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Cognition, Algebra, and Culture
in the Tongan Kinship Terminology

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Abstract

We present an algebraic account of the Tongan kinship terminology (TKT) that provides an insightful journey into the fabric of Tongan culture. We begin with the ethnographic account of a social event. The account provides us with the activities of that day and the centrality of kin relations in the event, but it does not inform us of the conceptual system that the participants bring with them. Rather, it is a slice in time of an ongoing dynamic process that links behavior with a conceptual system of kin relations and vice versa. To understand this interplay, we need an account of the underlying conceptual system that is being activated during the event. Thus, we introduce a formal, algebraically based account of TKT. This account brings to the fore the underlying logic of TKT and allows us to distinguish between features of the kinship system that arise from the logic of TKT as a generative structure and features that must have arisen through cultural intervention.

0. Introduction

Tongan social events such as first birthday, marriage and death are deeply intertwined with one's world of kin. The persons central to these events are kin of various kinds and the events serve to define and redefine core kin relations and relations between kin such as the *fahu* relationship. We begin the paper with the ethnographic account of a first birthday attended to by the first author. The events of that day highlight the interplay between the formal properties of kinship expressed through a kinship terminology and how the meaning of those kin relations are played out and reconstructed in the context of a family celebrating the first birthday of a daughter.

The ethnographic account provides us with the activities of that day and the centrality of kin relations in those events, but it does not inform us of the conceptual system that the participants bring with them as culture bearers to this event. Rather, it is a slice in time of an ongoing, dynamic process linking behavior with a conceptual system for kin relations and a conceptual system for kin relations with behavior. The events of the day are a co-production of the dynamic and the static; of kinship as it is lived and kinship as it is conceptualized. To understand this interplay we need not only the ethnographic account but also an account of the underlying conceptual system that is being activated during this event.

We argue that the genealogical framework in which kinship analyses have generally been implemented is inadequate for this task and instead needs to be embedded within a more encompassing framework. The genealogical framework assumes genealogical categorizations are primary to understanding a kinship system, yet it does not account for these categorizations. What does account for these categorizations is the underlying generative logic of a kinship terminology. That logic is made evident through commonly reported ethnographic observations regarding the way kinship terminologies are used directly to compute and thereby determine kin relations even when the genealogical connection between the persons in question is unknown. The underlying, generative logic of the terminology can be made explicit through formal, algebraic modeling of the logic of kin term computations. In addition, and important for our accounts of Tongan social life and kinship, the algebraic modeling makes it possible to determine those terminological features that do not derive from the underlying, generative logic and thus must have been adjoined to the terminology through cultural intervention. What is activated in social life, we argue, is a conceptual system relating how kin and kin relations are constituted.

1. Tongan Social Life and Kinship

We begin the argument with an episode (a child's first birthday) that occurred to one of us (the senior author) during his residence in Tonga. Through this event we introduce the specific ways in which the Tongan kinship system shapes social events such as child's first birthdays, marriages, and funerals and the kinship issues that these events pose.

It is a special day today in the village of Ngeleia, Tonga. Manu[1] and Mele's daughter Loisi,[2] their third child, is one year old. Traditionally in Tonga, the

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[1] Names have been changed as common practice in anthropology to maintain privacy of participants.

[2] The sex of the child would not bring any change in the episode I am about to narrate.

celebration of a child's first birthday is one of the few, major social landmarks in a person's life – the other two being a wedding celebration and one's funeral. Manu and Mele are living with Manu's parents and their house is not big enough to host the celebratory gathering and consumption of food. The celebration takes place in the hall next to the church located right in front of Manu's parents' house.

As I approach the hall, I see people carrying large pieces of *ngatu* 'tapa/ barkcloth' or mats being met at the door by Mele. I get a glimpse of Manu, still in the backyard of his parents' house, cheerfully chatting with other men while finishing the roasting of a few small pigs over a hot fire. My attempt to move in his direction is interrupted by his clear invitation to proceed to the hall. When I enter the hall, to my right, stands Manu's sister Nunia (she is much younger than Manu) holding Manu's daughter, Loisi. Of course, they are dressed up for the occasion wearing their best *ta'ovala* 'mat worn around waist,' as are all the guests either sitting on the numerous chairs available or just standing and chatting in small groups. Behind and next to Nunia and Loisi, a pile of pieces of *ngatu* and mats with other presents like pieces of fabric, canned food, meat, and money is slowly forming.

One side of the hall is occupied by a few tables with tablecloths on which many plates full of food have already been put on display. After a few celebratory speeches performed by the minister and a few elder guests, and after roasted pigs have been put on the large empty dishes on the table, guests are invited to help themselves to the food.

The celebration closed with Nunia choosing and keeping some of the presents for herself and with the remaining presents being distributed by her to some of the guests. After this distribution, almost all the guests left. Then, finally Manu entered the hall and had some food while gleaming with happiness about the successful completion of the celebration. During the whole celebration Manu was nowhere to be seen. The focus of attention during the whole event was either Loisi or Nunia (Loisi's *mehekitanga*) or Mele (Loisi's mother).

I must admit that I was already aware of the special role that the father's sister called *mehekitanga* plays in the life of Tongans, but witnessing its instantiation was quite a different experience. The *mehekitanga* of the celebrated child was the center of the whole ceremony. Presents were piled at her side, she chose how many to keep, and she decided which ones had to be given to the various departing guests. In the coming years, she would actively participate in the raising of the child, but exercise especially her privilege (called *fahu*) to ask and receive material objects and services from her brother's children. All sisters of a Tongan male will be *mehekitanga* to his children, but the eldest sister would be the only

one exercising the privilege of her position.[3] The same *fahu* relationship exercised by one's father's sister (*mehekitanga*) over her brother's children (*fakafotu*, both male and female) is also exercised by any individual over their mother's brothers (*fa'e tangata*).[4]

A Tongan female sibling is always higher in rank than her brother, and an older same sex sibling (*ta'okete*) is always higher in status than a younger one (*tehina*) (Gifford, 1929; Tupouniua, 1977; Bott, 1982; Gailey, 1987; van der Grijp, 1993). The gender hierarchy is further stressed by the brother/sister or *tuonga'ane* (male sibling for a female)/*tuofefine* (female sibling for a male) avoidance practice (Gifford, 1929; Tupouniua, 1977; Helu, 1999). Siblings of different sex are moved into separate sleeping quarters around the age of ten. Specific linguistic (e.g., topics like sex) and behavioral restrictions (e.g., dancing, watching a movie) are also part of this avoidance system that continues throughout one's life.[5] This partly explains Manu's behavior and his late entrance into the hall.[6]

The birthday celebration already highlights the complex and fundamental interaction between kinship and social life. This interaction is even more apparent in funerals. The death of an individual triggers a series of events that constitute the mold into which kinship relationships are poured in order to establish the social position of that individual for the last time and serves as one of the main occasions wherein "much of the enculturation of the young in Tongan tradition takes places" (Kaeppler, 1978:174). The reiterative enactment of these events with culturally constituted kin sets forth the conditions for the continuation of the form of praxis often referred to as 'tradition' (extensive accounts of Tongan funerals are found in Kaeppler, 1978 and van der Grijp, 1993).

The participants in a funeral all belong to the same *kainga* (bilateral kindred) and are constrained in their behavior by their kinship relationship to the deceased: "[F]unerals are the occasions *par excellence* when status and rank prescribe the actions of all concerned" (Kaeppler, 1978:174). Ranking in Tonga

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[3] In traditional Tonga this privilege was exercised by all *mehekitanga*. In contemporary Tonga this privilege is being often contested, especially when it is exercised in ways that tend to clash with the principles of a newly introduced market economy in a rapidly westernizing population (see Small, 1997; Morton, 1996; 2003).

[4] This type of *fahu* is also limited nowadays to "the eldest female child of the father's eldest sister." (Tupouniua, 1977:24).

[5] Many contemporary Tongans do away with separate sleeping quarters or avoiding the same dancing floor with one's opposite sex sibling, but the taboo is still very much in their consciousness and can still be cause of social embarrassment if broken.

[6] Traditionally cooks were also considered as the bottom of the society's ladder (see Martin, 1818) and this sentiment may have had a part in motivating Manu's behavior. After all, he had been preparing food all day up to the time of the birthday celebration.

establishes who is high (*'eiki*)[7] and who is low (*tu'a*)[8] (Kaeppler, 1971; James, 1991; van der Grijp, 1993). In the generation above ego, the father side is *'eiki* and the mother side is *tu'a*. However, rank acquired through the mother is more important than the rank acquired through the father. In the generation below ego, children are *tu'a* if the deceased is male and *'eiki* if the deceased is female (Kaeppler, 1971).

Only relatives that are *'eiki* to the deceased (ego) are allowed to touch the body and prepare it for the burial. The person who sits at the head of the corpse during the wake is the *fahu*. In the case of a dead woman, typically the child of one's 'father's sister' is the *fahu*. In the case of a dead man, a child of one's 'sister' or grandchild of one's 'father's sister' would be the *fahu*. All the relatives that are *tu'a* to the deceased belong to the *liongi* or group of people responsible for bringing presents that will later be distributed by the *fahu* after choosing some for personal use. The *liongi* are not allowed to enter the wake room where the corpse is lying and they must wear an enormous mat around their waist (at times covering even the back of their heads) as an overt sign of their sorrow and status.

It is important to notice that the conceptual content of the various kinship terms used in defining the *fahu* in a funeral (see Bennardo and Read, 2005:6) is more complex than suggested by simply referring to the positions in a genealogical space referenced by the transliteration of a kin term. In the genealogical space, for example, an ego is not marked with gender, but in Tongan kinship there is no ungendered ego and when calculating who is the appropriate *fahu* at a funeral, the calculations are based on gender marked terms (see Biersack, 1982:184). This seemingly small, yet substantial, difference between features of kin terms and features of the genealogical space – another one being relative age – has important consequences when we consider how the Tongan kinship terminology is constituted.

2. The Tongan Kinship Terminology

The Tongan Kinship Terminology (TKT from now on) spans over five generations with generation 2 up and 2 down containing only a closure term, *kui* 'grandparent' and *mokopuna* 'grandchild,' respectively (information about TKT comes from Aoyagi, 1966; Beaglehole and Beaglehole, 1941; Biersack, 1982; Bott, 1982; Collocott, 1924, 1927; Gailey, 1987; Gifford, 1929; Helu, 1999; Kaeppler, 1971; Korn, 1974, 1978; Marcus, 1977, 1978, 1980; Martin,

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[7] *'Eiki* also means 'chief.'

[8] *Tu'a* also means 'common people' and 'outside.'

1818; Morton, H., 1996, 2003; Morton, K., 1972; Rivers, 1916; Rogers, 1977; Tupouniua, 1977; van der Grijp, 1993; and from Bennardo's fieldwork in 1993-95). Table 1 contains the whole set of Tongan kin terms with partial genealogical descriptions – partial since the TKT is a classificatory terminology with terms that are not easily defined just using genealogical relations – for each kin term along with its closest transliteration. The three major generations (zero, 1 up, and 1 down) covered by the terminology contain between five and six terms each.

All the terms in generation zero (*tokoua, tuofefine, tuonga'ane, ta'okete*, and *tehina*) are also used for genealogical parallel cousins and cross-cousins, without regard to linking relative. Nonetheless there is a behavioral distinction between genealogical parallel cousins and cross-cousins (Biersack, 1982:184; Kaeppler, 1971:177). In fact, individuals would behave towards the two types of genealogical cousins in the same way as their parents do, and these latter distinguish them terminologically (i.e., using either *'fakafotu* 'child of tuonga'ane' or *'ilamutu* 'child of tuofefine.')

The behavior that distinguishes between genealogical parallel and cross-cousins is part of the *fahu* system discussed above. One is '*eiki* 'high' to one's mother's brother's children and *tu'a* 'low' to one's father's sister's children. Why this shift from labeling persons by kinship terms to labeling the relationship between persons without simultaneously labeling the persons involved in different relationships? Is this to be considered a gap in the terminology? Or is there enough computational power in the terminology already to make the addition of further terms unnecessary? Furthermore, why distinguish between siblings only according to gender and age (but only in some cases)? And finally, why only one term for same sex sibling? None of these questions are answered by mapping kin terms to a genealogical space but are answered through the more encompassing framework we present below.

Table 1
Tongan Kinship Terminology

Generation	Term	Partial Genealogical Description	Transliteration
2 UP	*KUI*	(FF, FM, MM, MF)	'grandfather'
1 UP	*MOTU'A*	(M, F)	'parent'
	FA'E	(M, MZ)	'mother'
	FA'E TANGATA	(MB)	'maternal uncle'
	TU'ASINA	(younger MB)	'younger maternal uncle'
	MEHEKITANGA	(FZ)	'paternal aunt'

Table 1 (cont.)

Generation	Term	Partial Genealogical Description	Transliteration
ZERO	*TOKOUA*	(same sex B, Z)	'same sex sibling'
	TUOFEFINE	(Z of male)	'sister of male'
	TUONGA'ANE	(B of female)	'brother of female'
	TA'OKETE	(older B, Z)	'older same sex sibling'
	TEHINA	(younger B, Z)	'younger same sex sibling'
1 DOWN	*TAMA*	(S, D of female)	'child of female'
	FOHA	(S of male)	'son of male'
	'OFEFINE	(D of male)	'daughter of male'
	FAKAFOTU	(BS, BD of female)	'child of *tuonga'ane* (brother of female)'
	'ILAMUTU	(ZS, ZD of male)	'child of *tuofefine* (sister of male')'
2 DOWN	*MOKOPUNA*	(SS, SD, DS, DD)	'grandchild'

The term *motu'a* 'parent' in the generation 1 up is very rarely used with the glossed meaning. Only a few people ever accept it as a cover term for both parents, and if so, they preferentially use it for father rather than mother. The four main terms in generation 1 up are, then, *tamai* 'father' and 'father's brother,' *fa'é* 'mother' and 'mother's sister,' *mehekitanga* 'father's sister,' and *fa'é tangata* 'mother's brother,' and are constituted by gender and siblinghood. The gendered terms *tamai* and *fa'é* are also applied to the same sex siblings of father and mother (and other genealogical relations), respectively. This highlights the saliency of the relationship between same sex siblings expressed in generation zero by the single term *tokoua*. Cross-siblings (parent's) are named in the same way as in generation zero by two different terms. But while on the father's side the term *mehekitanga* 'father's sister' stays the same irrespective of sister's age, on the mother's side the term *fa'é tangata* 'mother's brother' is replaced by the term *tu'asina* when referring to the mother's younger brother.

What are the regularities and repetitions of conceptual content (e.g., same sex siblings indicated by same term) in generation zero terms and in generation 1 up terms indicating about the underlying logic of the TKT? Is the basic logic for generation 1 up terms already present in generation zero terms? Why are there more terms on the mother's side (*fa'é tangata, tu'asina*) than on the father's side

(*mehekitanga*)? Again, these questions are not answered through reference to a genealogical space.

Finally, the five terms in generation 1 down display conceptual content partly similar to the terms in generation zero, but with a different combination than those in generation 1 up. *Tama* 'child of female' is not marked for sex, but the node by which it is reached must be female. On the other hand, both *foha* 'son of male' and *'ofefine* 'daughter of male' are marked for sex and need to be reached through a male node. These three terms are also applied to children of one's same sex siblings or *tokoua*. Both *fakafotu* 'child' of *tuonga'ane* and *'ilamutu* 'child' of *tuofefine* are not marked for sex, but they need to be reached by two nodes marked for sex (e.g., female → male sibling → child for *fakafotu* or male → female sibling → child for *'ilamutu*). These last two terms are also used for children of genealogical parallel cousins and cross-cousins in accordance with the fact that genealogical parallel and cross-cousins are addressed as *tuonga'ane* and *tuofefine*, depending on gender.

It seems as if gender has salience only when reference is made to a male's offspring (*foha* or *'ofefine*). The general tendency of the terminology at this generation level is not to mark for gender (see *tama, fakafotu, 'ilamutu*). Why? Is this part of the internal logic of the TKT? Or is this the result of cultural interventions that are skewing the otherwise lack of gender marking in the generation 1 down terms? We will address all the these questions in our analysis of Tongan kinship space.

3. Conceptual Basis for Kinship Space

One widely accepted view of kinship systems presumes that kin terms are labels for categorizations made of kin type products in a genealogical space. But this leaves unanswered the criteria upon which the presumed categorizations are based. Ethnographic evidence implies, instead, that there are, conceptually, two ways we consider individuals to be our kin. One is through tracing genealogical connections and the other is by using the computational logic through which the kin terms form a system of kin relations and thus is not simply a list of semantic labels for categories of kin types. Correspondingly, we argue that kinship space is composed of two conceptual systems. One conceptual system is based on the logic underlying the structural form of the genealogical space (see Lehman and Witz, 1974, 1979). The other conceptual system relates to the logic underlying the structural form of the terminological space determined from the way kin terms constitute a computational system and from which the genealogical categorizations may be deduced (Read 1984, 2001a, 2001b, 2005; Read and Behrens 1990). Together, these two conceptual systems form the kinship space (see Figure 1).

3.1   *Distinction Between Genealogical Space and Terminological Space*

Lack of a clear distinction between the genealogical space and the terminological space is conducive to unavoidable misrepresentations of both. Here are two examples illustrating the problem with restricting analysis of a kinship terminology just to features derived from a genealogical framework.

In Biersack (1982), the author presents an analysis of Tongan exchange structures by referring to the people involved as occupants of nodes in a genealogical space. In her exercise, though, she is obliged to introduce variants of the typical symbols used in representing a genealogical space. In fact, because she has the TKT in mind, and because she is centering the genealogical space on ego without sex marking, she cannot express the terms *tuonga'ane* (male sibling for a female) and *tuofefine* (female sibling for a male) with the symbols used to represent the genealogical space. Consequently she introduces the unconventional solution of labeling a node in a genealogical space by a linguistic expression such as 'opposite-sexed sibling.' But 'opposite sex sibling' is not a feature of the genealogical space and instead refers to a transliteration of the kin term *tuofefine* whose meaning is best understood by its relation to other terms through a kin term product (defined below). Thus, she is conflating information about the two domains of genealogical space and kinship terminology space.

Similarly, when trying to represent the TKT, van der Grijp (1993) maps it onto a genealogical space centered on a male gendered ego and is obliged to omit some of the kin terms such as *tuonga'ane* ('brother of female'), *tama* ('son, daughter of female'), *ta'okete* ('older brother, sister'), *tehina* ('younger brother, sister'), *fakafotu* ('brother's son, brother's daughter of female'), and also *motu'a* ('mother, father'). The author is aware of the omissions, but regards them as unavoidable and irrelevant for his purposes. Nonetheless, if we want to consider the totality of the terminological space in order to find its constitutive properties and generative logic, it is a conspicuous deficiency.

These two examples highlight the difficulty in faithfully embedding the Tongan terminology in a genealogical space centered on a hypothetical ego. In addition, the respective authors do not elucidate the underlying logic that leads to the distinctions considered by them and so their respective discussions remain at the level of a description of whatever pattern is made evident by a partial mapping of the terminological space onto the genealogical space. The mapping is partial as the logic of the Tongan terminology (and other classificatory terminologies) does not permit a faithful mapping of kin terms onto an ego-centered genealogical space.

The difficulty with mapping the Tongan kinship terminology onto an ego-centered genealogical space does not imply that the terminology is not "ego-centric" since in our analysis the "ego-centeredness" of a kinship terminology

arises from its structural form and what Read (1997) has defined to be a focal term for a terminology. A focal term is a term mapped to the individual identified as the reference self in the domain of discourse when the terminology is instantiated in usage. A focal term will be an identity element for the kin term product (defined below), either for the terminology as a whole, or for the terms having a single sex marking, depending on the particular terminology. In the American kinship terminology (and other descriptive terminologies) the focal "term" is the Self concept; in the TKT, as we will demonstrate, there are two, gendered focal terms, namely *tuonga'ane* ('brother (w.s.)') and *tuofefine* ('sister' (m.s.)), hence from a genealogical perspective an ego is necessarily gendered. The reason why these are the focal terms arises from the very core of the logic underlying the structural form of the TKT.

3.2　*Kinship Terminology Structural Form (Kin Term Products and Kin Term Maps)*

The structural form of a kinship terminology can be expressed visually by constructing a kin term map (Leaf 1971; modified by Read [Read and Behrens 1990]; see Figure 2 below for an example using the male terms of the TKT) based on referential usage of kin terms as described in ethnographic observations about kin calculations, such as the comment made by Marshall Sahlins:

> "…[kin] terms permit comparative strangers to fix kinship rapidly without the necessity of elaborate genealogical reckoning – *reckoning that typically would be impossible*. With mutual relationship terms all that is required is the discovery of one common relative. Thus, if A is related to B as child to mother, *veitanani*, while C is related to B as *veitacini*, sibling of the same sex, then it follows that A is related to C as child to mother although they never before met or knew it. *Kin terms are predictable. If two people are each related to a third, then they are related to each other.*" (Sahlins 1962:155, emphasis added).

And in a review of Scheffler's book *Australian Kin Classification*, Shapiro observes that his (Shapiro's) informants "were generally more comfortable operating through the relationship terminology; it made little or no personal or social difference to them whether (say) an alleged brother of the MM was in fact a MMB or a more remote 'brother' of the MM … [they] easily decode the messages 'aunt's children' and 'X's children' *but not the message 'father's sister's children'*…. (Shapiro 1982: 275, 274, emphasis added). Similar comments disconfirming the priority of genealogy in calculations of kin relationships can be found in Behrens (1984) for the Shipibo of Peru, Marshall (1976) for the !Kung san, Goodale (1971) for the Tiwi, among others. These ethnographic examples highlight the fact that kin relations are determined directly from the way in which kin terms

form an internally organized structure of concepts through which kin relations expressed using kin terms can be computed without first referring to a supposedly universal set of genealogical relations.

We can express kin term computations in the form of a kin term product described as follows. Consider three individuals labeled ego, alter and alter*. If K and L are two kin terms from a kinship terminology, the kin term product of K and L, denoted K o L, is the kin term that ego would (properly) use (if any) to refer to alter* when K is the kin term that ego (properly) uses to refer to alter and L is the kin term that alter (properly) uses to refer to alter*. For example, for the American Kinship Terminology, if ego refers to alter by the kin term Uncle and alter refers to alter* by the kin term Daughter, then ego properly refers to alter* by the kin term Cousin. The calculation may be made without knowing or tracing the genealogical connection between ego and alter, between alter and alter* and between ego and alter*.

Once we have constructed a kin term map using kin term products, we next determine whether or not the kin term map structure, unlike a structure formed on an ad hoc basis, has an underlying generative logic. In our analysis we infer from the kin term map what appear to be the primary/generating kin terms and the underlying kin term equations for generating the structure displayed in the kin term map. We validate the claim that the kin term map has an underlying generative logic by constructively determining if it is possible to generate the kin term map exactly (i.e., isomorphically) from products of the primary kin terms simplified by the inferred equations (Read and Behrens, 1990; Read, 1997, 2000, 2001a, 2001b). Failure to isomorphically generate the kin term map would constitute falsification of the claim that the kin term map has an underlying generative logic.

The claim of a generative logic for a kin term map has already been validated for the American Kinship Terminology, the Shipibo Kinship Terminology and the Trobriand Kinship Terminology (Read 1984; Read and Behrens 1990), among others. If the claim is validated for the TKT, delineation of the details of the generative logic will help answer the questions raised above. Our core analytical task, then, is to make evident the generative logic for a kin term map of the Tongan terminology by determining the primitive terms and structural equations that account for its structure. To do so, we first need to identify more precisely some of the salient features of a terminological space and its relationship to the kinship space.

3.3 *Terminological Space*

For the terminological space (see right side of Figure 1) the objects making up the space are the kin terms from a kinship terminology viewed as a set of (abstract)

symbols, along with a symbol, Self, serving as a label for the concept of self.[9] For a terminology such as the TKT, Self is a gendered concept. The entries in the middle right box in Figure 1 are transliterations of the generating kin terms for the Tongan kinship terminology. The kin term symbols are linked and form a structure through taking kin term products of the generating kin terms for the terminology. The form of a kinship terminology is specified through structural equations and structural rules (to be discussed below).
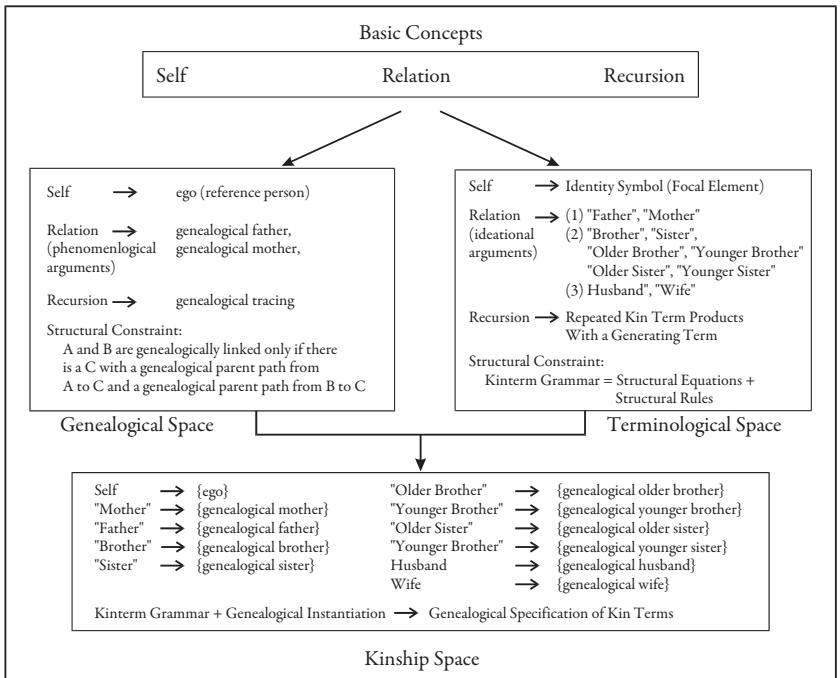

Figure 1. Concepts underlying genealogical space, kin term space and kinship space.

The kinship space is constructed through instantiation of the symbol combinations comprising the terminological space based on relations and symbols from the genealogical space (see bottom box, Figure 1). The last entry in the bottom box in Figure 1 connects the construction procedure for the terminological space with the prevalent assumption made in kinship studies that

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[9] By "concept of self" is meant the conscious awareness of one's own existence, in contrast to the existence of others, as a sentient being (see Mead 1967[1934]: 135-226).

genealogical definitions of kin terms are the primitives of kinship terminologies. (Instantiation is not limited to genealogical relations; e.g. kin terms are also instantiated via adoption (Read 2001b), among other possibilities.) These definitions are, in fact, predictable and derivable from the terminological space (middle right box in Figure 1) through instantiation of the generating terms for the terminological space with the generating genealogical relations for the genealogical space (middle left box in Figure 1) (Read 2001a) and then using the generative logic of the terminological space to predict the genealogical definitions for all of the other kin terms.

The instantiation of the generating terms via genealogical primitives for genealogical tracing also provides a way to link an abstract, conceptual system (the terminological space) to concrete individuals when genealogical ego is identified with a specific individual. In other words, Figure 1 provides the conceptual basis for going from concepts fundamental to any account of culturally constructed kinship, namely the concepts of self, relation and recursion, to the way in which a specific individual implements the conceptual structures (the genealogical space and the terminological space) that constitute the kinship space through the actual usage of kin terms.

For the Tongan terminology we now have two analytical goals. The first is to sketch out the algebraic argument that the terminology has a structure based on the concepts identified in the box labeled Terminological Space in Figure 1. (A more detailed argument can be found in Bennardo and Read 2005). The second is to identify the structural and conceptual location of the kin terms *tokoua, tuofefine* and *tuonga'ane* in the terminological space and to clarify the manner in which they are concepts fundamental to the generation of the terminological space. The conceptual embedding of these terms in the terminological space, we argue, is central not only to the production of the structure of the Tongan terminology, but provides a "cultural model" for many other domains in Tongan cultural conceptualizations.

4. Algebraic Analysis of the Generative Logic for the Tongan Kinship Terminology

4.1 *Kin Term Products and Cayley Tables*

As discussed above, when Tongans (and others) determine kin relations they need not first refer to a genealogical space and then to kin terms but can determine kin relations directly through kin term calculations such as "older brother" of "father" is "father". We may express the results of these calculations through what mathematicians call a Cayley Product Table (named after the

Table 2
Tongan Kin Terms Products and Kin Term Structure Predicted
From Products of Algebraic Symbols

Algebraic Symbols		C	P	I	A
	transliteration	"Y Brother"	"Father"	Male Self	"Son"
	Terms	**Tehina-M**	**Tamai**	**Tuonga'ane**	**Foha**
H	**Tehina-F**	0	P = Tamai	I = Tuonga'ane	Ei&Ai =Tama
G	**Fa'e**	0	PP = Kui	IG = Fa'etangata	I = Tuonga'ane
i	**Tuofefine**	0	P = Tamai	Ii = ♀Tuonga'ane	Ei&Ai =Tama
Ei&Ai	**Tama**	Ei&Ai =Tama	0	Ei&Ai =Tama	AA&EE = Mokopuna
D	**Ta'okete-F**	0	P = Tamai	I = Tuonga'ane	Ei&Ai =Tama
B	**Ta'okete-M**	I=Tuonga'ane	P = Tamai	B = Ta'okete-M	A = Foha
A (= AI)	**Foha**	A = Foha	I = Tuonga'ane	A = Foha	AA&EE = Mokopuna
I	**Tuonga'ane**	C = Tehina-M	P = Tamai	I = Tuonga'ane	EI = 'Ofefine
P	**Tamai**	P = Tamai	PP = Kui	P = Tamai	I = Tuonga'ane
C	**Tehina-M**	C = Tehina-M	P = Tamai	C = Tehina-M	A = Foha
PP&GG	**Kui**	PP = Kui	PP = Kui	PP = Kui	P = Tamai
IG	**Fa'etangata**	IG = Fa'etangata	PP = Kui	IG = Fa'etangata	I =Tuonga'ane
Ii	**Tuonga'ane**	Ii = ♀ Tuonga'ane	P = Tamai	Ii = ♀ Tuonga'ane	AIi&EIi = Fakafotu
AA&EE	**Mokopuna**	AA&EE = Mokopuna	Ei&Ai/A = Tama/ Foha	AA&EE = Mokopuna	AA&EE = Mokopuna
EI	**'Ofefine**	0	I = Tuonga'ane	A = Foha	AA&EE = Mokopuna
iI	**Tuofefine**	0	P = Tamai	I = Tuonga'ane	EiI&AiI = 'Ilamutu
iP	**Mehekitanga**	0	PP = Kui	P = Tamai	I = Tuonga'ane
AIi&EIi	**Fakafotu**	Aii&EIi = Fakafotu	Ii = Tuonga'ane	AIi&EIi = Fakafotu	AA&EE = Mokopuna
EiI&AiI	**'Ilamutu**	EiI&AiI = 'Ilamutu	0	EiI&AiI = 'Ilamutu	AA&EE = Mokopuna

Note 1: 1st row: algebraic generators; 2nd row: transliteration; 3rd row: kin term isomorphic to a generator. 1st column: algebraic symbol products; 2nd column: isomorphic kin terms. Body of table: Kin terms isomorphic to the algebraic product of column headings x row headings. Body of table is the predicted kin term for the corresponding column and row algebraic product; e.g. P (≅ Tamai) × G (≅ Ta'e) = PP and Kui corresponds to PP. Thus Kui is the predicted kin term for the kin term product: Tamai of Fa'e. In fact, Tamai of Ta'e is Kui as a kin term product.

Table 2 (cont.)

B	D	i	G	H	E
"O Brother" **Ta'okete-M**	"O Sister" **Ta'okete-F**	Female Self **Tuofefine**	"Mother" **Fa'e**	"Y Sister" **Tehina-F**	"Daughter" **'Ofefine**
0	i = Tuofefine	H = Tehina-F	G = Fa'e	H = Tehina-F	Ei&Ai =Tama
0	G = Fa'e	G = Fa'e	PP = Kui	G = Fa'e	i = Tuofefine
0	D = Ta'okete-F	i = Tuofefine	G = Fa'e	H = Tehina-F	Ei&Ai = Tama
Ei&Ai =Tama	Ei&Ai =Tama	Ei&Ai = Tama	i = Tuofefine	Ei&Ai=Tama	AA&EE = Mokopuna
0	D = Ta'okete-F	D = Ta'okete-F	G = Fa'e	i = Tuofefine	Ei&Ai = Tama
B = Ta'okete-M	0	i = Tuofefine	G = Fa'e	0	EI = 'Ofefine
A = Foha	0	EI = 'Ofefine	0	0	AA&EE = Mokopuna
B = Ta'okete-M	0	Ii = Tuofefine	G = Fa'e	0	EI = 'Ofefine
P = Tamai	0	iP=Mehekitanga	PP = Kui	0	i = Tuofefine
I = Tuonga'ane	0	i = Tuofefine	G = Fa'e	0	EI = 'Ofefine
PP = Kui	PP = Kui	PP = Kui	PP = Kui	PP = Kui	iP = Mehekitanga
IG=Fa'etangata	0	G = Fa'e	PP = Kui	0	i = Tuofefine
Ii = ♀ Tuonga'ane	0	i = Tuofefine	G = Fa'e	0	AIi&EIi = Fakafotu
AA&EE = Mokopuna	AA&EE = Mokopuna	AA&EE = Mokopuna	Ei&Ai/A = Tama/Foha	AA&EE = Mokopuna	AA&EE = Mokopuna
0	EI = 'Ofefine	EI = 'Ofefine	0	EI = 'Ofefine	AA&EE = Mokopuna
0	iI = ♂ Tuofefine	iI = ♂ Tuofefine	G = Fa'e	iI =Tuofefine	EiI&AiI = 'Ilamutu
0	iP = Mehekitanga	iP = Mehekitanga	PP = Kui	iP = Mehekitanga	i = Tuofefine
AIi&EIi = Fakafotu	AIi&EIi = Fakafotu	AIi&EIi = Fakafotu	0	AIi&EIi = Fakafotu	AA&EE = Mokopuna
EiI&AiI = 'Ilamutu	EiI&AiI = 'Ilamutu	EiI&AiI = 'Ilamutu	EiI&AiI = 'Ilamutu	EiI&AiI = 'Ilamutu	AA&EE = Mokopuna

Note 2: -M and -F are added to kin terms when the kin term depends on sex of speaker; e.g. Ta'okete is "O brother" only for a male speaker so the table lists the term Ta'okete-M.
Note 3: A kin term begins with a sex symbol to indicate when the sex of the speaker is necessary; e.g. ♂ Tuofefine is "Sister" (ms.).

19th Century mathematician Arthur Cayley; see Kronenfeld 1973 for an example of a kin product table for the Fanti terminology). We will use an abbreviated table (see Table 2) in which the generating terms for the Tongan terminology are listed as column headings. The generating terms for a terminology are a minimal set of kin terms from which every other term can be expressed as a product.

We initially adjoin a MaleSelf and a FemaleSelf symbol to the kinship terminology. As the argument proceeds, we will see that these symbols correspond to the kin terms *tuanga'ne* and *tuofefine*, respectively. We extend the kin term product to the symbol MaleSelf by defining MaleSelf o K = K o MaleSelf = K in the Cayley table for a kin term marked as male. Under this product definition, MaleSelf becomes the identity element for kin term products with male marked kin terms. Analogous comments apply to the FemaleSelf symbol.

We can display the kin term map as a graph by letting the graph nodes be the kin terms listed as row headings in the Cayley Table and then using an arrow to represent the result of taking the product of a kin term with one of the generating terms listed in the column headings. The tip of the arrow points to the kin term resulting from that kin term product. We use distinctive arrows, one for each generating term, to identify what kin term product is represented by which arrow.

A kin term map for Table 2 is quite complicated as 10 kinds of arrows are needed. Alternatively, we can graph one portion of the kin term map at a time by using a more restricted map such as male marked terms (see Figure 2) or female marked terms (not shown, but structurally identical to Figure 2). Note that the kin term *tuonga'ane*, which has transliteration 'brother (f.s.),' is not included in Figure 2 as it is properly used by a female speaker, hence is not a term from the viewpoint of a male speaker. Similarly, the male term, *fa'etangata* 'older brother' of 'mother,' is excluded at this stage in the analysis since it is isolated from the male marked kin terms in Figure 2 and so is not part of the structure shown in Figure 2. This term will be introduced into the structure as the analysis proceeds.

4.2   *Construction of an Algebraic Model*

The goal of the algebraic analysis is to determine whether or not the collection of kin terms making up the Tongan terminology has a structure that can be generated from a small set of atomic kin terms and structural equations relating to the products of kin terms; that is, it has the form of an algebraic structure. The algebraic analysis proceeds by first simplifying the kin term map, next finding an algebraic representation of the simplified kin term map, and then adding to the algebraic representation the structural aspects of the full kin term map

Figure 2. Kin term map for male terms.

removed through the simplification. Isomorphism between the kin term map and the resulting algebraic structure demonstrates that the kinship term structure has the form of an algebraic structure. But not all empirical structures can be represented in this manner, hence our claim that the kin term map for the Tongan terminology can be represented isomorphically as an algebraic structure would be falsified if there is no algebraic structure isomorphic to the Tongan kin term map. From the perspective of the genealogical "received view" that kin terms are added to a terminology for reasons exogenous to the terminology per se, there is no reason to expect that the collection of kin terms will have an algebraic structure.[10]

From the algebraic representation of the structure of the kin term map, a set of predicted genealogical definitions of kin terms can then be constructed.

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[10] The falsifiability of the claim that the kin term map has an algebraic structure contrasts sharply with descriptive methods such as componential analysis and rewrite rules as the latter simply provide descriptions, hence there is nothing to be falsified.

The predicted definitions are formed by first mapping the generating kin terms onto the genealogical space and secondly by determining the portion of the genealogical space that would be covered by a kin term based upon mapping the generating kin terms onto the genealogical space using the algebraic representation of the kin term map structure (Read 2005). Being able to generate genealogical definitions for kin terms falsifies the fundamental assumption of the "received view" that genealogical definitions of kin terms are the primitive kinship concepts upon which kinship structural analysis should be based.

The analysis proceeds by first simplifying a kin term to a core structure and then constructing (if possible) an algebra isomorphic to this core structure. Next the structural properties removed during the simplification of the kin term map are introduced into the algebraic structure.

4.2.1 *Simplification of a Kin Term Map*
A kin term map for the Tongan terminology can be simplified by first restricting the map to consanguineal terms of a single sex (including relevant neutral terms) (see Figure 2).[11] Next, we remove reciprocal terms. For the TKT, we first remove the reciprocal attributes older/younger by removing the terms *ta'okete* 'older brother' and *tehina* 'younger brother' and replacing them by *tokoua* 'same sex sibling,' since *tokoua* does not have the older/younger attributes. Then we remove the reciprocal of *tamai* 'father,' namely *foha* 'son'. This has the effect of removing the descending structure from the kin term map. The simplified kin term map is shown in Figure 3.

4.2.2 *Generating Elements*
We begin the algebraic construction by introducing an algebra symbol/element corresponding to each of the kin terms (which we will call generating kin terms) linked directly to the Self term in the simplified kin term map. Next, we add structural equation(s) that gives an algebraic element the defining structural property of the kin term that we anticipate will correspond to the algebraic symbol. We then take all possible products using the algebraic symbol(s) that have been introduced and use the equations wherever possible to reduce products to simpler expressions. As the algebraic construction proceeds we introduce additional symbols and equations corresponding to reciprocals of the generating terms in the kin term map.

The structural equations are of two kinds. One set of structural equations is responsible for (1) giving each generating element its defining structural

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[11] Some terminologies are simplified by considering neutral, "covering" kin terms; e.g., the terms Parent, Child, Grandparent, Grandchild, etc. in the AKT.
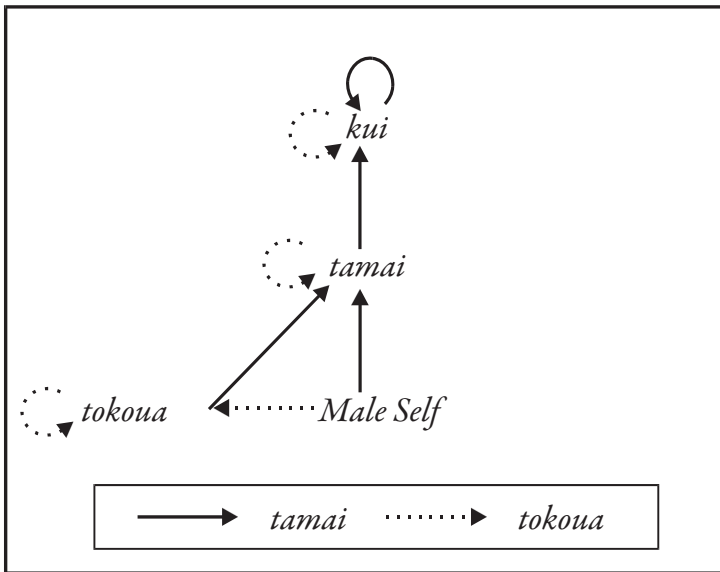
Figure 3. Kin term map from Figure 2 with sibling reciprocals and descending terms removed.

characteristics and (2) expressing the structural consequence of taking products of one generating element with another generating element. The other set of structural equations determines the overall form for the structure of the kinship terminology.

4.2.3 *Ascending Structure*

For the TKT we begin with the symbols B, F and I, where I will be an identity element for the algebra, B will have the structural property of a sibling term, and F the structural property of an ascending kin term. The symbol B has anticipated correspondence with the sibling kin term *tokoua*. A sibling term such as 'brother' satisfies the structural property that 'brother' of 'brother' is 'brother,' thus the first equation for the algebra will be:

BB = B (Sibling Structural Equation).   (1)

The symbol, F, has anticipated correspondence with the kin term *tamai* 'father,' an ascending kin term. An *ascending term* satisfies, from a structural viewpoint, the property that products of the term with itself can be repeated to generate new kin terms. For the Tongan terminology we have the sequence *tamai, tamai* of *tamai* is *kui*, and the term *kui* is then repeated when taking additional products with the term *tamai*. Thus for the Tongan terminology

we have the kin term computation: *tamai* of *tamai* of *tamai* is *tamai* of *tamai* is *kui*. We may express this equation algebraically as follows:

FFF = FF (Ascending Closure Equation).   (2)

Note that Equations (1) and (2) structurally distinguish a sibling term from an ascending term.

    We now need a structural equation to define the product between the symbols F and B. For a 'sibling' term and a 'father' term we have the structural property that

    'father' of 'brother' is 'father'.

Corresponding to this kin term equation we have the algebraic structural equation:

FB = F (Cross Product Equation).   (3)

At this stage the algebraic product, BF (read: 'brother' of 'father') is still a new, compound algebra symbol since there is, as yet, no equation in the algebra that would reduce this product to a simpler form. The structure produced by the generating elements B and F and equations (1) – (3) is shown in Figure 4. We will interpret this structure as representing the structure for the ascending male terms in the Tongan terminology.
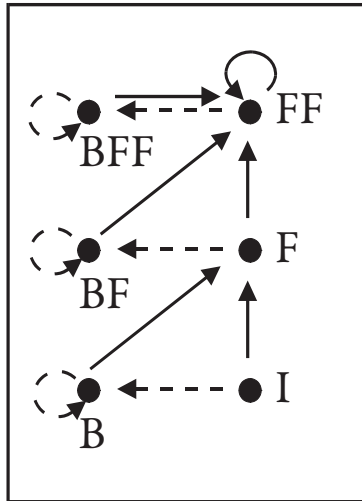
Figure 4.   Algebra with sibling and father generating elements.

4.2.4 *Descending Structure*

We construct the descending structure by making an isomorphic copy of the ascending structure. The descending structure initially has the same morphological form as the ascending structure. In the isomorphic copy we introduce an element S to be the element isomorphic to F. The elements I and B will be the same in both structures. The element I will thus be the identity element for both the ascending structure and the descending structure.

We introduce equations isomorphic to Equations (2) – (3):

$$SSS = SS \text{ (Descending Closure Equation)} \tag{2'}$$

and

$$SB = S \text{ (Cross Product Equation).} \tag{3'}$$

We now have a structure of ascending elements and a structure of descending elements 'linked' by the identity symbol, I, and with the sibling element, B, common to both the ascending and the descending structures.

4.2.5 *Combined Ascending and Descending Structure*

Next we consider all possible products using the symbols F, B, and S. For these symbols we have the equation:

$$SF = B \tag{4}$$

by virtue of the notion that the kin term product 'son' of 'father' yields a sibling kin term, namely B. Equation (4) implies that SFF = BF.

The product SBF = (SB)F = SF = B, thus we also have the derived equation:

$$SBF = B. \tag{5}$$

By a similar argument, we derive the equation SBFF = BF.

4.2.5.1 Reciprocal Elements: F and S

We want the elements F and S to be reciprocal elements. In general, structural equations that make the algebra symbols X and Y into reciprocal elements are of the form XY = I. This equation is motivated by the observation that if a male ego refers to a male alter by the kin term K, then the kin term K' used by alter to refer to ego is the reciprocal of the kin term K, hence KK' = MaleSelf since a male ego would refer to himself as MaleSelf. For the terms 'father' and 'son' we have 'father' of 'son' is MaleSelf, so we introduce the equation

$$FS = I \text{ (Reciprocal Structural Equation).} \tag{6}$$

4.2.5.2   Reciprocal Sibling Elements: B → B+ and B−

The reciprocal of the element B should be a symbol X with the property that either $BX = I$ or $XB = I$. This poses a logical dilemma as a candidate reciprocal for B is B since 'brother' is a self-reciprocal concept, hence at first glance it appears that we should introduce the equation $BB = I$. But from Equation (1), $BB = B$, and so this would imply $B = BB = I$. The Tongan terminological solution to the dilemma (and the solution of other classificatory terminologies) is to bifurcate the symbol B into the pair of symbols, B+ and B−, and to introduce the sibling equations

$$B+B+ = B+ \qquad\qquad (7)$$

and

$$B−B− = B− \qquad\qquad (7')$$

and the reciprocal equations

$$B+B− = I \qquad\qquad (8)$$

and

$$B−B+ = I. \qquad\qquad (8')$$

The symbols B+ and B− correspond to the terms *ta'okete* and *tehina*, respectively.
   Equation (8) implies:

$$FB− = F \text{ (Father Structural Equation)} \qquad\qquad (2A)$$

since $B+B− = I$ implies $F = FI = F(B+B−) = (FB+)B− = FB−$. Similarly, Equation (8') implies:

$$FB+ = F \text{ (Father Structural Equation).} \qquad\qquad (2B)$$

Equation (2A) has as its isomorphic copy the equation

$$SB− = S \qquad\qquad (9)$$

and Equation (2B) has as its isomorphic copy the equation

$$SB+ = S. \qquad\qquad (9')$$

Equation (4) ($SF = B$) and the bifurcation of B into B− and B+ imply the equations

$$SF = B− \text{ and } SF = B+, \qquad\qquad (10)$$

(that is, SF can either be B− or B+, but this potential ambiguity will be resolved in the next section). The algebraic structure corresponding to the combined ascending and descending structure is shown in Figure 5.
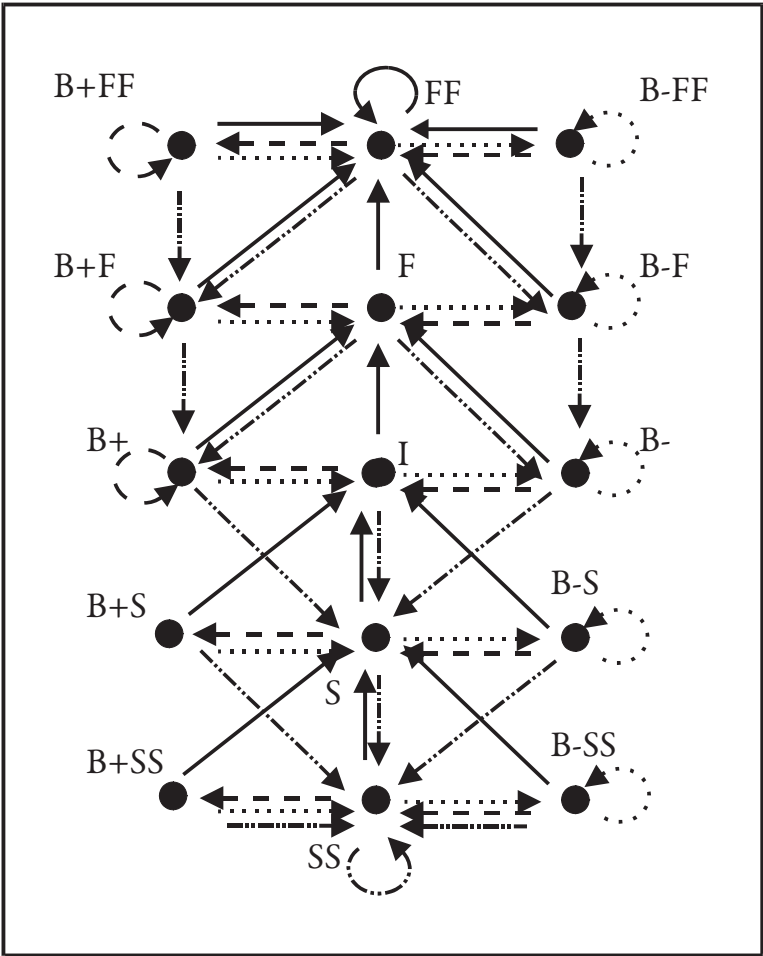
Figure 5. Ascending and descending algebraic structure.

4.2.6 *Reciprocal Equations*

A general property of reciprocal kin terms is that if $XY = Z$ is a structural equation for the terminology, then the reciprocal equation $(XY)^r = Y^r X^r = Z^r$ is a structural equation for the terminology, where X^r is the reciprocal term for the kin term X (and similarly for Y and Z). For the equations in 4.3.5.1, the reciprocal equations for equations (2), (3), (7), (8) are equations (2'), (3'), (7'), (8'), respectively, and (4), (5), (6) are self-reciprocal equations. Equations (2A) and (2B) have for their reciprocal equations:

$$B-S = S \tag{3A}$$
$$B+S = S, \tag{3B}$$

respectively.

These equations have genealogical interpretation: genealogical younger brother of genealogical son is genealogical son and genealogical older brother of genealogical son is genealogical son. Finally we include the reciprocal equations for the remaining two equations, $SB+ = S$ and $SB- = S$:

$$B-F = F \tag{2*}$$
$$B+F = F. \tag{9*}$$

Remarkably, we have now introduced precisely the fundamental equations for a classificatory terminology simply by following a general procedure for the construction of an ascending and descending structure for a kinship terminology when a sibling term is a generating element. The general procedure for generating an ascending and descending structure for a terminology underlies both descriptive and classificatory terminologies (see Read and Behrens 1990; Read 2005). The construction thus implies that the classificatory aspect of the Tongan terminology (and for other classificatory terminologies) derives logically from a general ontology for the construction of a kinship terminology and the fact that a sibling term is one of the atomic terms in the kinship terminology. This contrasts sharply with the construction of a descriptive terminology where the construction is based on a single ascending term and a sibling term such as Brother in the American Kinship Terminology is a compound term constructed from taking products of the Mother or Father term with the Son term (Read and Behrens 1990; Read 2005).

We cannot emphasize too strongly the importance of this result for understanding not only the structure of terminologies such as the Tongan terminology, but also the implications it has for the centrality of the sibling relation in Tongan behavior and cultural representations. The centrality of the sibling relation in Tongan life reflects the centrality of the sibling element as an atomic element in the construction of the Tongan terminology.

The construction also removes the potential ambiguity of Equations (4) $SF = B+$ and Equation (10) $SF = B-$ via the fact these two products imply, respectively, $I = B-B+ = B-SF = (B-S)F = SF$ and $I = B+B- = B+SF = (B+S)F = SF$ and so we now have $SF = I$. The results in this section modify Figure 5 to yield the male structure for the TKT shown in Figure 6, which is isomorphic to Figure 2.
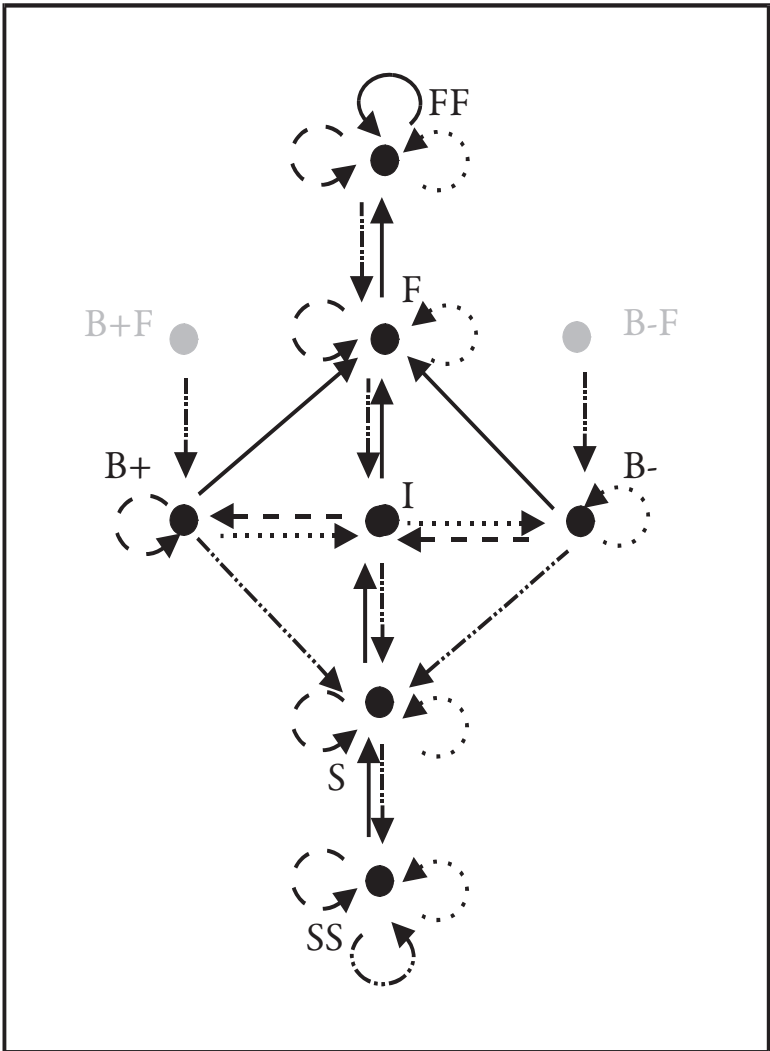
Figure 6. Algebraic structure for male elements.

4.2.7 *Male Structure*

We have now generated the structure for the male marked kin terms. The salient features are:

  Generating Elements: F, B+
  Reciprocal Elements: S, B–

Identity Element: I
Structural Equations:
    B+B+ = B+, B−B− = B−
    FB+ = F
    FB− = F
    FFF = FF
Isomorphic Structural Equations:
    SB− = S
    SB+ = S
    SSS = SS
Reciprocal Definition Equations
    FS = I
    SF = I
    B+B− = I
    B−B+ = I
Reciprocal Equations (not already included above)
    B−S = S
    B+S = S
Classificatory Equations
    B+F = F
    B−F = F

The structure corresponding to these generating elements and equations is shown in Figure 6.

4.2.8 *Female Structure*

We introduce female marked elements by making an isomorphic copy of the male structure summarized in 4.2.7. Under this isomorphism new female marked symbols, M, Z+, Z−, D and i, are introduced corresponding to each of the male marked symbols: M $\leftrightarrow$ F, Z+ $\leftrightarrow$ B+, Z− $\leftrightarrow$ B−, D $\leftrightarrow$ S and i $\leftrightarrow$ I. This yields a structure of female marked elements (see right side of Figure 7) defined by the same equations as for the male marked elements but with the male marked elements replaced by their corresponding female marked elements.

4.2.9 *Ethnographic Implications*

Note in Figure 6 the two nodes, B+F and B−F, in gray (and similarly the nodes for Z+M and Z−M in the isomorphic structure for female marked algebraic elements). These two nodes have been transformed into the "F" node since B+F = F = B−F. But the S arrows from these two nodes to B+ and B−, respectively, have not been transformed. Hence it follows that B+F and B−F are unlabeled, implicit nodes, yet their mapping to B+ and B− is still part of the structure.
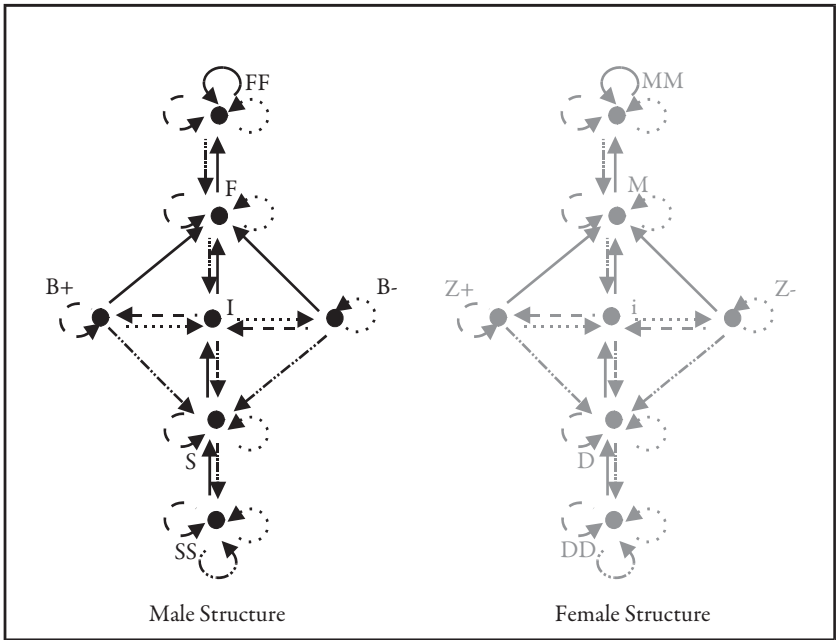
Figure 7. Algebra of male elements and algebra of female elements.

Consequently the algebraic structure implies that the genealogical instantiation B+F → {genealogical father's genealogical older brother} should have the property that (genealogical father's genealogical older brother)'s genealogical son will be genealogical older brother (since SB+F = B+) and similarly (genealogical mother's genealogical older sister)'s genealogical son will be genealogical older brother. Similar arguments apply to B−F.

Table 3
'Older/Younger' Sibling Terms

	man speaking	woman speaking
ta'okete	b+, fb+s, mz+s	z+, fb+d, mz+d
tehina	b−, fb−s, mz−s	z−, fb−d. mz−d

* modified from Table 1 (Biersack 1982)

This interpretation is ethnographically valid (see Table 3) and so the algebraic construction makes evident the structural basis for the factual information provided in Table 3 and thereby accounts for the different behavior ego has

towards genealogical older/younger siblings versus genealogical parallel cousins even though these two sets of genealogical relations are not differentiated terminologically as discussed previously.

4.2.10   *Joint Male Structure and Female Structure*

At this point we have two unconnected structures since we have introduced new elements {M, Z+, Z−, D, i} for the isomorphic copy of Figure 6 without any overlap with the generating elements {F, B+, B−, S, I} for the male marked elements (see Figure 7). We now consider how the male structure and the female structure are linked conceptually and structurally to make a single structure.

4.2.10.1   Conceptual Linkage: Sex Marked Identity Elements

The culturally formulated means for conceptually connecting the two structures together is ingenious. Consider the two symbols, I (MaleSelf) and i (FemaleSelf). If I is instantiated with a male person, then what female should be used to instantiate the i symbol? That is, who should be a female ego corresponding to a male ego? The cultural solution that has been introduced into many of the classificatory terminologies is to instantiate female ego with male ego's genealogical sister and if i has been instantiated with female ego, then instantiate I with female ego's genealogical brother. Under this instantiation it follows that the symbol I corresponds to a kin term from the perspective of a female ego, namely I corresponds to the kin term 'brother (f.s)', and similarly from the perspective of a male ego the symbol i corresponds to the kin term 'sister (m.s.)'! And we find in the Tongan terminology the terms *tuonga'ane* 'brother' used by a female speaker and *tuofefine* 'sister' used by a male speaker (see left and right sides of Figure 8).

Thus the I and i nodes in the structure labeled with the two terms, *tuonga'ane* and *tuofefine*, play a dual role: on the one hand, they mark the position at which an ego will be located (male ego at the *tuonga'ane* position, female ego at the *tuofefine* position) and on the other hand they determine the structural nodes for the kin terms to be used by a male ego for a female ego who is his genealogical sister, and vice-versa. Consequently, a male speaker has a *ta'okete* 'older brother' or a *tehina* 'younger brother' and he has a *tuofefine* 'sister' but he does not have a *tuonga'ane* 'brother;' similarly for a female speaker, she has a *ta'okete* 'older sister,' a *tehina* 'younger sister' and a *tuonga'ane* 'brother' but she does not have a *tuofefine* 'sister.' This is structurally a very ingenious solution to conceptually integrating together the structure of male terms and the structure of female terms. It also accounts for the pattern in which it is only the 'same sex sibling' term that has the attributes older and younger.

Although the element I is an identity element in the structure of male terms (left side of Figure 7) and the element i is an identity element in the structure of
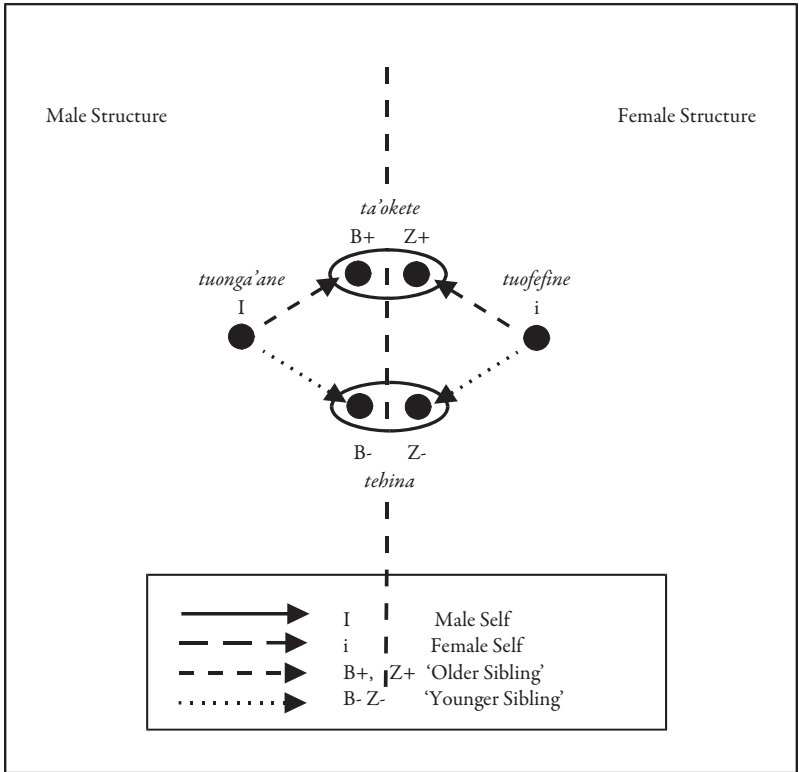
Figure 8. Structure for 'older sibling' and 'younger sibling' elements.

female terms (right side of Figure 7), these elements lose their status as identity elements when we form the structure containing both the male and the female structures.[12] Hence products using elements I and i with elements that have the opposite sex marking, including the products Ii or iI, will not simplify according to the equations for identity elements. Instead, products such as Ii and iI become new elements in the algebra. These two products correspond to *tuongaʻane* (f.s.) and *tuofefine* (m.s.) with instantiations 'brother of a female self' and 'sister of a male self,' respectively. Thus the algebraic structure accounts not only for the terms *tuongaʻane* (= I) and *tuofefine* = i), but also the usage of these kin terms according to sex of speaker, namely Ii = *tuongaʻange* (f.s.) and iI = *tuofefine* (m.s.). In other words, for the algebraic product Ii we have the interpretation that "i" is

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[12] An algebra can contain at most one identity element. If I and i are both identity elements, then I = Ii = i.

the algebraic element mapped to a female ego and for the algebraic product iI we have the interpretation that "I" is the algebraic element mapped to a male ego.

4.2.10.2   Structural Linkage: 'Older Sibling' and 'Younger Sibling'

Consider the algebra symbols I, B+ and B− from the male structure and the elements i, Z+ and Z− from the female structure. If the two algebra symbols B+ and Z+ are made equivalent (see oval in upper part of Figure 8), and similarly B− and Z−, are made equivalent, then we have a single older node and a single 'younger' node (see oval in lower part of Figure 8). These two combined nodes are not sex marked and structurally link further the male and the female structures. One combined node, call it B+&Z+, is labeled with the kin term *ta'okete* ('older same sex sibling') and the other combined node, B−&Z−, is labeled with the kin term *tehina* ('younger same sex sibling') under the isomorphism between the atomic algebra symbols and atomic kin terms.

4.2.11   *Implications of the Structural Linkage for Products with 'Son' and 'Daughter'*

A number of important structural consequences for the Tongan terminology with regard to terms for genealogical children of ego and ego's genealogical sibling arise from the fact that I, i, Ii and iI are distinct elements (see top part of Figure 9, expanded from Figure 8). Consider the products with S ('son') and D ('daughter') in the algebraic structure. For the nodes iI and Ii these products yield the nodes (1) SiI and DiI (that is, algebra symbols corresponding to the kin terms for the genealogical son or daughter of a woman who is the genealogical sister of a male ego) and (2) SIi and DIi (that is, algebra symbols corresponding to the kin terms for the genealogical son or daughter of a man who is the genealogical brother of a female ego), respectively. Products of S and D with the two nodes, I and i, yield the nodes (3) SI and DI (that is, algebra symbols corresponding to kin terms for the genealogical son or daughter of a male ego) and (4) Si and Di (that is, algebra symbols corresponding to kin terms for the genealogical son or daughter of a female ego) as new, distinct nodes in the algebra.

    Of these four pairs of products using S and D, each of the pairs except SI and DI becomes a single node without sex marking and each of these nodes is mapped to a different kin term (see Figure 9, bottom part of graph). Thus, the kin terms *'ilamutu* and *fakafotu* correspond to the products SiI&DiI ('child' of 'sister' of MaleSelf) and SIi&DIi ('child' of 'brother' of FemaleSelf), respectively (see Figure 9) and the kin term, *tama* ('child' of FemaleSelf) corresponds to the products Si&Di ('child' of FemaleSelf).

    In contrast, the nodes SI (= S) and DI ('son' of MaleSelf and 'daughter' of MaleSelf) correspond to different kin terms; namely, *foha* (with instantiation
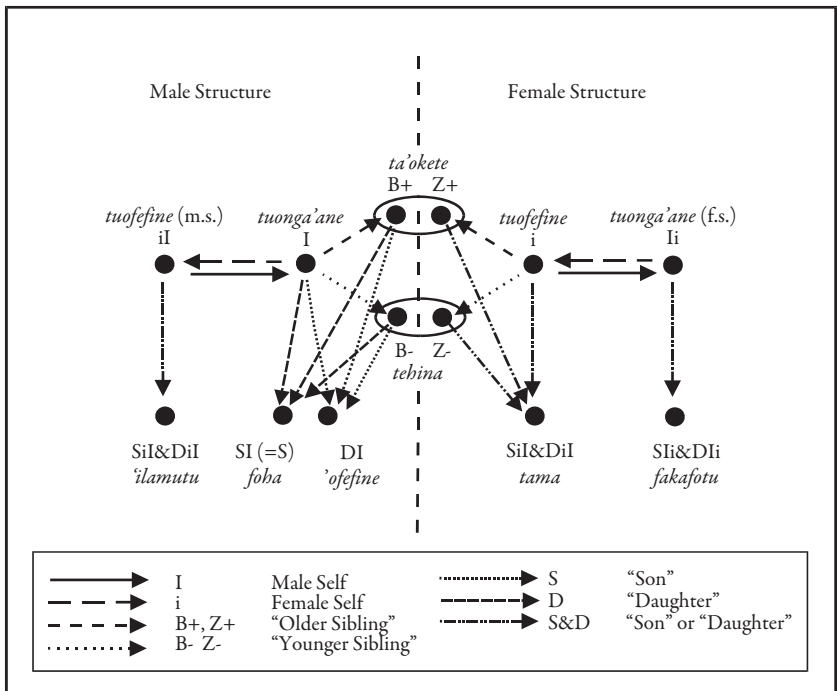
Figure 9. Structure for products of 'son' and 'daughter' elements with 'sibling' elements.

genealogical son, m.s.) and *'ofefine* (with instantiation genealogical daughter, m.s.). Keeping the terms SI and DI distinct appears to be a way to explicitly imbed the generating elements S and D into the kin term structure and has implications for the pattern of inheritance in Tongan society (discussed below). As a consequence, the Tongan terminology has the kin terms *foha* and *'ofefine* – but only for a male ego. In contrast a female has only the kin term, *tama* ('child' of FemaleSelf).[13]

4.2.12   *Structural Implications of the Term* Tokoua

In Bennardo and Read (2005:13-16), we presented an attribute analysis of TKT in which *tokoua* 'same sex sibling' appeared to be a central term in the kinship

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[13] Biersack (1982) lists *fefine* as an alternative term for *tama*, the term used by female ego for her child, regardless of sex. Hence the terminology appears to be symmetrical with respect to keeping the products SI, Si, DI and Di distinct, but asymmetrical with the property that the term *tama* is also used as a cover term for both Si and Di but no term is used as a cover term for SI and DI.

terminology, yet in the final algebraic structure there is no element corresponding to this term. Rather than arising from the algebraic construction, the term *tokoua* with its transliteration 'same sex sibling' appears to play an ontologically prior role as the label for the concept of a sibling relation fundamental to the Tongan terminology as discussed above in Sections 4.2.1-4.2.2.
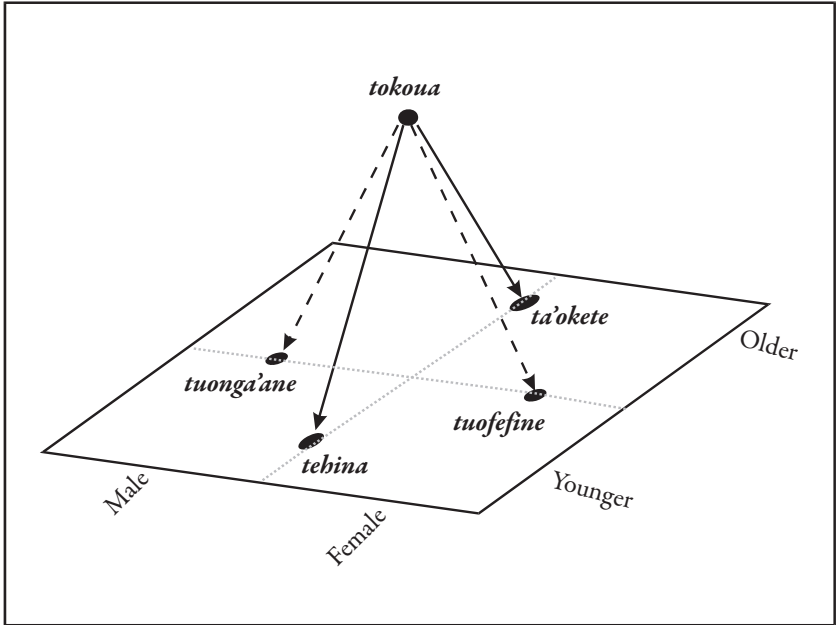

Figure 10. *Tokoua* and male/female and older/younger attributes.

We can illustrate the structural position of *tokoua* by considering it to be a concept lying above the sibling plane as shown in Figure 10. Within the plane we have two divisions: horizontally – male/female and vertically – older/younger. The horizontal division arises from the pair of algebra symbols I and i that correspond to the terms *tuonga'ane* and *tuofefine*, respectively. The vertical division arises from the bifurcation of *tokoua* into two sibling terms, *ta'okete* and *tehina*, with attributes that can be transliterated as older/younger.

Thus structurally the term *tokoua* represents a primitive concept ('sibling') to which the pair of 'opposite sex sibling' terms *tuonga'ane* and *tuofefine* are linked through the associated identity symbols, MaleSelf and FemaleSelf (see Figure 7), that are initially unlabeled and then become labeled when they conceptually join together to form the male and female structures (see Figure 8). The derived

sibling concepts *ta'okete* 'older (same sex) sibling'/ *tehina* 'younger (same sex) sibling' also arise from the term *tokoua*. *Tokoua* has the structural property of first giving rise to a pair of 'same sex sibling terms' with +/– marking in the structure of male terms (see Figure 6) and then to an isomorphic pair of 'same sex sibling terms' with +/– marking in the structure of female terms (see Figure 7), and finally to identification of the two + marked terms and of the two – marked terms so as to form a single pair of 'same sex' terms *ta'okete/tehina* with +/– marking (see Figure 9). *Tokoua* thus has structural status as the non-sex marked and non-relative age marked sibling term for the terminology as a whole from which one arrives at the two relative age marked terms and the two gender marked terms in the sibling plane. The English word 'sibling,' however, has connotations that are not applicable to the Tongan concept of *tokoua*, hence the transliteration 'same sex sibling,' which reflects the manner in which the pair of terms *ta'okete/tehina* are constructed from the term *tokoua*.

4.2.13   *Cross Products of Male Marked and Female Marked Algebra symbols*

The remaining part of the algebraic construction consists of working out the cross products between the elements in the Male Structure and the elements in the Female Structure. This entails adding equations that take into account the sex marking of algebra symbols. The diagram at this point becomes overwhelmed with arrows due to the fact that there are ten generating elements: F, M, B+, B–, Z+, Z–, S, D, I and i. The structure of the algebra is displayed, instead, in the form of an algebra Cayley Table in parallel with the kin term Cayley Table used to display the structure of kin term products (see Table 2). When these two Cayley Tables are compared we find that they are isomorphic.[14] The isomorphism is shown in Table 2 (see Bennardo and Read 2005 for a more detailed discussion regarding Table 2).

5. Tongan Social Life and Kinship Terminology Revisited

Various puzzling issues were raised about TKT in Sections 1-3. We can now attempt to clarify some of them using the results of the algebraic analyses just introduced. We do not claim that all features of a terminology arise from the logic of how a kinship terminology is generated. Rather, the algebraic analysis permits us to determine whether a feature arises from the internal logic of how the structure is generated or whether the feature arises from reasons extrinsic

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[14] All of the algebraic calculations, production of structures and testing for isomorphism has been done with the computer program, Kinship Algebra Expert System (KAES) (Read and Fischer 2004).

to the logic of how the terminology is generated. We need then to look for cultural interventions in order to account for the presence of those features in the terminology.

Here is a short list of the issues:

1. Siblings are distinguished only according to gender and age: a Tongan female sibling is always higher in rank than her brother; an older same sex sibling is always higher in status than a younger one;
2. The linguistic distinction between *fa'etangata* 'older maternal uncle' and *tu'asina* 'younger maternal uncle' is not present in the otherwise symmetrical relationship, *mehekitanga* 'paternal aunts';
3. The general tendency of the terminology at generation 1 down is not to mark for gender (e.g., *tama, fakafotu, 'ilamutu*), but oddly gender is used when reference is made to a male's offspring (i.e., *foha* or *'ofefine*);
4. *Fahu*, where one is *'eiki* 'high' to one's 'mother's brother's children' and is *tu'a* 'low' to one's 'father's sister's children,' is not a kinship term;
5. At a Tongan funeral, in the generation 1 up, the father side is *'eiki* 'high' and the mother side is *tu'a* 'low;' in the generation 1 down, children are *tu'a* if the deceased is male and *'eiki* if the deceased is female;
6. There is a term for 'same sex sibling,' *tokoua*, but no corresponding term for 'opposite sex sibling.'

Regarding issue 1, the participation of the two concepts of gender and age in the structural generation of the terminology has become clear after the algebraic analysis. Two structures are independently constructed for male and female members and later joined. We did the construction starting from terms with male attributes, but it was an arbitrary decision and one could start from either a male or a female structure without affecting the results of the process. It is relevant that two gender biased structures need to be independently posited to arrive at an elucidation of the internal logic of the whole TKT. This supports the conclusion we reached that the concept of gender plays a fundamental role in TKT.

These conclusions amend the picture of TKT we delineated in our attribute analysis in Bennardo and Read, 2005:13-16. The terminology is inherently gendered and aged. The gender neutral terms *kui* 'grandparent,' *motu'a* 'parent,' *tokoua* 'same sex sibling,' *tama* 'child,' and *mokopuna* 'grandchild', while they may still be considered the backbone of TKT, are not its starting point. They are a set of specific terms that perform an important role during the genesis of the terminology. They are the 'structural glue' that keeps together the two male and female structures shown in Figure 7 to obtain the TKT in its entirety.

Age difference for 'same sex sibling' terms is introduced as a necessary feature in order for there to be consistency with defining reciprocal terms for the sibling terms. Age distinctions are consequently expected to appear and play determinant roles in the final terminology structure through the logic of the terminology. For siblings, we find two gender neutral terms for older and younger by virtue of the logic of the construction and similarly for the child of same sex sibling of parent. For same sex siblings of parents the logic of the construction implies that an older/younger distinction will not be made.

Issues 2 and 3 therefore relate to an application of gender and age distinctions at junctures in the terminology that are not required by its internal logic. Algebraically, the age distinction at the mother's brother level (and not at the father's sister level where there is only one term, *mehekitanga*) realized in the two terms *fa'etangata* 'older MB' and *tu'asina* 'younger MB' is not necessary even though possible. In the same way, the distinction between male and female offspring of a male individual, *foha* and *'ofefine*, (a distinction not present for children of a female where there is only one term, *tama*) is not logically necessary even though possible. This double (gendered and aged) asymmetry points again towards a cultural intervention external to the terminology. Notice, however, that the two asymmetries are obtained by using two basic concepts inherent in the logic of the terminology, thus supporting further our axiomatic choices.

Issue 6 about the centrality of *tokoua* 'same sex sibling' in the terminology (also suggested in the attribute analysis in Bennardo and Read, 2005:13-16) has been confirmed and clarified by the algebraic analysis. We concluded that *tokoua* is a term that stands outside the logical plane of TKT and is situated in an ontologically prior level. It plays a central role and it functions as the basis from which age but not gender marked sibling terms are constructed. It also provides a contrast for the gender but not age marked sibling terms. This finding highlights the essential participation and central role played by siblinghood in the genesis of TKT and in Tongan kinship relations in general. Significantly, the structural starting point for all the terms is a term for an individual other than self, namely *tokoua*, and from there the terminology is allowed to "grow" and be realized. This finding is congruent with a proposal by one of us regarding the primacy of radiality[15] in the representation of spatial relationships and other domains of Tongan knowledge (Bennardo, 1996, 1999, 2001, 2002, 2005).

The algebraic analysis, however, does not explain why a female sibling is always considered superior to a male sibling. This is a fundamental parameter that

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[15] Thinking radially to locate objects in space implies looking for a fixed point of reference (other than ego) and describing the object to be identified as positioned from/toward that point.

regulates several cultural behaviors (e.g., brother/sister avoidance practices) and is at the root of the *fahu* practice as elucidated in issue 4 and 5. The logic of the terminology only points to the fundamental role that gender plays in the genesis of TKT, but does not indicate any necessity of superiority of one gender over the other. We are then confident in asserting that this parameter has been introduced by cultural considerations external to the terminology itself. Finding a possible cultural explanation would clarify the practice of *fahu* as well as the other two asymmetrical uses of gender and age indicated in issues 2 and 3.

Several authors have pointed out the centrality of the group over the individual in Tongan culture (see Gifford, 1929; Beaglehole and Beaglehole, 1941; Maude, 1971; Korn, 1974, 1978; Marcus, 1977, 1978, 1980; Kaeppler, 1978; Gailey, 1987; van der Grijp, 1993; James, 1995; Small, 1997; Helu, 1999; Evans, 2001; Morton, 2003). A comprehensive treatment of the various basic social units or groups of Tongan social organization and their historical and contemporary dynamics is found in Evans (2001). Without going into unnecessary details, we will focus on a couple of important points he makes in his discussion.

All groups described, including *ha'a* 'patrilineage,' *fa'ahinga/kainga* 'localized kin group, bilateral kindred, kin people,' and *famili* 'members of an individual's natal household,'[16] are essentially based on bilateral kinship relationships. *Kainga*, however, "was central to both political and social organization at the local level." (Evans, 2001:37). Moreover, "Title and thus political rank generally passed through men; 'blood' or social rank was passed through both men and women, and in this the rank of the women was more significant." (Evans, 2001:34). In "title" one needs to read rights to land use by the titleholder's group and distribution to the individuals making up the group. A male primogeniture principle is also in place, thus, reiterating the use of age as a constituting and salient part of Tongan social fabric.[17]

Being that this is the case, then why elevate one's sister status to create the *fahu* relationship wherein one's sister/s and one's sister/s' children have open access to one's property? From the point of view of the individual, this is not a positive outcome. From the point of view of a group, however, these children belong to one's lineal group and property is with this group after all, specifically and according to Evans the *fa'ahinga* (2001:40). Furthermore, because of the *fahu* relationship, children have open access to their mother's brother's property, who belongs to a different group (affinal) than one's own. One's group, then, is economically and eventually politically strengthened by this possibility.

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[16] The two terms *famili* and *kainga* often overlap in usage (Evans, 2001:62)
[17] When no male was present, the title was passed down onto a female child.

Another possible factor can be found in the attempt to maintain a balance between males and females. Since political power was "passed through men," it was made sure, in a complementary sense, that social power lay with women by making them superior to their siblings (with consequences at every generation level). The algebraic analysis of the terminology clearly indicates that such balancing processes are logically inherent in the genesis of TKT. Specifically, it occurs when the horizontal isomorphism joins the two gendered structures. In addition, the balance created goes beyond the two basic groups of males and females, and creates a new subtle balance between lineal and affinal groups. Then, in the final analysis we find two gender and bilateral groups that are sewn together by the threading role of the *fahu* relationships.

Three factors, keeping property in the lineage, acquiring property from another lineage, and balancing power between gender groups and lineages, all concur in creating the asymmetries of the TKT we have highlighted in issues 2 and 3. It is necessary for a male individual to distinguish between male and female children because inheritance practices demand that male children inherit title and land. Thus, the TKT includes two gendered terms for children of a male. Primogeniture also participates in the inheritance process, hence it is important to know not only the gender but also the relative age of an individual. This is especially true when exercising one's privileges over *fahu* individuals. It is really important to know who is the heir to the property if a male wants to take the best advantage of his privileged position as *fahu* towards one's mother's brothers. Hence, the TKT distinguishes between older and younger mbs as a cultural modification of the basic kinship structure.

We started this section by indicating a number of issues that our discussion of TKT in Sections 1-3 had raised. With the help of the algebraic analysis of TKT we were able to resolve these issues. Issue 6, about the centrality of *tokoua* 'same sex sibling,' has been confirmed and further clarified. Issue 1 is not directly resolved by the results of the algebraic analysis, but the same algebraic analysis makes apparent that a resolution is to be found in a cultural intervention. A centripetal process (inheritance) toward a basic social group (lineage) was suggested as a possible motivator. Inheritance practices were also suggested as possible causes for the asymmetries in TKT indicated in issues 2 and 3. Finally, issues 4 and 5 were found to be related to a basic social stance seen at work in the genesis of the TKT, namely, threading together centrifugal forces inherent in different gender and social groups (e.g., lineages). Both directly and indirectly, then, the algebraic analysis of the TKT provides needed clarifications and insights for the exploration of an unfamiliar social world.

6. Conclusion

Loisi, the child whose first birthday celebration was described at the opening of this work, is a teenager now and moved with her family to New Zealand and then Australia six years ago. She is bilingual, fluent in Tongan and English. We don't know about the extent of her biculturalism, but we know for sure that she is competent in using the appropriate Tongan terms for her siblings, her parents and grandparents, her maternal and paternal relatives. Most likely she is capable of understanding who a *fahu* is and who can claim that position in a funeral. In other words, she is a competent TKT user.

Tongans very rarely live in isolation when abroad (Small, 1997; Morton, 2003). They tend to live in communities that attempt to replicate the structure, feel, and pace of a Tongan community. This simple fact assures Loisi a life full of Tongan events (typically, first birthdays, marriages, and funerals) many of which are constructed around the kinship relationships expressed in the TKT.

Very likely Loisi is not aware of the generating logic of TKT that the algebraic analyses presented have brought to the fore. She is not aware of the struggle that her predecessors went through to knead together a single bi-gender structure from two gendered ones. The ingenious solutions they implemented to obtain gender equality while preserving differences, as well as the skillful way in which group welfare was given priority over individual interests are not much of her concern. She probably needs to decide how much of what she unconsciously knows about Tongan kinship can be preserved in the face of a different kinship system she is being exposed to and learning about in the new 'place' in which she is now living. The solutions for her are not yet available, but she stands tall on the shoulders of her ancestors whose exquisite reasoning and logic is partly inscribed in the kinship terminology they left behind.

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