices of shopkeepers and two types of customers: schooled and unschooled adults, such as the villages' elders (Saxe & Esmonde, 2012, loc 1623) during the purchase of two ordinary items. Unschooled adults, they found, would either bring change to the shop or ask for change from the shop-keeper before transacting. They would then count out exact change for each item, buy it, and count the remaining balance, before purchasing the next item using the same procedure (Saxe & Esmonde, loc 2590 ff). Schooled adult shoppers did not adopt this procedure.

This study shows cash being used as a counting tool, permitting unschooled shoppers to make calculations that they could not easily make without it. It also shows shopkeepers supporting demand-side information flows, in the process minimizing client transaction costs. It shows an adaptive response by shops (literate institutions) to oral cognitive requirements.

In monetizing economies cash may be the most useful device outside of a schoolroom for helping illiterate humans integrate the modern place-value, formal-zero numeral system into long-term semantic memory. Cash notes aggregate large numbers with precision in the numeric range of greatest relevance to daily oral life: that involving exchanges of economic value. Base-10 place value is reflected precisely: both visually and in action. Counting cash usually occurs either as part of a transaction, or in rehearsal for an anticipated one. This is an incentive that most oral adults find motivating.

Financial Inclusion

Historically the microfinance movement has stressed supply-side priorities. In the 1980s and '90s this meant building financially sustainable institutions to deliver services to poor people (see for example von Pischke et. al, 1983; Otero & Rhyne, 1994; Yunus & Jolis, 1999). In the past two decades the focus has shifted, first towards building inclusive national financial systems (e.g. Helms, 2006) and later to embrace the potential for mobile finance (e.g., Hughes & Lonie, 2007; Scharwatt et. al. 2015).

Studies of informal finance – which, with few exceptions, involves financial practices and institutions designed by oral populations for their own use – date back to the 1950s (e.g., Geertz,

[3] Data collected from www.oanda.com using the US dollar as base currency, on Wednesday, March 2, 2016.

1956; Ardener, 1964; Bouman, 1983). Research on transaction costs has offered an insightful window into demand-side costs that limit financial inclusions for decades (see Williamson, 1999; Coase, 1937). But it is only in recent years that research on demand-side needs and practices gradually entered -- and with the growth of behavioral economics, seriously began to influence – the discourse on financial inclusion (see for example, Rutherford, 2000; Kahneman and Tversky 2000; Collins et al., 2009; Roodman, 2012; Mullainathan and Shafir 2013; Banerjee et al., 2014).

As hard usability and capacity constraints, illiteracy and innumeracy impose far higher transaction costs on financial services users than the physical distance to a bank branch (a much more frequently studied indicator). In a 2006 briefing of mobile banking, CGAP warned "[m]ost mobile banking interfaces and processes require literacy." (Ivatury and Pickens, p. 2) A 2013 blog about Mushtaque, a Dhaka rickshaw driver, addressed this issue directly.

> Since Mushtaque can't read, he lacks the confidence to manage his own account. When he wants to deposit money, Mushtaque visits the agent across from his residence and hands the agent the cash and his phone number. Upon cash-in Mushtaque does receive an SMS confirmation, but … his trust in the agent is more important. After all, he can't read the SMS. (Chen, 2013)

Method

This field study of financial numeracy among illiterate adults, mostly female users of financial services, was conducted in March and April 2015 in four regions in rural Tanzania (Manyara, Kilimanjaro, Arusha and Singida) and two provinces in rural Cambodia (Preah Vihear and Kampong Thom). The 80 sampled individuals participated in a test/questionnaire that lasted 45-60 minutes.

The goal of this study was to assess the current level of basic financial numeracy skills among illiterate individuals, and the impact that these skill gaps may have on effective financial inclusion. The study also tested prototypes of oral information management (OIM) tools among individuals who are already using some sort of financial service, to evaluate their potential efficacy as instruments that could enhance transaction-relevant numeracy skills without adding to the governance or delivery costs of suppliers.

In Tanzania, areas were selected based on relatively low levels of literacy according to national census data. The main sample was composed of functionally illiterate villagers, as selected by the local village school teachers or financial delivery agents, such as Savings and Credit Cooperative Societies (SACCOS) in Arusha and Kilimanjaro, and savings groups in Manyara. Further qualitative and contextual information was drawn from a series of supplementary interviews with primary school teachers and visits to village markets.

In Cambodia the test was conducted in collaboration with Oxfam America. Their staff identified villages where literacy was relatively low, worked with local contacts to identify illiterate study participants, and provided translation and contextual support. All sampled Cambodian villages are among hundreds around the country where Oxfam is forming 'Savings for Change' (SfC) savings groups among adult women. Two focus groups were conducted among SfC members on the 'mental number line'.

Limitations

Sampling was not randomized. Results should not be assumed to be statistically representative.

Observations

General characteristics of the sample appear in **TABLE 2**. Out of a total sample of 80 individuals, 45 had received some schooling; on average about one and a half years. The balance had never attended school. Most were female, as illiteracy disproportionately impacts women.

TABLE 2
Sample Characteristics

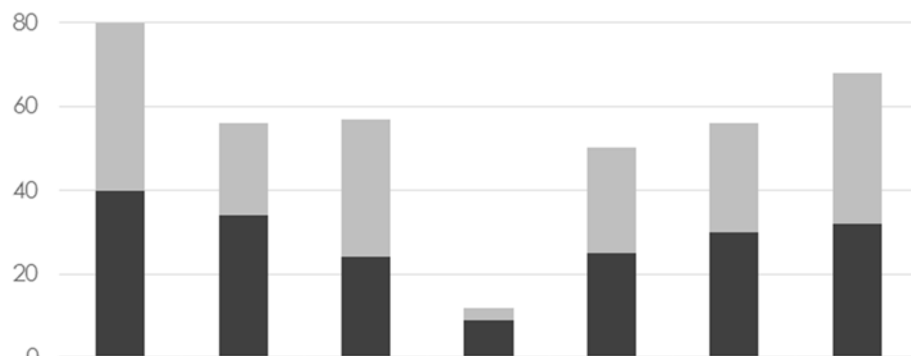
	N	Female #	Age (Average)	Schooling Average years	Schooling No schooling
Cambodia	40	40	37	1.5	13
Tanzania	40	32	51	1.5	22
Total	**80**	**72**	**44**	**1.5**	**35**

Everyone in the Tanzanian sample spoke Swahili. Mother tongues were many: including (largest sample first) Maasai, Chaga, Nyaturu, Gogo, Pare, Iraqw, Hehe, Nyamwezi, Sukuma, Meru and Burunge. The mother tongues of most of the Cambodian sample was Khmer, with the exception of four Kuoy participants in Rovieng village, Preah Vihear province.

Counting and Calculating

Respondents were given several tests. They were asked to count money and announce the figure, validate the written equivalent number, write the number of their children (or siblings) on a piece of paper, calculate change in a typical shop transaction, work out the price of 2.5 kilograms of rice based on a simple pricing, and estimate the fraction of a kilogram of rice depicted, when presented with a picture of a partly-filled container (see **TABLE 3**).

TABLE 3
Calculating and Counting



	N	Can write a 1-digit number	Can count money and state the right amount	Can correctly identify a written 6-digit number	Correct change in shop purchase	Can estimate a quantity	Can perform simple multi-plication
Tanzania	40	22	33	3	25	26	36
Cambodia	40	34	24	9	25	30	32

■ Cambodia ■ Tanzania

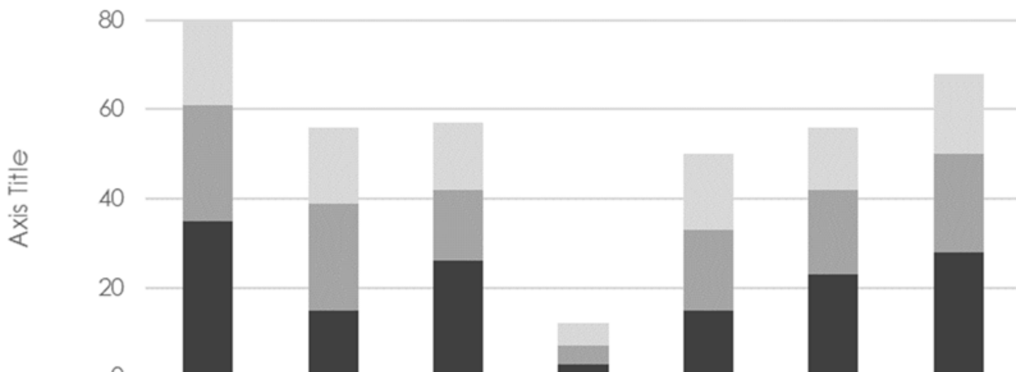
The ability to write a one-digit number showed the strongest correlation with schooling (see **TABLE 4**). Most individuals who had attended at least a year of school could do it, while nearly half of those who had not, could not. Schooling was a surprisingly weak predictor of performance on most other tasks. Most of the more numerate unschooled individuals had experience vending.

The sample were asked to count 107,500 Tanzanian shillings or Cambodia riels (collectively, local currency units or 'LCUs'). In Tanzania, this involved 16 banknotes (nine 10,000s, three 5,000s, a 1,000 and three 500s) and in Cambodia 18 (one 20,000, seven 10,000s, three 5,000s, two 1,000s and five 100s). Adding the notes also tests addition skill.

This is a sum of money that most economically active adults in these two countries must manage at various times in their lives. In Tanzania it was valued at about US $60, while in Cambodia it was valued at about US $25. The number 107,500 tests the ability to decode place-value. Without this knowledge, the meaning of the zero in the second position from the left won't be clear.

Most could count cash and correctly state the sum, but their skill varied widely. Some counted quickly in their hands, scrolling the notes with a thumb, and then confidently announced the result.[4] Others struggled: laying the cash in piles on the table in front of them, counting each individual pile one or more times, and trying to add the piles together to reach a total. There was

TABLE 4
Calculating and Counting, by Schooling



	N	Can write a 1-digit number	Can count money and state the right amount	Can correctly identify a written 6-digit number	Correct change in shop purchase	Can estimate a quantity	Can perform simple multi-plication
3 + years	19	17	15	5	17	14	18
1-2 years	26	24	16	4	18	19	22
None	35	15	26	3	15	23	28

Years of Schooling
■ None ■ 1-2 years ■ 3 + years

[4] In Cambodia some competent counters attributed their skills to *k'bach srey*. This informal art of mental arithmetic – clearly differentiated by users from skills learned at school -- appears to mean 'women's abacus': an appropriate framing since the abacus is a highly effective ancient tool for decoding positional notation. Most users described this method as self-taught.

no time limit. Nevertheless, about a quarter failed the task. Some counted in no order, and eventually lost track. Others arranged three or four piles of notes on the table and reached sub-totals, but couldn't total them. Two admitted that they had never counted such large sums, and did not know how.

How do people count money if they can't read the multi-digit notation on the currency notes? One 41-year old farmer spoke for many when she remarked:

> I recognize cash by colour and picture. When a new currency note is printed I ask for help.

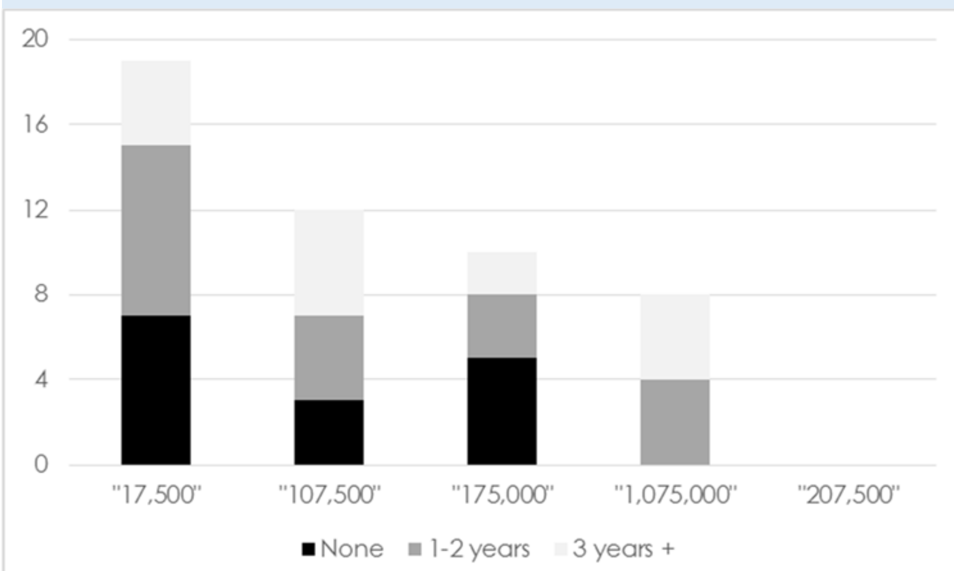
Once respondents announced the total, the researcher showed them a list of written numbers (see image at right) and asked them to select the correct one.[5] This exercise tests their ability to 'transcode' from oral to written symbols. It also tests their knowledge of place value by re-arranging zeros and changing orders of magnitude. Sixteen correct answers can be expected by chance.

17,500
207,500
107,500
1,075,000
175,000

As shown in **Table 5**, twelve responded correctly.[6] Most who ventured a response approached the question with great care, carefully tracing the choices with their fingers, and often counting the digits in each numeral string, first.

Half declined to answer. While no one was rushed, the appearance of 30 digits, in five distinct strings, may have intimidated respondents with limited fluency in individual digits. Some described the question as 'very difficult', waved it away in mock horror, or apologized for their inability. Some remarked that the numbers were too large: they knew smaller ones but not these.

Table 5
Selection of Written Numeral String, by Schooling



[5] If they produced an inaccurate count, they were corrected prior to this step.
[6] In fact this was the first choice of only eight; however four others achieved it after making uncertain erroneous choices first. We provided one opportunity for recovery, if it was immediate.

No one chose “207,500”: they all appear to have realized that the number they had counted did not contain a “2”.

One bright middle-aged Tanzanian mother who counted quickly and correctly examined the writing closely and stated “175,000”. She spoke for several others when she remarked:

> “I can identify 3 numbers here: 1, 7 and 5. The numbers are all together, so it seems to be right.”

The most common response was “17,500”. This response was so common that the order of presentation of the written numbers was varied to test for the possibility that respondents were simply selecting the first number to appear on the list. No change resulted.

Oral encoding in Swahili and Khmer (like English) focuses attention on positive integers, which may tempt people to cluster them together. Oral adults (unlike developing children) may also choose to be cautious, and err on the side of least risk. If respondents felt in any way responsible for the money, they may have shied carefully away from any over-statement.

To test subtraction (see **TABLES 3-4**), participants were asked how much change they should get from a 10,000 note, if they purchased an item in a shop costing 7,800 LCUs? They did not receive cash to support their calculation.

A small majority succeeded. Some calculated quickly in their heads, but most used their fingers and some took a long time. In this case years of schooling appears to have played an important role in success, though experience in the marketplace also mattered, especially among those with little schooling.

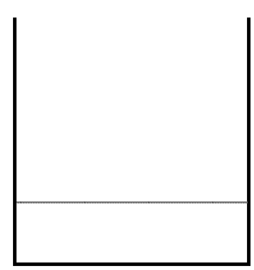
The first description is from a successful respondent in Cambodia, and the second from Tanzania.

> First I add 200 riels to 7,800 riels so the money is 8,000, then taking 10,000 minus 8,000 leaves 2,000 remaining. So the total money back to me is 2,200!

> I counted 7 fingers completely for the cost, then split the 8th finger with 200 going to change, and 800 to cost. Then I added the 9th and 10th fingers to complete my change.

The many erroneous responses ranged from “3,000” to “1,500”. In Cambodia responses clustered more closely to “2,200” than in Tanzania.

To test **multiplication** and **volume estimation** (see **TABLES 3-4**) respondents were presented with a picture of a 10 kilogram container, with 2.5 kilograms of maize flour or rice at the bottom (see image at right).



Both ‘2’ and ‘3’ kilograms were deemed correct, and 56 responded correctly. Several Maasai estimated 4 or 5, skewing up the average. This skill, which requires mental standardization of units of value, was only very modestly related to schooling.

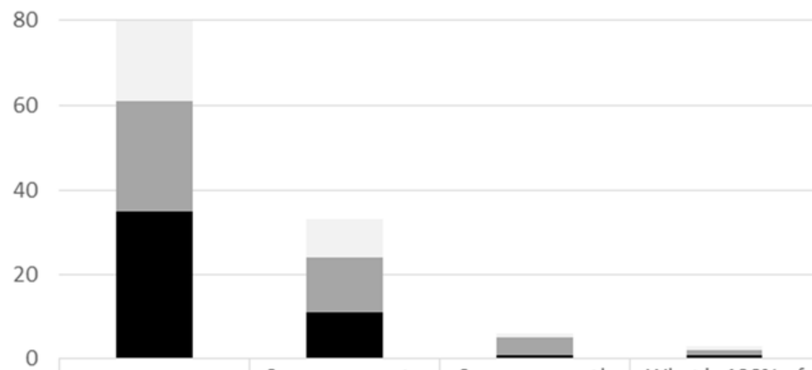
Most (68 respondents) accurately calculated the cost based on a quoted price of 1,500 LCUs per kilogram. This involves multiplying kilograms by price per kilogram.

Division and Interest

Facility with **division** appears in **TABLE 6**, and was generally much weaker than capacity to multiply. Participants were asked how much they would need to save each year in order to save 1 million LCUs in 5 years? If they succeeded, they were then asked how much they would need to save each month to achieve the same goal?

Instead of dividing, most successful respondents multiplied different numbers by 5 until they got one that matched 1 million. This is a laborious process with pitfalls.

TABLE 6
Division and Percent (Interest)



	N	Save per year to save 1 m in 5 years	Save per month to save 1 m in 5 years	What is 100% of [stated loan amount]?
3 years +	19	9	1	1
1-2 years	26	13	4	1
None	35	11	1	1

None 1-2 years 3 years +

At least one respondent struggled with the elementary properties of arithmetic.

> I know that one million is 200,000 times 5. Does this mean that one million divided by 5 is 200,000? That I don't know!

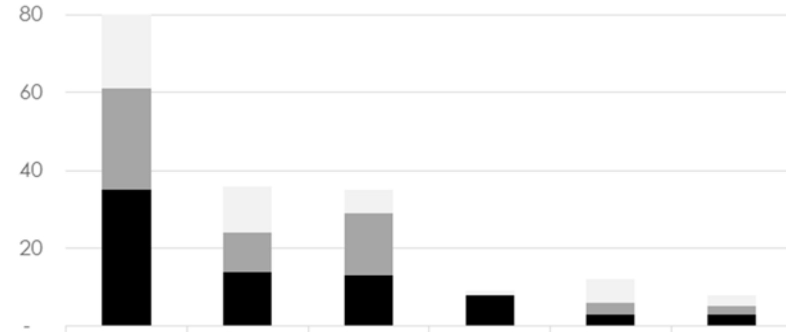
Only six respondents succeeded with the monthly question, which tests another basic skill – **estimation**. Estimating the answer – preferably at 20,000 for conservatism – is very useful for anyone planning in cash. Responses between 15,000 and 20,000 were deemed correct.

Respondents' knowledge of the concept of **percent** was also tested, by asking them an interest rate question based on a hypothetical loan: "what is 100% of 500,000 LCU?" Only three answered this question correctly.

Mobile Phones and Calculators

Nearly half the sample have a phone of their own (see **TABLE 7**), and a similar number share a phone with another family member, usually a spouse. Only nine respondents, mostly unschooled, have no access to a phone.

TABLE 7
Phone and Calculator Use

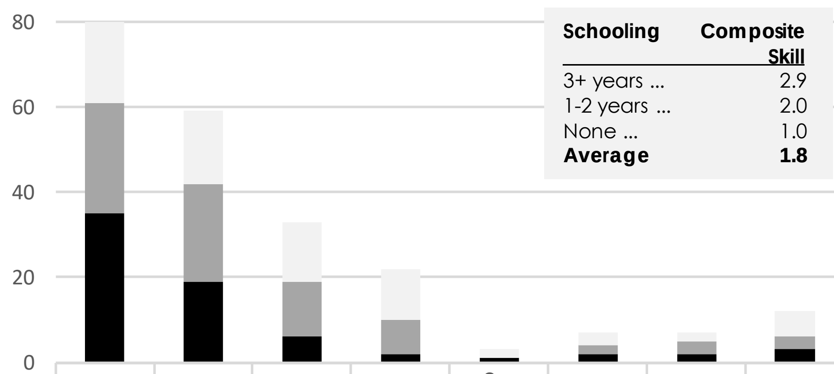


	N	Owns individual phone	Shares phone	No access to a phone	Has mobile money account	Can use a calculator
3 + years	19	12	6	1	6	3
1-2 years	26	10	16	-	3	2
None	35	14	13	8	3	3

The average respondent cited 1.8 capabilities related to using her mobile phone (see **TABLE 8**).

Abilities were comparable in Tanzania and Cambodia. Those who spent longer in school, and those who are younger, are generally extracting more uses from their phones.

TABLE 8
Ability to Use Mobile Phone Functions, by Schooling



Schooling	Composite Skill
3+ years ...	2.9
1-2 years ...	2.0
None ...	1.0
Average	**1.8**

	N	Receive call	Place call	Can use address book	Can create address book entry	Can use calculator	Can use calendar	Has mobile money account
3 years +	19	17	14	12	2	3	2	6
1-2 years	26	23	13	8	0	2	3	3
None	35	19	6	2	1	2	2	3

Two used the Nokia Torch to create address book entries. This is a $20 mobile phone with a built-in flashlight and a menu of simple images that can be attached to address book entries.

Calculator features are standard on most analog phones, but calculator adoption and use has been modest. Youth helps predict this skill. The average age of the eight calculator users was 30, and five were in their 20s.

> I learned by myself to work a calculator by selling rice. At first I guessed, and eventually I could do it.

Nevertheless, even in the under-30 group, another 10 don't have this skill. A 28-year old rice farmer with good division skills remarked

> I use a calculator sometimes. But I have a huge problem with numbers of digits in millions and hundreds of thousands. I am always counting digits and getting them wrong!

Mobile Money

Twelve respondents had access to mobile wallets, including eleven in Tanzania. These respondents were asked to transfer a small payment from a research account to their own account using their phone. Only two could do this, and one admitted that he has sent the wrong amount in the past due to weak place value skills, so he has stopped.

Of the ten who could not transfer funds independently, three use their accounts only through other family members, while seven use adaptive strategies that involve varying degrees of dependency, and associated risks.

Three respondents report giving their phone and PIN number to the agent.

> Yes, I use m-Pesa to send money to my grand-children in Dar. I take the money and my phone to the agent and tell him I want to send this money to this person. He finds the person in my phone address book, takes my PIN number, and sends the money. I call my grandchild to tell her about the money: when it is coming, and how much to expect.

Five will visit the agent themselves to receive cash. Each reported the same procedure.

> When I get money I get the message from Dar and go to the agent who takes my password and gives me the money. I don't get a paper receipt. The agent writes everyone's name, phone, and amount you get in his registry. I get an electronic receipt from the network.

In spite of their dependence on third parties such as agents and family members, oral mobile wallet owners have considerably greater financial numeracy skills than others in this sample. The three respondents in Tanzania who correctly identified "107,500" in writing all owned mobile wallets, and their average phone skill use was 4.2 compared to a sample average of 1.8. They were also much more likely than those without wallets to use a calendar for one or more purposes.

Like calculator use, mobile money use appears to be impaired by inadequate knowledge of place value.

Calendar Time

Calendar time shapes the time-value of money: a defining feature of modern finance. Oral time units are based on natural, non-standardized measures and events aligned directly with experienced livelihood requirements. Calendar time units are in principle, like the mental number line, standardized, linear and infinite.

Participants were asked if they had a calendar in their home? Whether they had a calendar at home or not, they were then asked if they could give a recent example of a way that they had used one? Awareness and use of calendars in this sample is summarized in **TABLE 9**.

About a third of the sample (27) have a calendar in their homes: mostly in Cambodia, which has a traditional calendar. There is a slight skewing in calendar ownership towards those with more schooling. Tabular syntax - which is embedded in calendars - is taught in upper primary school classes.

Less than a quarter of the sample (22) reported a specific purpose – such as planting, preparing for a festival, attending a meeting, or repaying a loan – for which they use a calendar. This included only 13 of the 27 calendar-owners.

Some could not see the point of the question.

> I don't know what to do with it other than look at the date.

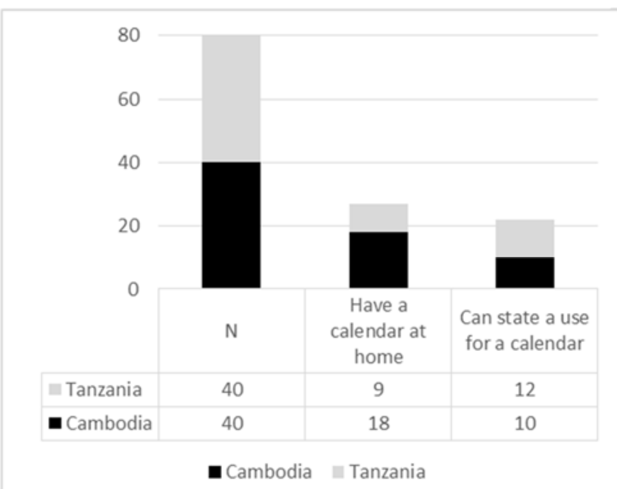
Many confidently stated that they could remember the dates of future meetings and other activities, and that if they couldn't, they could always ask someone.

A 35-year old Khmer rice and cassava farmer who belongs to three savings groups reported that she has no calendar in her home.

> I don't know exactly about the date. I do my activities by watching or following other people: for example, rice farming.

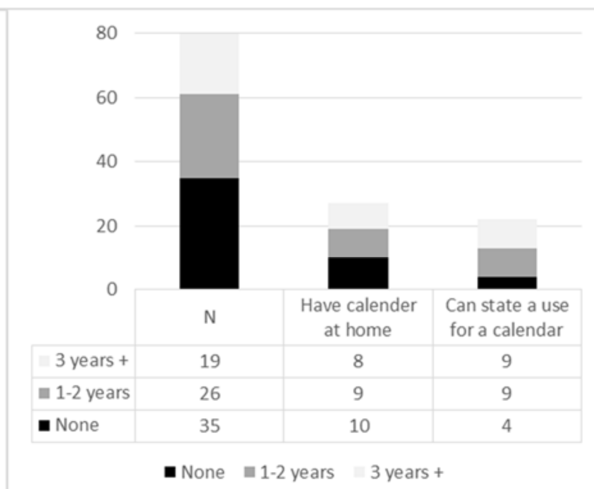
TABLE 9
Awareness and Use of Calendars

9.1 by Country



	N	Have a calendar at home	Can state a use for a calendar
Tanzania	40	9	12
Cambodia	40	18	10

9.2 by Schooling



	N	Have calender at home	Can state a use for a calendar
3 years +	19	8	9
1-2 years	26	9	9
None	35	10	4

Calendars are often introduced to oral cultures through religion. For example, one respondent mentioned counting the 40 days from Kwaresima to 'Great Friday' (Easter). One Khmer woman who is an active user of the calendar on her mobile phone is also a local moneylender. She has access to a mobile money account controlled by her husband.

> I have several calendars. I need to know when it is the day for people to repay me. I need to know when loans for rice wine have to be repaid. I need to know how many days between transplanting rice and fertilizing.

The traditional household planning strategy utilizes cash stores of value that are characteristic of pre-cash traditions, and requires virtually no numeracy. It is centred on sending children to school (and keeping them fed until they can look after themselves), building better homes, and acquiring land, jewelry and livestock. So unconsciously are these plans pursued that respondents may deny that they are actually 'planning for the future'.

> I got a calendar from my mother in law. It is in Khmer and I don't use it. I never think about the future. When I get money I build the house. I get wood in advance, and nails. That's how I plan. But the savings group is getting me planning in money.

The shift from traditional conceptions of in-kind value to modern conceptions of financial value depends on the acquisition of habits and skills related to calendar time. Calendars (with clocks) greatly expand the ability of individuals to invest their time to maximum effectiveness in a cash economy. However, in oral communities, time-keeping and scheduling are traditionally treated as collective practices that obviate the use of calendars, slowing the adaption to literate practices.

The Mental Number Line

Three supplementary components of the fieldwork sought qualitative insights into the oral 'mental number line' (see discussion above in literature review).

Before the formal survey began a subset of the Tanzanian respondents were asked to name the largest numbers they had discussed or heard someone mention in the past week. Most responses were single-digit, and none exceeded one hundred. They were then asked the largest number they had heard or discussed in their lives.

> 10,000. I used to buy kilos of maize and I would get 3,000 in change back"

> Millions! That will always be amounts of money. The biggest other numbers are the number of cattle: maybe 50 or 100.

> The biggest number I hear is maybe six, seven. But there are bigger numbers, always about money – for example 5,000 or 6,000 shillings.

Second, I observed practices in villages markets in Tanzania to understand the demands on the numeracy of vendors, who are often illiterate women. Vendors used neither written records nor calculators, although almost everyone had a mobile phone with a calculator. They sold many vegetables, in heaps based on standard pricing in Tanzanian shillings (Tsh): usually Tsh 500 or 1,000. It is the size of the heap, not the cash amount exchanged, that changes with price. Prices either parallel denomination values in shillings, or can be easily made up with a few standard Tsh notes. Most vendors have a half dozen or less stock-keeping units. Since transactions usually involve a very small number of items, and very regular numbers, vendors can tally the totals mentally. Some items, including salt, rice, oil and a variety of dried legume leaves are sold by the litre or kilogram. Shoppers are familiar with halves and quarters, and goods are sold in these fractions.

Unlike many practices used to deliver formal financial services to poor people, these practices economize on the limited working memory resources of users.

Third, two focus groups were conducted with 13 oral Cambodian women on the mental number line. Seven were native Khmer speakers and six native Kuoy speakers (all spoke Khmer). They ranged in age from 27 to 60, and in schooling from totally unschooled (five) to four years (one). Number lines were drafted on flip chart paper, on tables under their houses, with their active participation, comments and ongoing validation. The results appear in **DIAGRAM 3**.

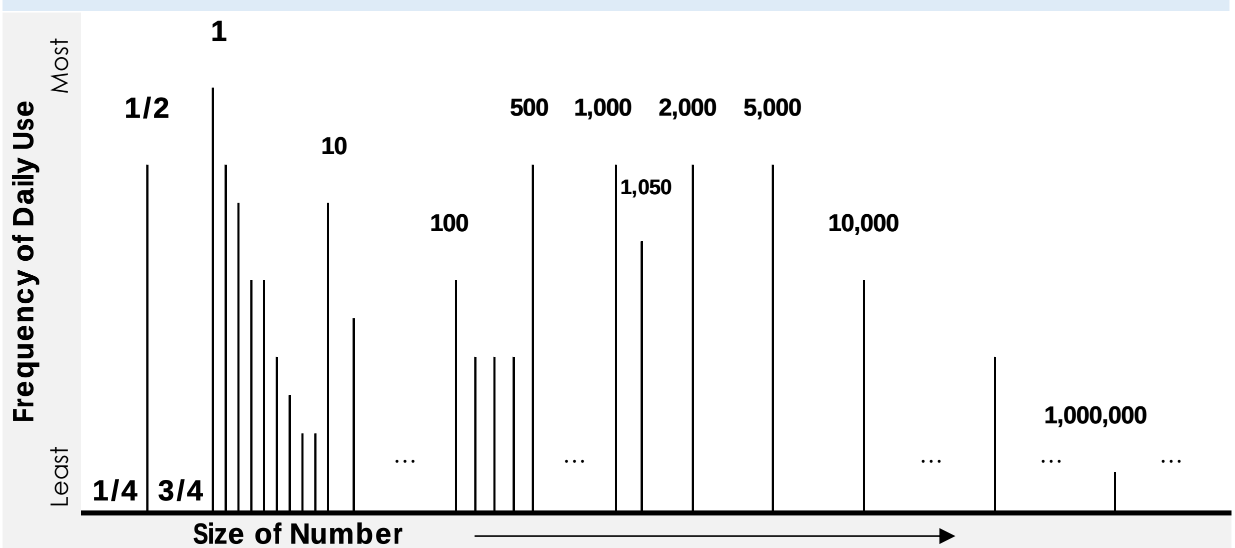
The participants all agreed that numbers and counting are very important in their day to day lives.

- 500, 1,000, 2,000 and 5,000 are banknote denominations used in many daily transactions.
- 1,050 is the price of a kilo of rice.
- 10,000 or 12,000 is a day's earning from selling labour.
- Numbers above a million are very rarely used.
- ½ is another 'daily' number, since many commodities are sold in half litre or half kilogram amounts. Interestingly, ¼ litre or kilogram amounts are unheard of.
- Percentages and decimals are unused and absent.
- 'Zero' is virtually never spoken or used, and is absent.
- Negative numbers are unused and absent.

In both countries day-to-day awareness of numbers greater than one thousand seems to exist almost exclusively in the domain of cash.

Participants in the focus groups did not want to deal with big numbers. A woman who makes rice wine remarked

DIAGRAM 3
Illustrative Mental Number Line, Oral Khmer Speakers



Source: prepared by the author based on the concept of the mental number line. See Dehaene (2011).

> I can make 48,000 in a day when I make wine for sale; when I make a batch I can earn up to 4 days like this.

"How much can you make from wine in a year?"

> Oh I don't know! [Laughs from the group.]
>
> Don't ask how much we make in a year. It is too difficult!

Long term planning in money requires visualizing and then manipulating large numbers – 10 million riels for example – and then adding and subtracting millions of riels. This stretch is simply too long for most oral Cambodian adults. The limitation in long-term planning becomes clearly visible in the steep descent of the number line after "5,000".

OIM Tools: Prototyping a Design Response

The prototyping exercise explored the potential for addressing two challenging financial numeracy issues noted above: tabular syntax/passbook navigation and place value. This involved testing basic prototypes of 'oral information management' (OIM) tools with respondents. The procedure involved:

- designing a basic OIM passbook in the local context;
- introducing it to respondents, and priming them with a 3-4 minute summary of the meaning of the various images;
- asking them to demonstrate navigational competence; and
- having them write an entry in the correct location.

DIAGRAM 4 shows examples of the prototypes used. The first is for SACCOS' (Savings and Credit Cooperative Society) members in Tanzania, based on the standard format of the SACCOS passbook for both villages. This passbook had 20 columns laid out in the same format and order, (without the images and arrows - added for this study). The second is for 'Savings for Change' (SfC) savings group members in Cambodia.

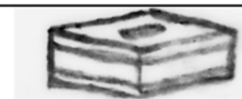
The images were generated in a 2-hour focus group with illiterate members of a farmers' SACCOS in the Arusha community. For example, the members associate saving with growing coffee, and the image of 3 coffee trees evokes the 3X leverage on loans the members associate with these deposits. Most loans are for housing or tractors, and for this group, the word 'penalty' easily evoked a crying man.

The Cambodia savings page was drawn from focus groups conducted with members of an agricultural co-operative in Kampong Os, Cambodia in 2010 (Matthews, 2014, p. 55). The image for 'interest' is a Khmer mnemonic cue. The Khmer word for flower is *p'gaa*, and the Khmer word for interest is *ka prak*. Focus group members found it easy to associate the two, as they sound very similar.

The interviewer/local research assistant then played the role of SACCOS or savings group record-keeper, and the member was asked to point with her finger to the cell in the book where today's date must be written. When the interviewer had written the date the author asked each member to point, with her finger, to 2-3 cells reflecting specific transactions that might take place on that day, varying the transactions randomly from one respondent to the next. For example, depositing 10,000 LCUs, paying interest of 20,000 LCUs etc. The numbers utilized were simple: all involved an initial significant digit, and 3-5 subsequent zeros.

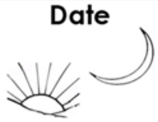
DIAGRAM 4
'Oral Information Management' (OIM) Passbook Prototypes

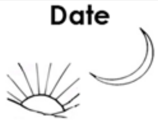
4.1 SACCOS Passbook (Tanzania)

	HISA  SHARES				AKIBA/SAVINGS 			AMANA/DEPOSITS 		
Tarahe Date	Hati Na.	Iliyopokelewa Paid in	Iliyochukuliwa Withdrawal	Baki Balance	Iliyopokelewa Paid in	Iliyochukuliwa Withdrawal	Baki Balance	Iliyopokelewa Paid in	Iliyochukuliwa Withdrawal	Baki Balance

MKOPO/LOANS 				RIBA/INTEREST 		ADHABU/PENALTY 		
Hati Na.	Uliatalewa Issued	Uliarejeshwa Repaid	Baki Balance	Iliyopokelewa Repaid	Baki Balance	Iliyopokelewa Repaid	Baki Balance	Saini Signature

4.2 Saving Group Passbook (Savings for Change, Oxfam, Cambodia)

Date 	Deposit 	Withdrawal 	Interest 	Balance 	Signed

Date 	Loan 	Repayment 	Interest 	Balance 	Signed

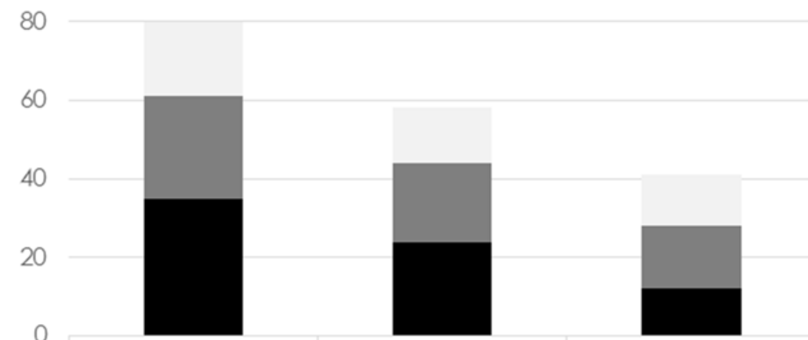
For the most part, passbook navigation was performed slowly, with fingers hesitating, lingering and moving abruptly on. The task is less simple than it looks. The SACCOS passbook has 20 columns and 11 rows (not all shown here) for a total of 220 cells. In the absence of priming, few clues help oral individuals to determine which of these 220 cells is correct.

If the member could point somewhat reliably to the correct cells, she was offered a pen and asked to write the most recently named entry in the correct cell. The 'spacing effect' – involving regular and frequent 'reviews' of learning – is known to be highly effective at building skills: in this case knowledge of place value. These reviews, if conducted during repeated meetings spaced two weeks apart for month at a time "… may do more than simply increase the amount learned; they may shift the [adult] learner's attention away from the verbatim details of the material being studied to its deeper conceptual structure" (Dempster, 1996, p. 318).

The results of this test appear in **TABLE 10**. Passbook navigation was reasonably successful in most cases, regardless of schooling or age. Even among older and less schooled individuals some were willing to risk using a pen and writing with it, suggesting that 'trend-setters' may be available to lead peers in many groups, if the environment is generally supportive.

The accuracy of the writing was surprisingly good. Only two respondents made an error in shaping a numeral. However, many individuals wrote the wrong number of zeros and/or showed their uncertainty with the final result.[7]

TABLE 10
Ability to Find a Cell in an OIM Record, and Write in the Cell, After Priming



	N	Find location for writing transaction entry	Write the entry
3 + years	19	14	13
1-2 years	26	20	16
None	35	24	12

None · 1-2 years · 3 + years

[7] At both test sites the SACCOS' managers requested permission to integrate OIM into their retail interface, which was happily given.

We shape our tools, and then our tools shape us.
► Marshall McLuhan

Conclusions

What does oral financial numeracy (OFN) in its most prevalent form – among nearly a billion adults in the monetizing villages of the modern world -- look like? What are its implications for financial inclusion?

First -- and most importantly -- while nearly three-quarters of oral respondents could count a six-digit cash amount and correctly state it, only 15% could recognize the same six-digit figure in writing. This pattern was substantially the same in Tanzania and Cambodia, and builds on findings in a previous study in Bangladesh. If validated in larger and more structured studies, this 'multi-digit divide' may prove to be a signature feature of OFN.

This divide may also go a long way towards explaining the burgeoning 'over-the-counter' markets for mobile money in Africa and Asia, as well as over 300 million dormant mobile money accounts, and hundreds of millions of other dormant 'bottom-of-the-pyramid' savings, current and payment accounts. When a product is being actively promoted, but large segments of the market cannot use it, this result is to be expected.

The fact that most respondents can accurately count a six-digit number in cash is remarkable. It reflects the development of a mental number line that is considerably better articulated among larger numbers than would be the case in a totally pre-cash setting.

During the monetization process the numbers in daily use gradually increase in size, from 1-2 digits in the early stages to 4+ digits later. The difficulties may only begin when the zero creeps to the left in a longer string: for example: "305" or "4,020". The longer the numeral string, and the further to the left the literate zero appears, the more oral capabilities begin to create barriers for adaptation by unschooled villagers.

As the village cash economy deepens -- through growth of village markets, proliferation of retail shops and integration of cash into traditional ceremonies – oral individuals may experience a need to learn to count and calculate in numbers with three or more digits. At the same time the cash economy and the *informal* financial system have adapted to the oral world -- shaping for example oral savings groups, village markets and funeral societies, which place demands on working memory that are consistent with oral capabilities.

Oral skill with arithmetic notation lags far behind. When asked to identify the correct numeral string, respondents were not just inaccurate: half declined to answer, as if wishing to avoid it altogether. The problem was not numeral recognition: 56 respondents could name a written one-digit number. Consistent with the observations of Ong and Nunes et al., modern arithmetic notation exhibits cognitive barriers to entry, reinforced by the economic and financial practices of oral, pre-cash culture.

Second, there are other distinctive features of the OFN (see **TABLE 11**) that depict an unmistakable 'double code' of mutually reinforcing capabilities and gaps - well adapted to an oral economy in which cash is a medium of exchange, but not a store of value.

- Addition, subtraction and even multiplication are moderately competent, especially for experienced vendors and shoppers. Calculators however, are rarely used.

	TABLE 11: Oral Financial Numeracy, by Prerequisites for Formal Financial Inclusion			
	Financial Numeracy Prerequisites	**Observation**	**Implication**	**Solutions**
1	Numeral recognition	Generally functional among unschooled people, but with limited confidence	Generally adequate for building positional notation.	Numeral recognition legends in passbooks and intelligent phone menus
2	Positional notation (place value), including role of zero	Generally weak, especially for larger numbers (3+ digits), relying on oral encoding of place value	Capacity can and should be built. Comfort with written place value is essential for confidence in any large-value cash transaction or financial service involving cash as a store of value	Cash-based numeric input tools and hovering cash-receipts in smartphones and calculators. Cash-based transcoding tools in passbooks, digital image wallets and phone menus.
3	Syntax of rows and columns	Generally weak, without oral analogs	Essential for decoding financial text or calendars. Can be absorbed while learning other skills.	Navigation cues like memorable pictures in passbooks and other tabular formats, including mobile phones. Navigation defaults in smartphones.
4	The four basic operations			
	: addition and subtraction	Generally functional, even among unschooled people	Adequate for engaging in oral economic and financial transactions. Good base for building other skills, including place value, division and percent	Calculators with cash-based numeric input tools. Calculation games and apps tailored for adults, that motivate practice
	: multiplication and division	Multiplication: modest Division: weak Percent: not functional	Capacity to recognize and use operator symbols (and calculators) can be built. This skill is essential to plan confidently for the future in cash.	Cash-based calculation guides in passbooks and phone menus. Calculation games and apps Structured support in savings groups and solidarity circles
5	Approximation	Generally weak in dealing 3+ digit numbers	Capacity can and should be built. Essential to plan confidently for the future in cash.	Approximation games and apps Structured support in savings groups and solidarity circles
6	Calendar time	Generally weak, but uneven	Capacity can and should be built. Essential to plan confidently for the future in cash.	Calendar/planning games and apps Plan-based (commitment-based) savings accounts

- Approximation of 3+ digit numbers is very weak. This skill has almost no oral analog, and can only be learned through practice.
- Reluctance to learn to use a calendar for planning may reflect both oral livelihood priorities and difficulty visualizing linear time: a temporal analog to the mental number line.

Taken together the cognitive gaps outlined in this fieldwork represent a limiting -- and often disabling -- transaction cost for oral individuals seeking to access financial services. The multi-digit divide affects a wide range of downstream activities from real time personal validation of a cash receipt or mobile payment, to estimation of future income requirements to pay for a child's higher education. The most effective instrument to support skill acquisition may well be cash, because oral individuals recognize cash notes and can use them with relative efficacy.

Escaping Oral Equilibrium

These observations also suggest a path for escaping oral equilibrium that builds on the strengths of oral culture. Contrary to many anecdotal assumptions, subtraction and even multiplication are moderately competent, especially for experienced vendors and shoppers. Oral respondents clearly appear to be acquiring numeric competencies through negotiating cash value. Further, they appear to be using cash as *an intermediate numeric system*, between verbal and written, that offers the capacity to count and manipulate larger numbers than would be possible for them in either oral or written modes (see **TABLE 12**, adapted from the child-development model of Kauffman et al., 2016).

The five stages of development of numeracy skills or abilities begin with the innate numeric understanding possessed by all humans, embedded in the approximate number sense (Pica et al., 2004; Gordon, 2004). Stages 2-5 all involve human-designed tools and solutions, gradually developed during our historical transition from primary orality to mass literacy. Unschooled oral adults acquire stage 2 from their culture and context. Stage 5 is most likely to be acquired though several years of primary school.

The sequencing of stages 2-4 is somewhat fluid. The cash value system – represented here as Stage 3 – may appear as Stage 4 in some contexts, depending on the level of local monetization, traditional numeracy practices and related factors. Unschooled or partially-schooled adults utilize numeric abilities, and acquire them, through manipulation of cash value. These skills may be acquired somewhat iteratively, and somewhat uniquely. Pre-existing skills, livelihoods and home resources will play a large role in learning trajectories.

Stage 3 represents a partial equilibrium: many unschooled adults manage throughout their adult lives based on a combination of innate, verbal and cash manipulation skills. This equilibrium is adequate when monetization is not too advanced. But in the absence of Stage 5 skills, individuals are likely to distrust cash as a store of value. This distrust in its turn reduces the

TABLE 12:
Stages of OFN Skill Development

Capacity of working memory	Primary orality (innate numeracy)	Residual orality *Human-designed tools that economize on working memory*			Mass literacy
Cognitive representation	Approximate number system Concrete (non-symbolic) quantity	Verbal number system /one/two/ … Number words (multiple languages)	Cash value system 10 50 100 1000 Denominations (multiple currencies)	Indo-Arabic numeral system …, 13, 14, 15, … Digits	Place value and formal zero (mental number line) 0 10 100 1 000 10 000 Spatial image
Ability	Subitizing, approximation	Verbal counting, small number (1-2 digits) calculation	Large number (3+ digits) counting + calculations	Written calculations, market fractions and decimals	Approximate calculation, calendar time, planning in cash
					Skill development →

Adapted from Kaufmann et al., (2016), *The Development of the numerical brain* , Oxford Handbook of Numerical Cognition, p. 489.

incentive to acquire Stage 5 skills, since it is often the case that in an oral village the primary use of these skills is to plan for the future in cash.

Unlike other number systems, cash is a *physical abstraction* - useful both as an object and as an abstraction (see **TABLE 13**). Users of cash can be located anywhere on this physical-abstract spectrum. Users adapting to the cash economy and financial system will migrate from dependence on the physical to increasingly fluency with the abstract. Digital financial services suppliers need to be aware that the journey of their customers to active mobile money use may depend on migration along this spectrum. This is unlikely to happen quickly without proactive efforts by suppliers (see recommendations below).

Many oral individuals identify notes based on physical features like colour, images and shape. A basic model of the number system, including larger (3+ digit) numbers, can be acquired through counting and using cash as well as through verbal practice, without any need to decode the digit strings on the cash notes. As Nunes and her colleagues (Nunes et al., 1993) observed, cash notes more easily afford counting and calculating from large numbers down than written notation, making it simpler for individuals to retain the meaning of the calculation, and reducing their risks of error.

Very few of the villagers in this study were able to think of a number larger than a hundred that they had used in the previous week. Most probably had much more cash, denominated in Tanzanian shillings, in their pockets. Does the physical nature of cash act as a kind of cognitive shield from the need to cope with the size of the numbers involved? Is 10,000 Tsh a reference to the 5-digit Indo-Arabic numeral string '10,000'? Could it instead denote '10' one-thousand Tsh notes or '1' ten-thousand note (etc)?

Fully literate individuals may scarcely notice the physical properties of the cash they handle. Instead, they may experience cash as standardized units of value - numeric extensions of their bank account balances that happen to be stored in their wallets. They may have trouble providing even a simple physical account of notes they have handled every day for years.

Progress in closing the OFN gap can be measured, and progress towards fluency with decoding multi-digit numerals may offer a strategic and parsimonious entry point. A team at the Numerical Cognition Lab at the University of Western Ontario recently developed a 2-minute test of symbolic and non-symbolic numeracy that closely tracks mathematical competence in children (Nosworthy et al, 2013, pp 6, 12).

TABLE 13:
Cash as a Physical Abstraction

Useful Features as Physical Object	**Useful Features as Abstraction**
* supports counting by one-to-one physical correspondence * physical variation by type (denominations), in size, shape, colour and image * denomination values parallel useful exchange values * can embody relatively large numbers (3-6 digits, depending on context) * easily affords counting from large numbers down, supporting retention of meaning	* standardized nominal values, with standardized relationships between them * explicit formal zero and place value * denomination values facilitate rapid large-number counting and processing * references and evokes the Indo-Arabic (linear, infinite) number system * supported by highly established ecosystem of institutions and practices

From Digital Divide – to Multi-Digit Divide
Financial services – including mobile money – depend on the emergence of written numeracy. In a strictly technical sense, this dependency may weaken in 10 or 15 years, once most oral adults exchange their analog phone for a smart one that can talk to them. Improvements in intelligent, responsive voice technology will certainly increase the use of mobile payments. But the evidence here suggests that over-reliance on voice technology to close the financial inclusion gap would be a grave error.

Individuals who cannot plan for the future in cash cannot be meaningfully included in the financial system. Talking smartphones will struggle to address this challenge, or the underlying values gap that drives so much of OFN. Most respondents here see little need to learn to use a calendar, or a calculator, and they appear to be in no hurry to learn place-value notation or the meaning of percent, either. The unthinking calls for a hurried abolition of cash in some technology quarters (e.g. Wolman, 2012) -- purportedly to 'free' poor people from a cash economy they haven't entered yet – cannot make the case for this vital transition.[8]

However, smartphones offer a potent opportunity to achieve meaningful financial inclusion -- once the use-needs and incentives of oral individuals are adequately understood. Building a sound base of OIM evidence that can be applied across the retail interface of microfinance, and migrated to smartphones at the earliest practical moment, may open a vitally important avenue for the early realization of meaningful financial inclusion.

To date, the evidence-base about oral financial numeracy is very weak, in spite of decades of effort to achieve financial inclusion. This weakness reflects a cluster of **dangerously complacent assumptions** among practitioners, businesspeople and policymakers who have been literate since early childhood – namely, that anyone who:

- can handle cash can decode and manipulate written numeral strings of equivalent quantities,
- can do simple addition and multiplication can plan for the future in large numbers and in cash,
- has access to a calendar knows how to use it, and
- does not acquire these skills is too lazy or unmotivated to get themselves or their children out of poverty.

These assumptions lead practitioners, businesspeople and policymakers to fail to see the world from the perspective of the illiterate and, especially, the innumerate.

The evidence presented above suggests that this literate bias against seeing oral culture more clearly is itself a barrier to financial inclusion.

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[8] A recent book by economist Kenneth Rogoff entitled The Curse of Cash (2016) makes a more balanced case: calling for the gradual and staged elimination of large-value denominations while leaving small-value banknotes in circulation indefinitely.

Recommendations

The scope of the challenge of OFN, particularly in the context of achieving universal financial inclusion, merits deeper and more sustained scientific attention, for example through collaborative field-work linking universities and researchers in developed and developing nations.

In the context of financial inclusion:

- Develop a robust global financial numeracy indicator based on positional notation and track it in Global Findex and national-level financial inclusion surveys.
- Financial services providers (FSPs) should test and pilot oral information management tools at their retail interfaces and encourage customers to up-date their own balances – that is, acquire working knowledge of place value and zero notation.
- Financial numeracy learning aids and games should be packaged with mobile money in oral communities.
- Wherever possible, FSPs should provide oral financial consumers with a safe place to take their time validating calculations, and the resources to do it (e.g. play money, group-based systems).
- Savings groups should be encouraged, because they actively support the flows of information about formal finance that are critical for individual migration from oral to literate equilibrium. OIM designs should be tested in savings groups.
- Develop brief and specific financial numeracy modules that can be integrated quickly and effectively into NGO livelihood projects, adult education, value chain projects and delivered by civil society/community groups.
- Accelerate financial numeracy in primary schools, so that children who leave after 2-3 years recognize the numerals 0-9 and have mastered place value code and tabular syntax.

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