PROBABILITY, UNCERTAINTY AND THE TONGAN WAY

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Problems teaching probability in Tonga (in the South Pacific) led to the question how language and culture affect the understanding of probability and uncertainty. The research uses a discursive approach to find the endorsed narratives which underlie Tongans' reasoning in situations of uncertainty. I aim to justify the claim that the Tongan Language and the Tongan way of life interact to make the concept of uncertainty unimportant and the concept of probability almost redundant in day to day discourse.

INTRODUCTION – A BAYESIAN ARRIVES IN POLYNESIA

As a teacher of statistics at 'Atenisi University in the Kingdom of Tonga (a group of Islands in the South Pacific) in 1994 and again in 2010, I experienced great difficulty explaining the concept of probability to students, who were otherwise proficient at learning mathematics. The students did not appear to relate to examples of uncertainty in the way in which I had expected.

Preliminary observations indicated that the Tongan language does not provide Tongan students with the tools and the intuitive ideas which are so important in developing the ideas of uncertainty and of probability. Although secondary and tertiary education is supposed to be in English, my students regularly switched to Tongan when discussing what I was teaching. Tongan is the language that mediates and organises these students' lives and activities. It is an integral part of their culture. These observations motivate the research question: *How do the Tongan language and culture shape discourses on probability and measuring uncertainty*? More generally, the hypothesis to be tested is that the linguistic tools provided by the Tongan language differ significantly from European languages and as a result the western concepts of probability and uncertainty do not exist in the community of native Tongan discourse (this said, as the result of the arrival of English language and Western forms of life, both the discourse on uncertainty and activities that require probabilistic thinking are in the process of developing in Tonga).

I should state from the start that my approach to statistics is that of a somewhat dogmatic Bayesian. Bayesian statistics is an axiomatic approach, which defines a rational way of making decisions in situations of uncertainty. My aim had been to try to teach this approach to my Tongan students, an attempt which ended in abject failure. The aim of this research is to explain, understand and learn from this failure.

My research (for which Anna Sfard serves as an advisor) has led me to the conclusion that discourses on probability are closely related to discourses on fractions but in this paper I will concentrate on the topic of probability and uncertainty and only mention

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findings about fractions in passing. In this paper I make use of a few samples from my field work in an attempt to explain the discourse on probability and uncertainty which I observed in Tonga.

THEORETICAL BACKGROUND

Language, culture, and mathematical thinking

The idea that language shapes people's view of the world dates back to the mid twentieth century and is known as the Sapir-Whorf hypothesis (Whorf, 1959). Initially there was great interest in the hypothesis and then for many years it did not receive much attention. Recently there has been a renaissance of interest (Cole, 1996, Deutscher, 2010, and many others). It is suggested that part of the reason that Whorf's ideas did not receive more support is that he over stated his case. He claimed that our mother tongue restricts how we think and prevents us from being able to think certain thoughts. The dominant approach today is "that when we learn our mother tongue, we acquire certain habits of thought that shape our experience in significant and often surprising ways" (Deutscher, 2010).

In his research, concerning the Oksampin communities in Papua New Guinea, Saxe develops the idea that not only language but culture and history are related to how mathematical ideas are understood. He proposes a methodological approach "rooted in the idea that both culture and cognition should be understood as processes that are reciprocally related, each participating in the constitution of the other" (Saxe, 2012, p. 16). My research in Tonga originated with the idea that language affects understanding but it quickly became clear that the cultural and historical background of the community had to be taken into account.

The development of probabilistic thinking – cross cultural studies

Little has been written concerning cross cultural studies of probabilistic thinking. In his survey of the literature Jones raises concern about "the lack of probability research outside western countries" (Jones, 2007, p. 944). In an earlier survey Shaugnessy stresses the need for “cross cultural comparison studies using in-depth interviews on decision making and probability estimation tasks” (Shaughnessy, 1992. p. 489).

I have only located two articles that deal with cross cultural studies on understanding probability. In the first (Amir and Williams, 1999), the authors compare two cultural groups within the same school in England. Language, beliefs, and experience were shown to influence the 11-12 year old children's “informal knowledge” of probability, which was defined as “the intuitive knowledge they bring to school and use in thinking about probabilistic situations" (ibid, p. 85). In the second article (Chassapis & Chatzivasileiou, 2008), the authors compare conceptions of chance and probability held by children who live in Greece and in Jordan. They also compare a group of Palestinian children living in Greece with children from the local Greek Christian community. They conclude that more religious Muslims tend to attribute random

events to God, while less religious Greek Christians tend to attribute random events to chance.

Ian Hacking (1975) provides an historical dimension to the present study. The author looks at the preconditions for the sudden emergence of probability, as we know it today, in mid seventeenth century Europe. These preconditions included:

- The development of a simple notation for fractions
- Developments in the insurance industry and the theory behind annuities
- Changing attitudes to religion, fatalism and causality.

There are striking similarities between the historical process described by Hacking and the emergence of probability, which I observed, in Tonga. Understanding how the idea of probability emerged in Europe helps to explain what is happening in Tonga today.

CONCEPTUAL FRAMEWORK – A DISCURSIVE APPROACH

In this study I adopt the discursive approach proposed by Anna Sfard (Sfard, 2008) in which mathematics is defined as a form of communication or discourse. People are members of various overlapping "communities of discourse". A community of discourse is defined as those individuals participating in any given discourse and by the endorsed narratives which they use. An individual can be a member of a number of overlapping communities of discourse. This approach supplies a powerful framework through which to understand and explain the observations which I made in Tonga.

Using this theoretical framework the aim of the research is to identify, analyse and contrast the various communities of discourse that exist in Tonga, how they overlap and how they compare with typical western communities of discourse. In this paper I aim to analyse the endorsed narratives about uncertainty and probability, which I observed in Tonga.

SOME EMPIRICAL FINDINGS ABOUT PROBABILISTIC THINKING IN TONGA

The seeds of this research were planted while I was trying to teach basic ideas of uncertainty to a university level class. I (the "lecturer") was attempting to teach how future events can be assigned probabilities and had the following conversation:

Lecturer:	What is the probability that the sun will be shining at this time tomorrow? (*in my way of thinking there was a reasonable chance of cloud cover*).
Student:	It will be sunny.
Lecturer:	Are you certain that it will be sunny?
Student:	Yes.
Lecturer:	Why are you certain?
Student:	Because the angels told me.

The reader can imagine how frustrating I found this conversation when trying to teach basic ideas of probability from a Bayesian perspective. The student was an able student and spoke good English. The remainder of this paper should be seen as an attempt to understand what way of thinking lay behind my student's response.

The research started with a collection of anecdotes and progressed to include the use of questionnaires, semi-structured interviews, classroom observations, audio and video recordings of conversations with children and adults, as well as interviews with various professionals.

Vocabulary for uncertainty

In English, as in many other languages, there is a large spectrum of words for different levels of uncertainty: *Almost certain, ninety nine percent certain, very likely, probable, possible, conceivable, rare, slim chance, almost impossible* and many more. In Tongan, the only word in common use, which is similar to the above list, is 'mahalo', which is best translated as "maybe" or "perhaps".

An example to show how the dearth of suitable vocabulary affects the teaching of probability can be found in the Tongan version of the school curriculum for primary schools (Mathematics for Life Syllabus, 2009). The syllabus is written entirely in Tongan except for the section on probability, which is written together with an English translation. When I asked why the English translation was included, I received the explanation that the Tongan speaking teachers would not understand the Tongan and would need to refer to the English version to understand what they were supposed to teach!

Probability is measured using fractions but there were no words for fractions in Tongan until the missionaries introduced a rather complex way of expressing them during the second half of the nineteenth century. I found strong evidence that fractions are not understood in the same way as they are in the West, for example a large majority of Tongans (including some maths teachers) did not know how to answer "What is a half of a half?" My research led me to the conclusion that the Tongan discourse does not relate to fractions as numbers between zero and one. This has a clear effect on how probability is understood.

Answers to questions about the likelihood of future events

I conducted sixty structured interviews with a cross section of the population. The interviews took place near the main market. Unless my respondents spoke good English the interviews were carried out in Tongan by my assistant. Some of the questions were about the likelihood of future events such as "What are the chances that it will rain tomorrow?", "What are the chances of getting a head when tossing a coin?" and "What are the chances of a first child being a boy?" In all cases less than twenty five percent of the answers were in terms of uncertainty. All the other answers were in terms which to a Western way of thinking may appear dogmatic:

The chances of rain:	"The sky is cloudy so it will rain"
	"It is not going to rain"
	"Check at the internet [if it is going to rain]"
The chances of a head:	"You will know when you turn it over"
	"Depends who tossed the coin"
	"Toss it four times to get a head".
The chances of a boy:	"I believe they will get what they wish for"
	"Depends on the scan"
	"Sleep on time, wake up on time [then it will be a boy]"

The place of uncertainty in the Tongan community of discourse

In an attempt to understand the place of uncertainty in Tonga I interviewed a large number of people including teachers, church ministers, bankers, bingo players, government ministers, micro finance managers and Tongan language experts. The picture which emerged is of a community which, historically, has had little need for uncertainty. Definite answers are valued above uncertain answers and this is combined with a fatalism about the future. I have categorised some of the responses in terms of Hacking's preconditions for the emergence of probability.

Hacking suggests that developments in the insurance industry were one of the preconditions for the emergence of uncertainty in Europe in the seventeenth century. Insurance companies exist in Tonga but most people only take out insurance policies when the bank demands this as a condition for a loan. A typical response was "I insured my house until we had repaid the bank loan and then I stopped paying the premium". This is despite the fact that there is a serious danger of burglary, fire, flooding and hurricanes. Life insurance is also seen as unnecessary – while interviewing the minister of education, she said "I think they [Tongans] are quite certain that the processes and the checks and balances we have in the society insure that the future will be taken care of. .... If you ask a Tongan to pay out for life insurance they will think it is a total waste of money – I agree."

Another precondition, suggested by Hacking, concerns attitudes to religion, fatalism and causality. For more than a hundred and fifty years the Tongan way of life and value system has been dominated by what is known as the "Tongan Way", which aims to combine traditional Tongan values of respect and obedience with a deeply held belief in Christianity. In my research I explored how this belief system affects attitudes to free will, predetermination and the inevitability of future events. Most the people whom I interviewed expressed a strong belief that future events depend on the will of God and that we do not have free will to control them. A church minister suggested that "The might of God reinforced by concepts of monarchy and of culture and of respect and of dominance and of control [...] come through at the every person level as a sort of fatalism." I found evidence that the importance of obedience to God and to those of

higher status led people to regard expressions of uncertainty in a negative light. I asked one of my respondents why she had given a definite answer and had the following conversation:

Interviewer: Why do you say that you are certain that it will rain?

Respondent: A 'maybe' answer would be dishonest. A definite answer is more honest. Not good to have doubts when you answer question. If you have doubts that is bad. If you ask the child and he answers 'maybe' the child will get a slap (you are being cheeky).

Interviewer: What about when you get it wrong [when it does not rain]?

Respondent: I feel good that I am positive about something that I believe in I didn't have doubts.

DISCUSSION

I suggest two interpretations of the above findings and in particular, two explanations for what my student meant when he said he was certain that the sun would be shining. The first looks at the lack of vocabulary for uncertainty and the limited use of fractions. The second is based on an analysis of fatalism and predetermination. Finally I suggest a synthesis of these two approaches by comparing the observations made in Tonga with the emergence of probability in seventeenth century Europe.

Language, vocabulary and fractions (Sapir-Whorf)

Whorf claimed that "We dissect nature along lines laid down by our native languages". My observations in Tonga support the Sapir-Whorf hypothesis that language, and in our case the dearth of vocabulary, limit how uncertainty can be expressed or understood. Since there is no discourse on probability in Tongan, my student, when asked, what is the probability that the sun will be shining tomorrow, did not have the tools to give an answer in terms of uncertainty. Instead he understood the question as a prediction about the future – will it be sunny tomorrow? The concept of giving a reply in terms of probability by using fractions or percentages was not part of his discourse.

Religion, Fatalism and Predetermination

Through interviews and discussions I found strong evidence that the religious belief, which dominates Tongan society, includes a kind of fatalism by which an all powerful God controls our lives. Future events have been predetermined and we only have to wait to observe that future. Thus future events are not uncertain but are waiting to be revealed.

How does all this help us to understand the Tongan discourse on uncertainty? I suggest the following endorsed narrative:

God is almighty (a translation of the much used Tongan phrase 'Otua Mafi Mafi).

The future is predetermined because God is almighty and controls our destiny.

> It follows that there is no such thing as uncertainty regarding whether it will be sunny at this time tomorrow. It is no more uncertain than whether it was sunny yesterday.
>
> Thus any discourse about future events is a discourse about definite events which are known to God.
>
> When asked whether it will be sunny tomorrow there is no need for vocabulary describing uncertainty. Any question about what will happen in the future is a question about what has been predetermined by God.
>
> Given all of the above, what better way to answer the question about what God has decided than to go through the intermediary of "the angels"?

Both the above explanations combine to explain the developing discourse on probability and uncertainty, which I observed in Tonga. There are striking similarities with the process in seventeenth century Europe, described by Hacking (1975). In both cases the emergence of probability depends on a combination of a number of different preconditions.

This leaves us with the question: how would my student have felt if the sun did not shine at the same time tomorrow? (I was never able to answer this specific question as the angels provided correct information and the sun was shining at the same time the next day!).

CONCLUSION – A MORE MODEST BAYESIAN LEAVES POLYNESIA

This research originated with some surprising observations which I made while teaching at 'Atenisi, an institute founded in 1975 and dedicated to the encouragement of critical thinking amongst the young people of Tonga. The immediate purpose of this study is to contribute to the aim of encouraging critical thinking, not only at 'Atenisi but throughout the Tongan education system. Its broader purpose is to deepen our understanding of factors that shape mathematical thinking. The data already collected, only a small fraction of which has been presented on these pages, brought ample evidence for the strong interdependence between cultural practices, discourse (thus language), and thinking.

As noted above, I am a convinced Bayesian and over the years have made great efforts to convince family, friends and colleagues to make rational decisions in situations of uncertainty (usually with frustratingly little success). This research has led me to a more modest expectation from the Bayesian program, while also providing a framework on which to build a wider program to enable Tongans and people elsewhere to understand how to make rational decisions when faced with uncertainty.

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