Ritual Evolution in Pama-Nyungan Australia

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Concentric circles linked by parallel lines, depicting the journey of the *K.* pythons to Mutitjulu, Uluru (Layton 1992: 53). See chapter 3.

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Abstract

Ritual is present in all societies and plays a pivotal role in many. Its universality and importance, together with uncertain benefits, means it has long been a subject of interest to anthropologists. This study contributes to this field through a comparative examination of ritual variation in Pama-Nyungan Australia using phylogenetic methods. The documented language expansion of these societies, and the role ritual may have played in this, make them a particularly relevant case study for analysis. 90 ritual traits were recorded across around 100 Pama-Nyungan societies focusing on three ritual forms important in Australian life: adolescent initiation, mortuary practice and rock motifs. Analysis was in three parts: a broad examination of ritual variation by form, a higher resolution analysis of individual traits, and a comparison with ecological and sociological influences.

The key findings were, firstly, cultural inheritance had a significant influence on initiation and rock motif variation, but less effect on mortuary practice. Secondly, costly initiation rites were particularly associated with linguistic diversity, suggesting they may have played a role in Pama-Nyungan language expansion. Thirdly, there was a clear association between such rites and the occupation of desert habitats. Whilst these may have facilitated closer within-group alliances (theorised by a number of authors) contextual analysis did not indicate that collective practices such food sharing or warfare were particularly different in these societies. What did appear different was the presence of a greater volume and complexity of mythical-geographic knowledge. Such knowledge is particularly important to those inhabiting the Australian desert, providing information on routes between water sources and productive foraging grounds. Traumatic rites may result in prolonged ritual exegesis and it is possible that accumulating this knowledge was the primary impetus for developing costly rites in Australia.

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Statement of Copyright

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Introduction

Ritual is present in all societies and plays a pivotal role in many. Its universality and importance suggest that, like language, it is an integral part of what it means to be human. The objective of this study is to better understand ritual's role, examining the societal and ecological influences that could have led it to evolve, and the different processes, including cultural inheritance and exchange between societies, which may have shaped the diversity in ritual practices visible today.

What is meant by the term ritual? The subject has been studied from a variety of scholarly perspectives and consequently been defined in a myriad of ways. In a recent discussion of ritual definitions, Stephenson (2015: 3) suggests that, when conceived in the broadest terms, ritual encompasses action and idea together, forming a way to think and know about the world. Such ways of knowing are often described in terms of religious (or perhaps magical) beliefs and this type of definition, of ritual as an enactment of such beliefs, is often adopted in ethnographic descriptions. Whilst this somewhat narrows the scope of what could be described as ritual, it usefully encapsulates this 'thinking and knowing' dimension. In addition, since ethnographic material is the focus of this study, defining ritual in these terms *i.e.* as enactment of belief, provides us with a useful and relevant way of thinking about the subject in this thesis. Definitions of ritual also expand on the types of actions commonly practised, emphasising, in particular, the focus on acts of personal or collective presentation, for example, the enactment of a narrative or of a stylised set of actions. Such ritual performances tend to follow prescribed forms and often include symbolic elements. Another characteristic frequently referred to as important in defining ritual is the idea of purposeful intent. Rituals take place for a reason, for example, to initiate an adolescent, crown a new monarch or prepare a body for the afterlife. A further feature is that rituals are often large-scale affairs, involving both multiple participants and an audience (James 2003).

Bringing these elements together suggests a useful working definition of ritual for this study, namely that rituals are purposeful actions of assembly, performance and belief. As well as encompassing relevant characteristics from ritual theory and literature, this definition usefully demarcates the range of behaviours of interest in this thesis. As will be discussed later, this analysis of ritual evolution and diversity focuses, in particular, on the

costliness associated with acts of assembly and performance and on the symbolism of acts associated with religious or magical belief. The definition is also consistent with the way in which rituals are described in the Australian ethnography analysed in the thesis. Here, rituals have been characterised as 'stylised and symbolic actions carried out with specific ends in view' and 'having additional meaning and implications for social living either here or in the hereafter' (Berndt & Berndt 1996: 259). Furthermore, this thesis definition has the advantage of cross-cultural resonance. Lexical analysis indicates that many different societies specify a domain of life that draws together clusters of interrelated actions that include those of assembly, performance and belief (Stausberg 2006). This suggests that the word 'ritual', defined in this way, is a relevant collective term for describing an important component of human behaviour (Stephenson 2015: 71).

In focusing on ritual as a collection of behaviours associated with assembly, performance and belief, I plan to explore, in particular, the costliness inherent in ritual practice. Rituals may require a large amount of co-ordinated effort to achieve their aims, taking time away from activities that might be regarded as more obviously beneficial. Commitment and resources are needed to create the symbolism through, for example, body decoration and ceremony, which connects participants to deeper ideas of belief and meaning. Performative acts can involve a multiplicity of media including music, dance, enactments, symbolic objects, myths and stories. As well as physical effort, creative energy is required to represent beliefs in these more concrete terms. Christian ceremonies utilise many of these elements including, for example, depictions of heaven and hell to represent the idea of an afterlife. Those involved in rituals may have to travel long distances to take part, either as active participants or audience members, in activities that are themselves frequently time-intensive. Major life events tend to be marked by ritual and the regular births, deaths and marriages in a community may each require ritual attendance. For some rituals, such as adolescent initiation, there can be direct costs to the individual such as painful mutilations. Taken together, the implementation of these elements of ritual, its symbolism, participation and suffering, requires a high degree of effort and commitment from group members.

That ritual is common and often costly suggests it must be playing an important role. The objective of this study is to better understand this role, firstly, through an examination of the societal and ecological influences that could have led this costly behaviour to evolve. Secondly, through analysing the effect different processes, such as cultural inheritance and exchange between societies, may have had on the diversification of ritual practices. A wide range of theories have been proposed to address these themes but they have

typically been developed from ethnographic material that is qualitative in nature. Whilst this has generated important hypotheses, testing their general or wider validity requires quantitative datasets and statistical methods. In this study, hypotheses of ritual's role and models of ritual history are developed from the available literature and quantitatively tested using material from a large group of Australian hunter-gatherer societies as the case study for analysis.

Ritual theory – psychological and sociological approaches

The universality and importance of ritual, together with its uncertain benefits, means it has long been a subject of interest to anthropologists. This has led to a number of theories that attempt to explain its role. Generally, these emphasise its ability to connect participants to sources of authority and meaning, essentially a psychological or cognitive origin, or its role in connecting participants together and promoting social cohesion, essentially a sociological one.

In the former category, ritual is a way of accessing higher authorities to influence unexplained hazards or outcomes (Frazer 1922, Malinowski 2002 [1922], Tambiah 1990) or of enhancing the reality and emotional resonance of meanings and beliefs (Lévi-Strauss 1963, Eliade 1965, Schechner 1988). These theories emphasise ritual's role in helping humans make sense of the world, but how did such a need arise? Authors have examined the human capacity for such teleological thinking - that because life exists it must have purpose - suggesting it results from the application of agency-thinking to uncertain events and hazards (Guthrie 1993, Barrett 2004). Failure to react to danger leads to the death of an organism, therefore mechanisms of hazard avoidance are likely to have been strongly selected for in evolutionary history. Studies suggest we do not learn to be afraid of snakes, but are born with this fear (Öhman & Mineka 2001, LoBue & DeLoache 2008). Since two of the major threats to human survival (predators and other humans) have intentional agency it is plausible that other hazards, such as lack of rain or shortage of game animals, could also be caused by intentioned agents. This thinking may have led to the positing of supernatural agents, such as gods and deities, who have purposeful intentions and influence on the world (Guthrie 1993, Kelemen 2004, Barrett 2004, Rosset 2008). Participants access these higher authorities through ritual, helping to resolve unexplained hazards or outcomes and provide life with structure and meaning. Often these ideas are expressed through a framework of complex myths and narratives that are commonly characterised as systems of religious belief.

Other authors suggest connection to supernatural agents is a way of relieving the cognitive burden brought about by navigating the complexities of group living. Individuals are constantly evaluating others and being evaluated themselves, leading to mental states of perpetual anxiety (Sartre 1956, Bulbulia 2008). Deities tend to be formulated as like-minded, anthropomorphic beings (Barrett & Keil 1996) with whom our feelings, goals and concerns can be safely aired, reducing anxiety and anchoring ourselves in a more meaningful and understanding world (Bering 2008). Examining whether making sense of the world was the stimulus that led ritual and religion to evolve has been the goal of experimental work in areas such as agency and intuitive theism (Kelemen 1999, Scholl & Tremoulet 2000, Bering & Parker 2006), and cognitive burden (Paloutzian & Kirkpatrick 1995, Pargament 2002, Pinel *et al.* 2006). Such analyses are beyond the scope of the present study, however, the use of ritual in this way, to connect to supernatural agents to make sense of the world, is an important influence on ritual practice and diversity that is returned to later.

As well as connecting participants to meaning and purpose, ritual also seems to have a powerful ability to bring them together. Durkheim (2001 [1912]), in his analysis of Australian ritual, was one of the first authors to posit a sociological origin. He suggested ritual was a way of harnessing, and constructively dealing with, the positive emotion released through the act of people coming together. Turner (1969) focused on ritual's innovative ability, through the use of liminal or threshold states, to construct socially useful categories such as adulthood or marriage, which enabled the community to operate more effectively. For Rappaport (1999), the key element of ritual is its focus on mutually shared performance. It brings a sense of permanence and continuity to the group that provides a foundation from which shared connections, values and meanings can be established. Shared representations of purpose can, in particular, inspire and motivate those involved; serving as powerful catalysts for collective action (Weber 1958). Rituals can be traumatic or emotional experiences for individuals and this may build solidarity with others who have shared memories of them (Whitehouse 2004). While such collective action may help all individuals, societies need to resolve the free-rider problems that result; ensuring those receiving a benefit pay their fair share of the costs. Irons (2001) points to the costliness of ritual action as a solution because it serves as a 'hard to fake' signal of the individual's commitment to the group. Another collective problem is persuading participants that shared representations are valid, particularly those invoking intangible deities and counter-intuitive concepts. Henrich (2009) suggests costly rites are a way of doing this because they act as 'credibility enhancing displays'.

Only those deeply committed to beliefs would engage in such costly acts and these demonstrations persuade others of their validity.

If ritual's benefit is harnessing the power of co-operation, what was the stimulus that led it to evolve? Irons (1996) suggests warfare as a particular collective action problem which may have been successfully overcome by the development of painful, costly rituals. A cross-cultural analysis of male rituals across 60 societies (Sosis *et al*. 2007) found a significant association between costly rites, assessed as a relative score of suffering, and the presence of warfare, but no association with other collaborative activities such as co-operative food production or food sharing. They suggest reciprocity can be employed in these pursuits to prevent free-riders from accruing long-term benefits, but that in warfare men cannot solely rely on expectations of future cooperation, since they may not be alive to reciprocate. The study also found that costly rites were more associated with hunter-gatherer societies, suggesting that larger societies can coerce participation in warfare through punishment (*e.g.* imprisonment), so are less dependent on ritual signs of commitment. That rituals involving high levels of suffering are associated with warfare, and that these rites are particularly prevalent in hunter-gatherer societies, suggests it could be a candidate for the stimulus that led ritual to evolve.

Ritual pain has also been interpreted as a way of building solidarity with others. Whitehouse (2004), in his imagistic theory of ritual, examined the connection between extreme negative arousal and the production of enduring episodic or 'flashbulb' memories. Dysphoric, painful rituals trigger this arousal and the intensity of these recalled memories leads to strong emotional connections between those who went through rites together. Glucklich (2001) suggests pain may be used in rites because of its transformative quality. Acting in a similar way to psychotropic agents, intense pain releases opiates that induce both euphoric and dissociative feelings, making the novice more receptive to new mental states such as unity with others and the submergence of individual concerns. Strong group bonds may be particularly important in marginal habitats because of the need to cope with greater fluctuations in resources. Hayden (1993) suggests that, because of this, rites of passage into manhood are likely to feature greater pain intensity in more challenging environments.

As well as promoting solidarity within groups, ritual may have developed as a way of stabilising relationships between neighbours. Drawing on parallels with repetition and patterning in animal behaviour, Huxley (1914) noted ritual's ability to stimulate 'efficient patterns of action in other individuals'. Rossano (2009) suggests that ritualised activity inhibits natural defensive responses, giving mechanisms of pro-sociality time to operate.

The capacity to endure rituals, such as initiation, requires a degree of mental control over reflexive responses that only humans have mastered. Benefits gained from reduced conflict with neighbours could have been the stimulus that led ritual to evolve. Rossano suggests, as a test for this hypothesis, that where more extensive inter-group relations are noted, more elaborate and demanding social rituals will also be present.

Ritual can be also used to construct socially useful categories within groups that enable them to operate more effectively (Turner 1969). One such category is adulthood; the values, know-how and attributes required of adults are modelled in initiation rites which the adolescent needs to pass through to be accepted as a full member of the social group. Whilst analyses of initiation ceremonies often focus on male rites, in a cross-cultural study of 182 societies, Schlegal & Barry (1979) recorded more ceremonies for females (46%) than males (36%), suggesting differences in their presence may be related to the social significance of gender. In a cross-cultural study of 75 societies, Brown (1963) found that female rites were more likely to be present where women's contribution to subsistence was above the median level.

Ritual's ordered yet flexible structure may provide an effective platform for the resolution of differences within groups (Turner 1969). Conflict between sexes arising from exogamous marriage practices *e.g.* female affines living with male kin, or *vice versa*, may be mediated through mortuary ritual. The act of separating the (female) flesh of the corpse from the (male) bones in a second, later ceremony symbolising reversion to the original social state. Bloch & Parry (1982: 20) suggest that, where such rites of secondary corpse disposal are present, the societal distinction between kin and affines is likely to be more marked.

In re-affirming the social order, ritual may serve to mask the underlying reality of relationships thereby maintaining the advantage of particular groups (Bloch & Parry 1982, Bloch 1989, Geertz 2000). On this basis, hunter-gatherer societies, which tend to have minimal social stratification (Barnard & Woodburn 1988), would be expected to have less ritual complexity. This is often the case for hunter-gathers in Africa, for example, but not for those in Indigenous Australia where elaborate ritual plays a central role (Woodburn 1979 & 1982). Bloch (1989: 17) suggests this is because these societies are much less egalitarian; men betroth their daughter's in marriage and, through the promise of daughters to others, obtain control over other men, establishing a complex age-based hierarchy over access to wives (Rose 1960, Berndt & Berndt 1996: 202, Binford 2001: 282).

Unequal power relations may also be due to differences in control over resources. Although this is a regular feature of agricultural societies, it is much less common in hunter-gatherers because of their frequent mobility. Some favourable habitats may, however, encourage longer-term residence patterns leading to the emergence of differences over resource access. Ritual has been suggested as a way of legitimising rights over favourable resources, in particular the use of mortuary ceremony and grave marking to indicate territorial claims (Saxe 1970, Goldstein 1981, Bloch & Parry 1982).

This theoretical background suggests a number of influences that could have shaped the pattern of ritual diversity and led different ritual systems to evolve. The objective of this study is to examine the relative importance of these through testing of models of ritual history and specific adaptive hypotheses. To do this, ritual practices from a large group of societies in Pama-Nyungan Australia are analysed to provide comparative material for the study.

Pama-Nyungan Australia – a relevant case study

Pama-Nyungan societies have a number of characteristics that make them a relevant choice for understanding ritual evolution and diversity. As already mentioned, ritual plays a central role in Australian life and is frequently complex, time-intensive and costly to the individual (Berndt & Berndt 1996). Rituals vary between societies, in symbolism, ceremony and individual suffering, allowing for meaningful comparisons to be made. Australian ritual has been the subject of considerable ethnographic research, much of it recorded before colonial expansion began to severely disrupt hunter-gatherer life from the early 1800s (Arthur & Morphy 2005). Due, at least in part, to its geographic location, there appears to have been little influence from other societies from (at least) 3,000 years ago until Indonesian trade links began in the 1600s, and British penal colonies were established in 1788 (Bellwood 2013: 116).

Another significant characteristic of Pama-Nyungan societies is that all are hunter-gatherers. At least 95% of human history has taken place using this type of subsistence and, to understand more about how ritual has shaped that history, they are important societies to study. Subsistence is particularly relevant when analysing ritual because later, more intensive methods such as agriculture, have tended to result in hierarchical structures, such as those enforcing rights over land (Binford 2001, Bellwood & Renfrew 2002). These are commonly associated with complex ritual practices linked to greater challenges in maintaining social cohesion (Turner 1969, Bloch 1989). Maintaining a monarch's authority through costly, elaborate rituals that re-affirm their divine right to

rule is one obvious example. The effect of different types of subsistence on ritual makes comparisons between societies more difficult. By looking only at hunter-gatherers, this study focuses on societies not only with the same subsistence method, but one that is most closely aligned to the majority of human history.

The expansion of agricultural societies in the last 10,000 years has significantly reduced the number of hunter-gatherer populations in the world, obscuring much of the evidence of our cultural and linguistic past (McConvell 2001, Bellwood 2013). Australian societies did not adopt agricultural methods to any great extent, despite proximity to New Guinea horticulturalists in the north (Lourandos 1997, Barker 2009: 70). Low or unpredictable rainfall and soil quality means that even today less than 10% of land is suitable for crop production (www.abs.gov.au). Material from these societies represents something of a unique case because they are the largest group of hunter-gatherers in the world for which we have not only comprehensive ethnography, but also a detailed linguistic history. The Pama-Nyungan language family consists of around 300 languages spoken across 90% of the Australian continent. A language tree was recently developed (Bowern & Atkinson 2012, Bouckaert *et al*. 2018) using phylogenetic methods successfully applied to other families such as Indo-European (Bouckaert *et al.* 2012), Austronesian (Gray *et al.* 2009) and Bantu (Currie *et al.* 2013). The availability of this phylogeny provides important analytical advantages, enabling comparison between ritual and language histories and rigorous testing of adaptive hypotheses using the phylogeny to adjust for shared ancestry.

That Pama-Nyungan language history can be derived from existing language variation, suggests these speakers were part of an expansion process. The reasons for this and the mechanisms behind it are, however, far from clear. Other language expansions, such as Indo-European, Bantu and Austronesian, have largely been driven by known factors such as agriculture and technological development (Bellwood & Renfrew 2002, Currie *et al.* 2013, Gray *et al.* 2009). Much less is known about why hunter-gatherer language expansions, including Pama-Nyungan, might have taken place although they are likely to have occurred many times in the past (Anthony 1990, McConvell 2001). Examining such expansions can help us understand the forces which have shaped cultural diversity and enabled humans to inhabit most of the world's ecological niches (Bellwood 2013). As Pama-Nyungan is the only large-scale group of hunter-gatherer societies with a language phylogeny, it provides us with a unique opportunity to use quantitative methods to examine the reasons behind its expansion.

Changes in hunter-gatherer societies have tended to be examined through the lens of social complexity with processes leading to these changes suggested to include resource co-operation (Binford 1980, Arnold 1996), competition (Coupland 1988, Fitzhugh 2000) and developments in food production technology (Woodburn 1982, Madsen & Schmitt 1998, Binford 2001). Theories examining social complexity have been adapted to explain Pama-Nyungan expansion. Linguistic analysis, calibrated using archaeological evidence, suggests an expansion date beginning around 6,000 years ago (Bouckaert *et al.* 2018). A number of sources indicate population increases around this time, possibly linked to the transition to a post-glacial climate and less arid conditions (Lourandos 1997, Hiscock 2007, Williams *et al.* 2015). Other changes in this period are suggestive of new processes that could be related to language expansion including increased prevalence of multi-purpose small stone tools for food processing and hunting (Lourandos 1997, Hiscock 2007) and possibly warfare (Mulvaney 1975, Lourandos 1977), and evidence of new production techniques (Beaton 1977, Lourandos 1983, Smith 1986). Evans & McConvell (1998) suggest adoption of a more 'open culture of outward-reaching social alliances' was the driving force behind expansion, achieved through a combination of new kinship systems and the introduction of large-scale ceremonial activity. These events supported the formation of new alliances through shared rights of enactment during epic cultural performances. Orientating ceremonies around lengthy novice initiations provided a mechanism for onward transmission of the new culture. Layton (1992: 245) suggests adoption of new clan identities, cross-cutting existing relationships, led to an expansion of alliances. New obligations were reinforced through ceremonial gatherings and new forms of imagery, such as geometric motifs, developed to signify these new relationships.

How might these new processes have led to language expansion? Commonly, this occurs through physical migration into new habitats or via replacement of existing languages (Nicholls 1998, McConvell 2001). Comparison of genetic and linguistic variation can help to interpret these effects with close correlation pointing to the significance of physical migration (McConvell 2001, Bellwood 2013). In Australia, genetic evidence is mixed with some indication of correspondence with Pama-Nyungan groups, but little differentiation between these populations and those speaking other languages in the north (Malaspinas *et al.* 2016). Bouckaert *et al.* (2018) suggest expansion took place mainly through absorption of cultural innovations into existing groups. Language replacement could occur, for example, via female exogamy with mothers favouring the teaching of a prestige language to their offspring and thereby acting as agents of language spread (McConvell 2001). Other authors suggest the timing of new site occupations, especially in arid in

central Australia, corresponds to likely Pama-Nyungan timescales (Veth 2000, Smith & Ross 2008) suggesting that physical migration may have played a role in some regions.

The characteristics of Pama-Nyungans, ritual-orientated, hunter-gatherer societies living across variable ecological conditions, together with the history of their language expansion and the role ritual may have played in this, make them a relevant case study for ritual analysis. However, despite the wealth of ethnographic material available, no large-scale, quantitative analysis of Australian ritual has been carried out before and no dataset of ritual characteristics currently exists. As well as covering new analytical ground, a substantial part of the present study focuses on the collation of material from ethnographies into a form suitable for quantitative analysis.

Building a representative ritual dataset

A dataset is required that includes a representative cross-section of Pama-Nyungan ritual traits, varied and substantial enough to support meaningful conclusions. Three ritual types were chosen for inclusion, based on their relevance and on availability of material. Firstly, adolescent initiation is probably the most significant ceremony in Australian life, frequently involving complex settings, multiple age-stages and painful ordeals and mutilations for both males and females (Berndt & Berndt 1996: 150). Initiation practices were observed frequently during the late 1800s, across most of the continent, and recorded in a number of later publications including Mathews (1894-1917), Spencer & Gillen (1899-1904), Howitt (1904) and Roth (1897-1910). Secondly, mortuary rituals play an important role in Australian societies. They often involving large numbers of mourners and significant use of symbolic elements such as grave markings, body disposal methods and, sometimes, separate later rituals associated with the bones of the deceased (Berndt & Berndt 1996: 453). Here, it was possible to draw on work from Meehan (1971), who summarised mortuary characteristics from a large number of earlier ethnographies, to provide initial material for the dataset. In total, for each of these rituals, data was collected on the presence/absence of around 25 traits in over 100 Pama-Nyungan societies, using material sourced from multiple ethnographies (see Chapter 1). Traits commonly observed and recorded were selected, with particular focus given to including those with a tendency to recur across the continent, and on achieving a representative mix of ceremonial *e.g.* body decoration, and more obviously costly traits *e.g.* genital mutilation.

The third ritual form, rock motifs, are present in multiple sites throughout Australia and are important symbols of cultural identity closely aligned to belief and ritual (Maynard

1975, Layton 1992, David & Lourandos 1998). They represent a way of measuring symbolic differences between societies that is complementary to the collection of material on ritual practices. Rock imagery is complex; many designs are ambiguous and difficult to classify or obscured through weathering or being overlaid with other designs. Nonetheless it is possible to discern certain types of motif that recur in multiple site locations. Layton analysed the presence/absence of 38 such motifs across over 100 locations (1992: 253) and his study provides the material for this dataset. Taken together, these three ritual forms provide a substantial amount of data for the study with a total of 98 traits collected across multiple linguistic groups. It provides a representative sample of Pama-Nyungan ritual that is expected to be sufficient to enable meaningful conclusions to be drawn from the analysis.

Quantitative ritual analysis – using evolutionary thinking

Cross-cultural studies of ritual indicate many similarities between societies, for example, the frequent use of rites for life transitions such as adulthood (Schlegal & Barry 1979) and death (Robben 2018), which suggest a common purpose or origin. However, the large variation in symbolism, ceremony and participation between these rites, indicates other forces are also at work. This combination of features, a common core with peripheral variations, suggest some type of evolutionary or 'descent with modification' process may be involved in ritual change. This inference leads to the proposed use of quantitative phylogenetic methods for the analysis. These techniques assume that similarities between entities reflect their common inheritance, examining these to infer what their evolutionary history may have been. They were originally developed in biology to understand the evolution of species, and have more recently been applied to the study of culture change (Mesoudi *et al*. 2004, Currie 2013, Gray & Watts 2017). Cultural elements share some of the evolutionary features of species; they develop gradually over time with new elements being added or lost as they pass through generations. Consequently, phylogenetic methods have been productively applied to examining histories of languages (Gray *et al.* 2009, Bouckaert *et al.* 2012, Currie *et al.* 2013), manuscripts (Barbrook *et al.* 1998), folk tales (Tehrani 2013) and material objects (Tehrani & Collard 2002, Buchanan & Collard 2008, Jordan & Shennan 2009). They have also been used comparatively, to test theories of cultural adaptation using a linguistic phylogeny to control for the effect of shared history ('Galton's problem', discussed later). Examples include kinship changes associated with pastoralism (Holden & Mace 2003), the evolution of political complexity (Currie *et al.* 2010a) and the development of ritual human sacrifice in stratified societies (Watts *et al.* 2016).

The key debate surrounding the application of phylogenetic methods to culture is whether they sufficiently address horizontal mixing between societies (Borgerhoff Mulder *et al.* 2006, Currie *et al.* 2010b, Gould 2010, Norenzayan *et al.* 2016, Gray & Watts 2017). Cultural traits may be borrowed from neighbours because they are beneficial, or perhaps novel, in some way or repeated contact between societies may lead to a general drift towards similar cultural forms. The effects of horizontal transmission were summarised by Boyd *et al.* (2005) in their influential book chapter, '*Are Cultural Phylogenies Possible?'.* They suggest the feasibility of historical reconstruction depends on the extent to which a cultural entity is able to resist horizontal mixing, and identify four cultural types along a continuum of decreasing levels of stability:

1. At one end, all of the elements that make up a culture cohere and resist recombination. Cultures, in this case, are analogous to biological species and phylogenies are relatively easy to infer.

2. At this point, a core cultural tradition remains identifiable, and is rarely affected by recombination, but horizontal mixing between societies may be frequent for peripheral cultural elements. Reconstructing history requires distinguishing between core and peripheral traits.

3. Further along the continuum, cultures are best represented as packages of smaller elements. Each package, or cultural domain, is relatively unaffected by recombination and stable over time, but with its own pattern of inheritance. Reconstructing history requires the identification of stable cultural domains and determination of their separate phylogenies.

4. At the other end of the continuum, there are no observable entities of culture that are sufficiently coherent, or stable over time, for phylogenetic reconstruction to be useful.

We don't know which of these types' best characterise Australian rituals. Ethnographic accounts suggest at least some myths and rites were transmitted between neighbouring societies during the colonial era (Layton 2003: 282), so horizontal mixing is likely to have played a role. Phylogenetic methods can be applied inductively to examine the relative stability of ritual traits to assess whether they can be best characterised as core cultural traditions (type 1 or 2), trait 'packages' with their own, independent history (type 3) or are insufficiently coherent to have resisted horizontal mixing (type 4). Ritual history is expected to be complex; some traits are likely to be exposed to horizontal transmission and, potentially, adaptation, masking signals of shared inheritance. Importantly, these issues also occur in biological systems, such as horizontal gene transfer between bacteria,

and the phylogenetic techniques used to address them can also be utilised in cultural analysis (Gray & Watts 2017).

Study design – three approaches

To understand the processes involved in Pama-Nyungan ritual evolution, three complementary phylogenetic approaches are proposed which form the forthcoming chapters of this thesis:

- Modelling ritual history
- Ritual trait variation and language
- Hypotheses of ritual adaptation

The methodology starts broadly, examining ritual diversity as a whole, followed by higher resolution analyses that focus on individual trait variations and then examining particular, potentially adaptive, traits in comparison to ecological and sociological influences. In this way, the aim is to build up a picture of the processes involved in ritual variation. The first approach ascertains whether each type (initiation, mortuary and rock motifs) demonstrates sufficient coherence to be able to reconstruct its history, and which Boyd *et al.* categories (1 to 4) best characterises them. The second examines whether analysis of individual trait variations can improve our understanding of ritual's role in Pama-Nyungan language expansion. The third explores the influence of societal and ecological factors, testing whether they could have been the impetus that led ritual to evolve and considering their potential effect on ritual history. The three approaches are described in more detail below.

Modelling ritual history

What do we already know about ritual coherence that can help us to model it? Rituals can be considered as integrated systems of traits (relating to symbols, ceremony and meaning) that only make sense together *e.g.* as part of a system of belief. In this way, they could be similar to languages, which are integrated systems of words, grammar and meaning whose elements only make sense as part of that system. Grammatically-specific words are a good example and this quality of specificity may make them particularly resistant to borrowing. Likewise, ritual traits concerned with symbolism may be highly specified to the cultural tradition and resistant to transmission between neighbours. However, some ritual traits could be subject to relatively high levels of borrowing. For example, people may seek ways of improving representations of complex meanings and

beliefs by copying novel ideas from neighbours. These effects may impact some traits more than others. If particular traits are a core part of the tradition, they may be fairly resistant to change over time, whereas others may be more peripheral and subject to faster rates of mixing. This effect is present in language and therefore reconstructions use commonly-used words *e.g.* you, this, two (Swadesh 1952) because frequent usage within a population increases resistance to borrowing and linguistic change (Pagel *et al.* 2007).

In light of this background, and that some Pama-Nyungan ritual traits are known to have been transmitted between societies, the level of horizontal mixing is likely to make historical reconstruction of ritual problematic. To minimise the effects of this, trait data from societies closely related by language are grouped into linguistic area entities for the analysis. This approach removes the effects of mixing between near neighbours. There may still be borrowing of ritual elements across language area borders but, since there are often significant cultural differences between such entities (see chapter 2), the amount of ritual transmission across these borders may be much lower.

As well as borrowing, trait variation may be affected by other influences, such as adaptation. Since different traits may be impacted by different processes, underlying signals of cultural inheritance are likely to be difficult to unravel. Because of this, phylogenetic network analysis is used to model ritual history. Networks, as opposed to single bifurcating trees, represent the range of possible relationships between groups graphically, highlighting areas where reconstructed history is uncertain and therefore other influences may have played a role (Huson & Bryant 2006). In this study, two different analytical approaches are used to create networks; a distance method and a Bayesian, character-based method. Adopting complementary approaches allows for a more nuanced view of relationships and provides additional support for any conclusions drawn.

The distance method used is *Neighbour Net* (Bryant & Moulton 2004) which has been productively applied to analysing conflicting signals of inheritance in both biological and cultural systems (Morrison 2005, Hamed 2005, Kennedy *et al*. 2005, Gray *et al.* 2010, Walker & Ribeiro 2011, Chen *et al.* 2013, Tehrani 2013). The approach assumes that distances between groups, measured as similarities of ritual trait presence, are representative of their phylogenetic history. The model generates a distance matrix of trait presence/absence between all possible pairs of taxa (in this case language areas) and uses a neighbour-joining algorithm to array them in circular space based on the distances between them. The number of parallel lines between taxa, and the length of those lines, provides a visual indication of the level of conflicting signal associated with their

phylogenetic history. To provide a statistical measure of this conflict, a network delta score can be calculated with 0 indicating the distances between groups exactly fits a bifurcating tree, otherwise the score is between 0 and 1 (Holland *et al.* 2002, Gray *et al.* 2010). Delta scores can be compared to other cultural network analyses including languages (Gray *et al.* 2010) and folktales (Tehrani 2013).

The Bayesian, character-based method used is *Mr Bayes* (Huelsenbeck & Ronquist 2001) which applies Bayesian inference to generate phylogenies based on their likelihood of fitting the observed distribution of trait data. This approach is used widely in biological and cultural, particularly linguistic, phylogenetics because it provides an efficient way to search for possible trees together with the ability to model different evolutionary scenarios. A posterior sample of trees is obtained that are in proportion to their likelihood of fitting the dataset, thus reflecting the most likely trees but also uncertainty in the phylogeny. The tree sample can be represented by a consensus network (Holland & Moulton 2003) and by a majority-rule consensus tree including clades supported in at least 50% of the posterior sample (Ronquist *et al.* 2012). The small size of the ritual character datasets suggests that nodal support values above 70% are likely to provide positive evidence of existence of phylogenetic fit (Soltis & Soltis 2003, Alfaro *et al.* 2003).

Results from these two methods are used to ascertain whether phylogenetic reconstruction is feasible and which Boyd *et al.* cultural type best characterises each ritual form: type 1 ('full coherence', if all rituals have a similar phylogenetic structure), type 2 ('core', if some rituals vary together or with language), type 3 ('independent', if they have their own phylogenetic history), or type 4 ('no coherence', if the dataset has little or no phylogenetic structure). Ritual phylogenies are also examined to see if they represent plausible pathways of cultural transmission. A phylo-geographic model (*Geo* in *Bayes Traits* – Pagel & Meade 2006) is used to derive positions of ancestral nodes on the phylogeny, with the feasibility of this pathway verified in relation to geographic constraints, particularly water availability in the desert interior. Comparison is also made to a physical pathway derived from language change in a recently published phylo-geographic model (Bouckaert *et al.* 2018), to determine the degree of alignment between them.

Ritual trait variation and language

The second analytical approach focuses on individual traits compared to language to examine whether ritual may have played a role in the expansion of Pama-Nyungan societies. If this hypothesis is valid, particular ritual traits, for example those associated

with more complex ceremony or possibly geometric motifs, should be closely associated with language. Such a finding, in conjunction with results from the first analysis, would support the idea of ritual being linked to Pama-Nyungan expansion. However, traits could simply be neutral, passed along with language change without conferring any particular benefit. To assess whether there is positive evidence for ritual advantage, traits are examined for an active connection to Pama-Nyungan expansion by measuring their association with linguistic diversity.

The analysis is in three parts, firstly, trait variation is compared to language variation using D-values (Fritz & Purvis 2010) which measure the extent to which the clustering of trait presence follows that of the language phylogeny. If patterns are similar, it suggests traits have been conserved as part of linguistic history and could be associated with language expansion. Secondly, the potentially confounding effect of geographic proximity is examined. Since language and geography are often closely related, a trait might appear to vary with language when in fact proximity is a better explanation. Such traits are more likely to have been horizontally transmitted and excluding them allows us to better identify traits with true phylogenetic signal. To examine variation with geography, an autologistic model developed by Towner *et al*. (2012) is used. This compares neighbour graphs of language similarity and geographic proximity to trait distribution to assess whether trait variation is best explained by language, geography or some other factor.

Thirdly, traits are examined for an active connection to Pama-Nyungan expansion by measuring their association with linguistic diversity. Here, it is important to clarify what is meant by language expansion. The Pama-Nyungan family has expanded both geographically, to cover 90% of the Australian continent, and in terms of its diversity, to encompass over 300 separate languages. Typically, though not necessarily, such processes tend to occur together. As speaker numbers expand across a territory (due to replacement of existing languages or migration into new habits) ecological self-sufficiency within groups and the isolating action of natural landscape barriers tends to slow the spread of linguistic variants. This leads to an accumulation of language change that ultimately results in languages becoming distinct from their neighbours (Collard & Foley 2002, Axelsen & Manrubia 2014). In the case of Pama-Nyungan, geographic expansion does appear to be associated with linguistic diversification; the regular patchwork of language distribution throughout the continent is suggestive of an on-going fissioning process (see figure 0.1). In this study, I use a novel method, BiSSE (Binary Speciation and Extinction - Maddison *et al.* 2007), to examine whether the presence of particular ritual traits is associated with higher levels of language diversity, as defined by larger clades in

the phylogeny. The BiSSE method is widely used in biology to analyse whether a trait is linked to greater species diversity. In this study, I am suggesting it can also be applied to the cultural realm as a way of examining whether the presence of a particular trait is associated with language fissioning. Since fissioning seems to be associated with increasing Pama-Nyungan speaker numbers, such results might also provide evidence that these traits were associated with the spread of the Pama-Nyungan language family across the Australian continent.

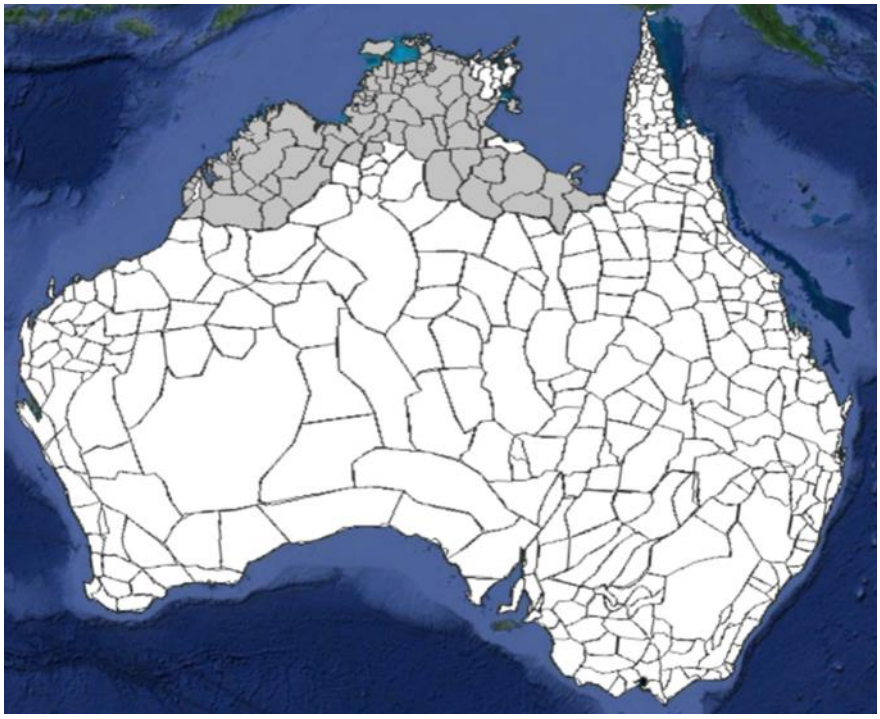


FIGURE 0.1 DISTRIBUTION OF AUSTRALIAN LANGUAGES; PAMA-NYUNGAN IN WHITE, NON-PAMA-NYUNGAN IN GREY (BOWERN 2016, WWW.PAMANYUNGAN.NET; MAPPED USING GOOGLE EARTH)

Hypotheses of ritual adaptation

The third approach focuses on particular, potentially adaptive, ritual traits in comparison to ecological and sociological influences. These results should indicate whether adaptation has played a role in shaping ritual history and, potentially, whether this has provided the impetus for particular rituals to evolve. The hypotheses tested are drawn from the earlier outline of ritual theory, but specifically focusing on the Pama-Nyungan case.

As highlighted previously, ritual may have developed as a way of stabilising relationships between neighbours. Rossano (2009) suggests this hypothesis can be tested by examining the association between extensive inter-group relations and the presence of 'elaborate

and demanding' rituals. Population density can be used to quantify the extent of inter-group relations assuming that, where this is higher, more residential groups are likely to be in contact with one another. The relative elaborateness of the ritual, and the associated demands this places on participants, can be quantified by examining the number of attributes used in the staging and performance of initiation rituals (probably the most significant ritual in Australian life). If the hypothesis is valid, we would expect more attributes to be associated with higher population density Pama-Nyungan societies.

The costliness of ritual action has been suggested as a 'hard to fake' signal of the individual's commitment to the group (Irons 2001) and an association was found between costly male rites and the presence of warfare (Sosis *et al*. 2007). Conflict is recorded in Australian ethnography, suggesting it is a relevant collective action problem that is testable in the Pama-Nyungan case. As well as costly signalling, ritual pain has been interpreted as a way of building solidarity with others through shared memories of traumatic or emotional experiences (Whitehouse 2004) or because of its transformative quality (Glucklich 2001). Such alliances may be particularly critical in marginal habitats because of the need to cope with greater fluctuation in resources (Hayden 1993). This link is examined in the study, specifically whether more costly rites are associated with more challenging ecological conditions.

Rituals may mask the underlying reality of relationships and thereby maintain the advantage of particular groups. In Australia, unlike many other hunter-gatherers, elaborate ritual plays a central role, potentially acting to support a 'gerontocracy' of age-based control over access to wives (Rose 1960, Bloch 1989: 17). If this hypothesis is valid, greater inequality would be expected to require more elaborate rituals to maintain it. Inequality can be quantified using the age difference between males and females at the time of marriage, assuming the larger this is, the more the society is orientated towards elder male control. Elaborateness can be quantified using ritual attributes as above.

Unequal power relations may also be due to differences in control over resources and ritual has been suggested as a way of legitimising territorial rights, in particular through mortuary ceremony and grave marking (Saxe 1970, Goldstein 1981, Bloch & Parry 1982). In Australia, seasonal camps were often established in areas of plentiful resource (McBryde 1978, Flood 1980) resulting in some societies adopting a partially sedentary lifestyle with relatively few camp moves during the year (Binford 2001: 271). Many Pama-Nyungan societies have specific burial grounds marked with carved trees or other objects (Meehan 1971, Berndt & Berndt 1996: 461, Pardoe 1988). The role of ritual in legitimising

access to resources is tested in the study, specifically, is the presence of grave marking in Pama-Nyungan Australia associated with partial sedentism in these societies?

Rituals can construct socially useful categories within groups that enable the community to operate more effectively (Turner 1969). Adulthood is one such category and, whilst analyses typically focus on males, initiation ceremonies for girls are also common. Their presence may be related to women's social significance and Brown (1963) suggested such ceremonies were more likely when women's contribution to subsistence was higher than men's. In Australia, plant foods mainly foraged by women form a greater proportion of the diet in some societies, such as those in more arid conditions. If the hypothesis is valid, this higher contribution should be associated with the presence of girls' initiation ceremonies and this is tested in the study.

Ritual's ordered yet flexible structure may provide an effective platform for the resolution of differences (Turner 1969). Conflict arising from exogamous marriage practices may be mediated through mortuary ritual and Bloch & Parry (1982: 20) suggest that, where rites of secondary corpse disposal are present, the societal distinction between kin and affines is likely to be more marked. The act of separating the (female) flesh of the corpse from the (male) bones in a later ceremony symbolising reversion to the original social state. In Australia, this distinction is expected where patrimoieties are present because home estates are held through patrilineal descent, therefore female affines will nearly always live with male kin away from their childhood home (Dousset *et al*. 2015). Secondary corpse disposal rituals take place in Pama-Nyungan societies and similar symbolic references are present. For example, the generational (although not descent) moieties of the *Pitjantjatjara* are bone (*nganantarrka*) for one's own moiety, and flesh (*tyanamiltyan*) for the alternative moiety. It suggests the hypothesis linking secondary rites to patrimoieties may be a relevant one for Australian societies and this is tested in the study.

The hypotheses outlined above result in seven proposed tests of ritual adaptation. In examining the associations between ritual and other influences, it is important to understand whether positive results provide evidence of adaptation or could instead be the result of societies having a common ancestry. Pairs of traits may be associated with each other because of their shared history and we can only be confident the trait is an adaption if it has evolved (or been lost) more than once in association with another trait or environmental condition. The problem of non-independence of trait values (often called 'Galton's problem', after first being noted by Sir Francis Galton in 1889) is addressed in this study by using phylogenetic comparative methods. Failure to correct for

shared ancestry can lead to high error rates, both in registering false associations but also failing to detect positive ones (Nunn 2011: 144). The issue is particularly important in this study because Pama-Nyungan societies are known, through linguistic evidence, to share a common history. The method used to test associations is Pagel's (1994) discrete trait test for binary traits (either present or absent), part of the *Bayes Traits V3* software platform (Pagel & Meade 2006). In these tests, linguistic phylogenies are used to correct for shared inheritance on the basis that language and population history tend to be closely correlated (Mace & Holden 2005, Bellwood 2013).

Forthcoming chapters

The next chapter focuses on the development of the ritual dataset required to meet the needs of the three approaches outlined above. The analyses themselves are then covered in chapter 2 (Modelling ritual history), chapter 3 (Ritual trait variation and language) and chapter 4 (Hypotheses of ritual adaptation).

Chapter 1: Building a ritual dataset

Rituals play a central role in Australian life and are frequently complex, time-intensive and costly to the individual. This study aims to understand why such rituals take place, examining the processes shaping their diversity and the societal and ecological influences that could have led to their development. Theories proposed to explain ritual evolution have typically been developed from qualitative ethnographic material. Whilst this has resulted in many important hypotheses, testing whether they have wider applicability requires the use of comparative, quantitative datasets and statistical methods.

The characteristics of Pama-Nyungan societies, ritual-orientated, hunter-gatherers living across variable ecological conditions, make them a relevant case study for ritual analysis. Whilst the quality and availability of cross-cultural datasets is increasing (Gray & Watts 2017), no dataset of Australian ritual currently exists and a substantial part of this study involves the collation of ethnographic material into a form suitable for comparative analysis. In this chapter I briefly review existing cultural datasets and their limitations, discuss the data requirements for this study and consider in detail the types of ritual selected.

Existing datasets

There are few existing sources of quantitative ritual data. The cross-cultural Ethnographic Atlas (EA) (Murdock 1967, Gray 1999) includes some ritual variables which have formed the basis of evolutionary studies (Roes & Raymond 2003, Johnson 2005, Peoples & Marlowe 2012) and Binford's hunter-gatherer database (2001) also contains ritual material. Two cross-cultural datasets focus specifically on ritual and religion, the Database of Religious History (DRH) (Slingerland & Sullivan 2017) and the Global History Databank (Seshat) (Turchin *et al.* 2019). An important issue to be addressed in cross-cultural analyses is that societies may be related to each other through common ancestry or processes of cultural diffusion such as trading contact (Dow & Eff 2008). In examining associations between traits, it is important to understand whether they provide evidence of adaptation or could instead be the result of these relationships. This problem ('Galton's problem', discussed earlier) can be addressed with phylogenetic comparative methods that use language trees as proxies for cultural history (Mace & Holden 2005, Currie 2013). Unfortunately, cross-cultural datasets such as EA, do not easily accommodate such

methods because there are currently no credible linguistic or cultural phylogenies for globally sampled societies (Dow & Eff 2008). There are however many well attested regional language phylogenies that can be utilised and this study focuses on Pama-Nyungan. Whilst a regional approach allows phylogenetic methods to be used, the problem then becomes sufficiency of data; both in terms of numbers of societies and cultural variables. Cross-cultural datasets have low coverage of Australian material; the EA has 12 societies, the DRH only 2 and Seshat none. Binford has a greater number (56) but an insufficient number of relevant ritual traits. It does, however, represent an important source of sociological variables for testing hypotheses of ritual adaptation. To examine ritual evolution in Australia therefore requires development of a specific dataset, and this is the focus of the current chapter. An example of a similar approach is the development of *Pulotu*, a database of religious practices in 116 Austronesian societies designed to facilitate the use of comparative phylogenetic methods (Watts *et al.* 2015b). Another important development is *D-Place* (Kirby *et al.* 2016) which collates relevant data from other databases sources, such as EA and Binford, matching it to available linguistic phylogenies to allow the use of comparative phylogenetic approaches. Currently, however, this dataset does not contain sufficient ritual-orientated traits to meet the requirements of the present study.

Dataset requirements

Sufficient ritual data is needed to pursue the three approaches outlined in the Introduction, which also form the forthcoming thesis chapters:

- Modelling ritual history
- Ritual trait variation and language
- Hypotheses of ritual adaptation

Material needs to represent a broad enough cross-section of Pama-Nyungan ritual to allow meaningful, generalised conclusions to be made as to ritual's role. Both psychological and sociological influences are likely to be important, therefore symbolic elements, that represent ideas or beliefs for example, as well as performative and physical aspects of ritual, should be included. To be phylogenetically informative *i.e.* to be able to detect signals of inheritance, traits need to reflect practices that are not unique to one or two groups, nor present in nearly all groups.

It is important to engage with this material sensitively, particularly within the historical context of the European invasion of Australia and its disastrous impact on Indigenous

Australian people and their culture. The consequences of this have continued to reverberate throughout Australian society for over 200 years. Aboriginal culture was often so severely and unsympathetically affected that recovery was impossible. Where the culture has survived, it has been due to the remarkable resilience of a people who, during this 200 year period, have been under attack in one way or another (Berndt & Berndt 1996: viii). In this context, sensitive engagement around cultural material is especially necessary. It is important to acknowledge Indigenous Australian ownership of traditional cultural knowledge and, in particular, to respect secrecy over certain elements. Whilst all the material included in the dataset has been previously published, particular care is required with initiation ceremonies as this ethnography was first published over 100 years ago in very different historical circumstances. In addition, there are particular sensitivities over these rites because certain ceremonies have restricted access based on seniority, gender and other factors. This is discussed in more detail in the section on Initiation data collection. As well as these general considerations, more specific requirements for the three chapters are set out below:

Modelling ritual history. Traits should be integrated within specific ritual systems that themselves demonstrate some coherence. Such traits are more likely to be inherited as packages and more resistant to horizontal mixing, thereby improving the likelihood of phylogenetic reconstruction. The higher the number of traits recorded, the greater the likelihood that ritual history can be recovered. A larger number of traits compensates for the fact that some may have limited stability over time, due to borrowing between groups, adaptation or rapid change, which is likely to obscure any underlying signals of inheritance. It also helps to improve the resolution of the reconstruction; the larger the number of traits relative to the taxa analysed, the fewer the number of tree topologies that are possible fits to the trait distribution. As far as possible, traits need to be independent of one another. If they co-vary together (and therefore don't behave as separate traits) this is likely to obscure any underlying signal in the phylogenetic reconstruction (Nunn 2011: 25).

Ritual trait variation and language. Results from these analyses are used to identify traits associated with Pama-Nyungan expansion. Since we don't know in advance which traits these are likely to be, it is important to collect material from a wide range of trait types. In initiation, for example, this includes ceremonial or symbolic aspects, as well as ordeals and physical markings.

Hypotheses of ritual adaptation. Traits are required that are associated with the ritual theories being tested including, for initiation, elaborate ceremony and costly, painful

rites, and for mortuary, grave markings and secondary disposal practices. Data is also required for the independent variables, those hypothesised to lead to ritual change, encompassing both ecological and sociological parameters. In most cases these can be taken from alternative data sources, such as Binford (2001), but in one case, warfare, data needs to be collected directly from ethnographies (discussed below).

To meet the requirements of trait coherence, breadth, variability, quantity, independence and relevance, with consideration of the sensitivity of some ritual elements, three specific ritual systems were chosen for inclusion in the dataset: initiation ritual, mortuary ritual and rock motifs. As well as fulfilling these criteria, they represent ritual forms whose source data is reasonably accessible from ethnographic material including, in the case of mortuary ritual and rock motifs, from previously conducted pan-Australian reviews. The three forms are reviewed in detail below. General perspectives from the literature are considered, followed by specific discussion of the Australian case, concluding with the methodology applied to data collection.

Initiation

General perspectives

Rituals take place for a reason and initiation is a good example. The values, know-how and attributes required of adulthood are modelled in initiation rites and the adolescent needs to pass through these to be accepted as an adult member of the social group. Adolescent rites are common, with a presence in 40-70% societies depending on the definition and type of society considered (Alcorta 2006). Whilst ritual theory often focuses on the initiation of boys, girl's initiation ceremonies maybe equally common (Schlegal & Barry 1979). In general terms, female rites tend to be orientated towards fertility, and males towards responsibility (*ibid*). Exactly how *i.e.* through what mechanisms, initiation rites facilitate the transformation to adulthood is frequently unclear but common themes have been identified:

Performance. Physical action is usually employed as a mode of communication. Dance, music and enactments feature regularly and may trigger feelings of release and emotion in the novice (Schechner 1988), provide a greater reality and sense of drama to events (Lévi-Strauss 1963) and, when collective, encourage sociality and communal values (Seligman *et al.* 2008). Myths and narratives may be enacted, providing frameworks of meaning and purpose and reproducing features of the socio-political order. Through their engagement the novice tacitly assents to this order, thereby solidifying societal norms (Rappaport 1999). The repetition and ambiguity or vagueness common in ritual may

contribute to this state of deference; others in authority are relied on to guarantee the value of what is said (Bloch 2004).

Liminality. Rites often feature a liminal phase where the status of the novice is ambiguous (Turner 1969). In this period, deceptions and reversals of expectations may take place that demonstrate the complexity of reality; consigning notions of good and evil to childish fantasy (Gill 1979). Trials and ordeals may also feature, designed to create isolation, humiliation or intimidation (Stephenson 2015). There may be gender differences in ordeals, with segregation more common for girls and painful mutilations for boys (Schlegal & Barry 1979). Kratz (1994) describes the liminal phase as a 'culturally-constructed danger point'; initiates must brave physical hurt, emotional shame and loneliness to pass through. In doing so they demonstrate their personal control and readiness for the adult world. The new status may be confirmed through the revelation of sacred knowledge, exchange of gifts or receiving of new names and body decoration (Stephenson 2015).

Painful mutilations. Markings and mutilations that cause severe pain are common features of initiation (Schlegal & Barry 1979). The use of pain has been interpreted in a variety of ways. It may signal the presence of a supernatural force (Glucklich 2001) or the symbolic death of the novice (Eliade 1965). As a form of sacrifice, it may represent payment for the benefits of adulthood or the receipt of sacred knowledge (Gill 1979). Glucklich (2001) suggests pain is used for its transformative quality. Acting in a similar way to psychotropic agents, intense pain releases opiates that induce both euphoric and dissociative feelings, making the novice more receptive to new mental states. In social terms, painful rites may represent 'hard to fake' signals of the individual's commitment to the group (Irons 2001). Sosis *et al.* (2007) found an association between these rites and the presence of warfare, an activity requiring a high level of a collective action. Ordeals linked to pain may also build solidarity based on shared traumatic experience (Whitehouse 2004). When this is outside social norms it may be transformed into a 'dark loyalty' (Crapanzano 1980). Genital mutilations commonly feature in initiation rites. As sources of pleasure and fertility such forces, new to the adolescent, require direction in relations with others (Glucklich 2001). Mutilations may trigger sexually-charged anger, with subsequent healing associated with the new state of adulthood away from the mother's authority (Beidelman 1997).

Initiation in Australia

Adolescent initiation is probably the most significant ceremony in Australian life, frequently involving complex settings, multiple age-stages and painful ordeals and mutilations (Berndt & Berndt 1996: 150, Maddock 1974: 131). Ceremonies take place for both males and females beginning around puberty and focusing on the responsibilities of adulthood including marriage. They effectively act as marriage ceremonies (or authorisations to marry), there being little separate ritual associated with the union itself. Male ceremonies tend to have wider social participation, are longer and more intricate, and have a greater focus on the acquisition of knowledge, particularly religious knowledge. They may also take place multiple times for one individual, at different ages following puberty. Because of the additional complexity, and probably because ethnographers have tended to be male, more ethnographic material exists for male ceremonies and these have a greater focus in the dataset. Male initiation has a similar general pattern across the region: the novice is removed from the main camp and segregated, transition rites are performed and secret knowledge revealed, the boy then returns to camp as an adult. Although the mechanisms used to effect these steps are variable between societies, common themes can be identified that are similar to those encountered cross-culturally:

Performance. Ceremonies are highly collaborative and one of the few occasions where members of different residential and sometimes linguistic groups encounter one another (Berndt & Berndt 1996: 22). Messengers are sent to invite participation and novices may tour other camps beforehand. Male adolescents are normally initiated in groups and there is an emphasis on their kinship relationships; the novices' male kin, mother, sisters and betrothed wife are often key participants. Dance, music and enactments feature regularly providing a sense of drama to events. The novice is normally painted first, with red ochre for example, and his release by the women of the camp is often associated with a performance such as a bark beating ceremony. Myths and narratives are commonly enacted, providing frameworks of meaning and purpose. In central regions, tossing the novice in the air represents the flight of women pursued by an ancestral being (*ibid*, 170). Ancestral stories and songs may be repeated for many hours with meanings that are often unclear to participants, possibly illustrating a 'state of deference' to the authority of the group, and to male elders in particular (Bloch 2004). Deference appears to be a common general feature; the form of rites are largely fixed and invariant, the novice is largely passive during them, their silence is enforced, and, except in later age-stages, participation is mandatory (Berndt & Berndt 1996: 166).

Liminality. In this phase, transition rites are performed and secret knowledge revealed. Often this takes place in a demarcated sacred ground that may contain various earthworks and platforms. In some regions, there is a processional journey to the ground via sculptured mythical beings, objects and carved trees. Elders, sometimes disguised and painted, act out deceptions and tricks, discrediting childhood beliefs and mocking the novices (Maddock 1974: 138). In male rites, women are forbidden from viewing this phase (on pain of death) and revelation of sacred knowledge to a woman or child is punishable by the novice's death. Painful mutilations and ordeals occur in this period that may provoke disgust or test personal control *e.g.* sitting close to fire for a long period of time. Afterwards, boys may be segregated (usually with other males) for long periods of time, sometimes many months, before being permitted to return to camp with the new status of an adult. Girls may also be segregated but this tends to be for a shorter period, often related to menstruation. Readmission, as an adult male or female, maybe marked with new styles of body painting, hair decorations and gifts such as spears, shields, armbands and human hair belts. Elaborate food taboos are often enforced over the whole of the childhood and adolescent phase, with lifting after initiation, and in some cases, after completion of further age-related stages.

Painful mutilations. These are common features of Australian initiation. In males, the act is often linked to supernatural authority and a bullroarer (a shaped rectangular piece of wood tied to a cord which when swung in an arc produces an unearthly, eerie sound) may be used to represent the voice or presence of a mythical figure. Common mutilations include:

Tooth avulsion; knocking out one or more front teeth, usually with a stone or wooden mallet.

Hair removal; usually pulling out of pubic and/or beard hair, sometimes the whole body.

Scarification; across many different areas of the body, usually linked to processes that increase the size of the scars such as adding ash or plant extracts to the wound.

Finger removal (female); usually the tip of the fourth or fifth finger, often the joint is bound tightly until the tip atrophies and falls off.

Circumcision (male); foreskin usually cut with a sharpened stone or piece of shell. This ceremony, and sometimes sub-incision below, may take place on the back of a male elder who is held up by other elders to form a platform the novice lies down on. Circumcision

is widely performed across central Australia but largely absent from the coastal north and most of the East and West coastal regions.

Genital mutilation (female); cutting either of the vulva or from the vagina to the perineum (Berndt & Berndt 1996: 181). The latter was recorded by Roth (1897), who termed it 'introcision', and by others in Central Queensland. Some doubts have been raised by Pringle (2004) as to the accuracy of these accounts but observations of similar practices elsewhere in Central Australia (Spencer & Gillen 1899), suggest some form of female genital mutilation was present.

Sub-incision (male); the underside of the penis is cut with a sharpened stone and the urethra (tube connected to the bladder) opened lengthwise, from the tip of the penis down towards its base. The slit can be of varying lengths and sometimes the cut is extended in further ceremonies. This severe mutilation is common in Australia (particularly across the central desert regions) but rare elsewhere. It has been reported in Fiji (and possibly Tonga), in Kenya as a custom of the Samburu youth and as a medical intervention in the Amazon basin to remove small parasitic fish (Basedow 1927, Lobdell 1975). Sub-incision usually requires the person to squat while urinating; sexual function is not thought to be significantly impaired according to ethnographic accounts, and it does not seem to be intended as a contraceptive measure (Berndt & Berndt 1996: 175). Symbolic references vary, but one 'widely acknowledged across the Northern Territory' (*ibid*, 176) is that the penis represents the fertility earth mother figure the rainbow snake, and the sub-incision cut is her uterus. Thus, the rite represents the combination of male and female organs required for fertilisation to take place.

Initiation data collection

Systematic collection of material relating to indigenous Australian life began around 1850 (Arthur & Morphy 2005: 249) and this study uses material predominantly from then until around 1910. Colonial dispossession affected many communities during this period, beginning in south-eastern coastal regions. Although ethnographic observations tended to take place further inland many communities were still impacted by European expansion, particularly by the end of this timeframe. Despite these challenges, initiation ceremonies were often maintained by Indigenous Australian societies, serving to reinforce community solidarity in the face of increasing dislocation and settlor violence (Thomas 2007: 196). They also tended to be located in rugged or forested sites less accessible to settlors (*ibid*, 193). Consequently, valuable records of ceremonial life were collected, despite the challenges of this complex historical situation. Authors such as

Howitt (working between 1846-1904) and Mathews (1870-1912) in the south east, Taplin (1859-1873) in the south, Roth (1894-1906) in the north east and Spencer & Gillen (1896-1901) in the centre and north, travelled extensively over a number of years recording different aspects of Indigenous Australian life, including initiation rituals (Berndt & Berndt 1996: 535). They also corresponded with informants in more remote locations. This information was consolidated in subsequent publications that form the core source material for the dataset. Greenway's *Bibliography of the Australian Aborigines* (1963) provided a useful source of additional material. In total, 92 publications from 21 different authors were used and material from most areas of Pama-Nyungan Australia is included, with the exception of Western Australia. The core authors referred to above consolidated their material in book form except Matthews who published around 70 separate papers that include information on initiation ceremonies. A specific bibliography of Matthew's work (Thomas 2007: 257) was used to ensure completeness of these records. The full list of 92 publications is included in Appendix 1a_References.

Anthropology was not an established scientific discipline at this time and these early authors had backgrounds in either science (Spencer, Howitt), administration (Gillen, Roth, Matthews) or missionary work (Taplin). Importantly, this study is concerned with the recording of ritual practices themselves rather than their interpretation, therefore lack of formal anthropological training is less problematic. Whilst this early material is subject to ethnocentric bias, it is evident that the authors brought a generally rigorous approach to observations, and to correspondence with informants, to establish clarity around the practices recorded. Matthews, for example, was a trained surveyor and his detailed recordings of the settings and practices of ceremonies form an important part of this dataset. The focus of the study is on this early work because of the greater number of Indigenous Australian communities for which material is available and because there was less impact from European contact. Both factors help to support the validity of any conclusions drawn. Later authors also made detailed accounts but by this time many communities had suffered such severe disruption, including forced relocation to Aboriginal stations away from their homelands, that interpretation of this material is difficult. In particular, it becomes challenging to allocate practices to specific linguistic groups which is a key requirement of this study.

Whilst all material in the dataset has been previously published, in most cases this took place over 100 years ago and it is important to address ethical considerations associated with its re-use in the public domain. There is considerable sensitivity concerning items defined as 'secret-sacred'. This composite term is used to refer to Australian Aboriginal

rites, songs, and objects only accessible to specific people, based, for example, on their clan membership, age or gender (Gibson 2019). Material associated with initiation ceremonies is particularly likely to be secret-sacred and therefore require careful handling. Whilst particular sensitivity is associated with ritual objects, such as bull roarers and *churinga* boards, and with photographs of ceremonies and sacred sites, written descriptions of rituals can also be sensitive. Whilst there may be differences in interpretation as to what constitutes secret-sacred (Gibson 2019), this study takes a cautious approach. Only generalised ritual traits have been re-published and descriptions of ceremonies and material associated with religious knowledge, such as mythical names and narratives, are excluded. Traits are considered generalised if they have been extensively characterised in the public domain, for example in widely read publications such as Berndt & Berndt's *The World of the First Australians*. First published in 1964, this has been revised or re-printed ten times and the latest version (1996) is used as the reference point for this analysis. Another source for considering acceptability of re-publication is Thomas's (2007) English translations of initiation ceremonies described in three papers by Mathews (originally published 1904-1910) after consultation with Indigenous Australian community representatives. A further source are accounts of contemporary initiation ceremonies such as Curran 2011 and Morton 2011. Two of the 27 selected traits (see below) did not meet these generalised conditions and have been anonymised naming them ordeal1 and ceremony1 in place of a fuller description. The full list of attributes used to create the selected traits (and ceremony trait categories) is not included in the published thesis. However, further consultation is planned for it be more widely available. This will enable researchers to analysis the attribute list directly, add material from additional sources and correct any errors or omissions.

In total, 279 attributes were recorded across 129 linguistic groups. Each group had a mean of 2.4 publication references (range 1 – 10) and 1.6 separate authors (range 1 – 5). 20 groups were considered insufficiently observed, as they had 10 or less recorded attributes, giving an adjusted total of 109. The majority of attributes were associated with male initiation (although see discussion on reporting bias below): setting and staging (42 attributes), ceremony (95) and physical ordeals (43). Male rites tend to be associated with wide community involvement and a number of attributes were associated with participation: women's involvement (29), neighbouring groups (23), guardians and relatives roles (18). Attributes recorded specifically for female initiation were: ceremony (14) and physical ordeals (15). The objective was to record as much detail as possible and then sub-divide this raw data into generalised traits suitable for analysis (discussed below).

Allocation of material to linguistic group was consistent with the original ethnographic approach. Authors, or their correspondents, noted the ceremonial details of societies in a particular location whose members primarily spoke a specified, identifiable language. Language and location were cross-checked for accuracy using the comprehensive language database *Austlang* (https://collection.aiatsis.gov.au/austlang). Although different authors often used different naming conventions, it was usually possible to accurately allocate the material to a specific language as *Austlang* is searchable by multiple ethnolinguistic name variations and by geographic location. In the few cases where allocation was uncertain for a particular location, the nearest language was used. Authors often described ritual practices taking place within a small geographic area *e.g.* between the Richmond and Clarence rivers in New South Wales. If this contained more than one linguistic group, the attributes were recorded as present in all of them. In most cases, this would be no more than two or three groups. If authors made broad, generalizable statements *e.g.* this practice occurs along the eastern coast or in central desert regions, such references were deemed insufficiently precise to be included in the dataset. Allocation of each society, traced from publication reference to linguistic group, is listed in Appendix 1a_Allocation. The geographic distribution of the 109 groups is illustrated in figure 1.1.

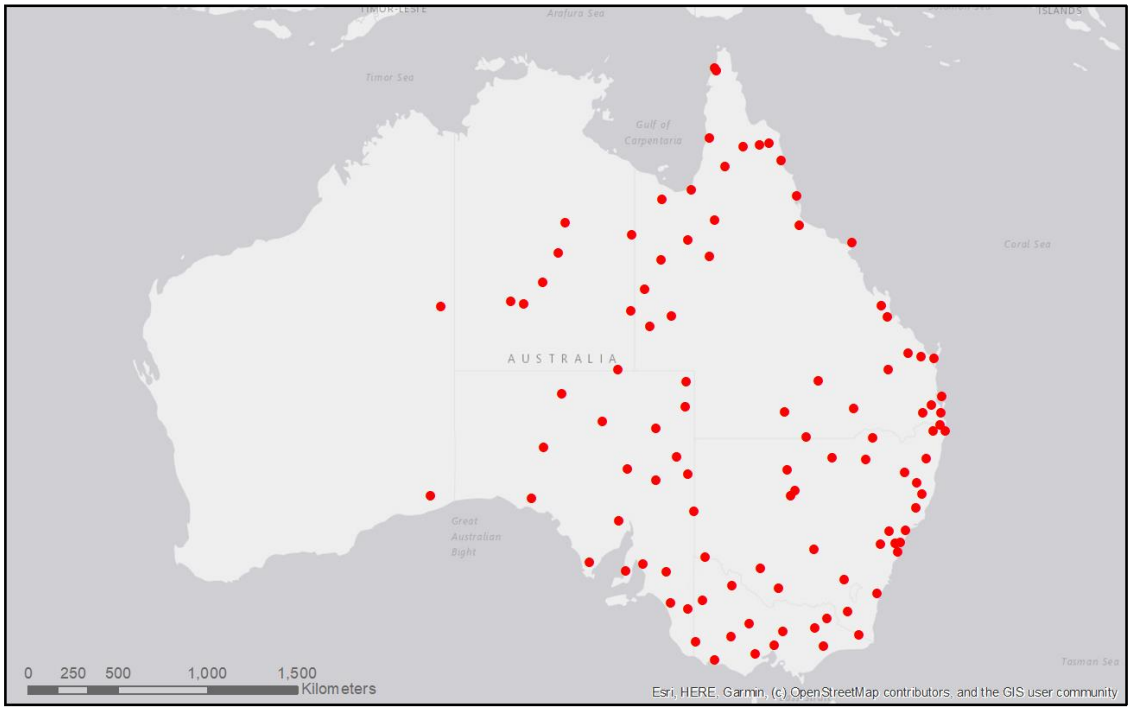


FIGURE 1.1 LOCATION OF 109 PAMA-NYUNGAN SOCIETIES WITH INITIATION DATA.

Initiation traits for chapter 2 & 3 analyses

For theses analyses (modelling ritual history & ritual trait variation) criteria were applied as discussed earlier. Traits were identified based on: variability, independence, breadth and relevance.

Variability. To be phylogenetically informative *i.e.* to be able to detect signals of inheritance, ritual traits need to reflect practices that are not unique to a small number of groups or present in nearly all groups. Many attributes were too infrequent to be selected. Of the 279 recorded, around half (141) had 10 or less observations. For example, there was significant variation between groups related to novice decoration and gifts, earthworks produced as part of the ceremonial setting, and narrative enactments used. Some traits were too ubiquitous to be selected. For example, the presence of multi-stage rituals, bullroarer use, the covering of novice's heads and food taboos were recorded for nearly every group.

Independence. As far as possible, traits need to be independent of one another as co-variance may obscure any underlying signal in the phylogenetic reconstruction (Nunn 2011: 25). A number of traits were excluded on this basis. For example, many of the 42 attributes associated with the setting category only feature if the initiation has a processional path to the sacred ground. These attributes are likely to co-vary strongly with each other and with the use of this ceremonial style. Therefore, for the phylogenetic analyses, only one trait from the setting category was selected – whether or not initiation was processional.

Breadth & Relevance. A broad representation of traits improves the likelihood that conclusions are relevant to the interpretation of Pama-Nyungan ritual practice as a whole. Therefore traits were selected from each different attribute category: setting, ceremony and ordeals (for males) and ceremony and ordeals (for females).

Finally, one of the challenges with preparing the dataset is reporting variation both within and between societies. Whilst data has been collected within a specific period (1850-1910), variation might still occur in this timeframe, especially since societies were heavily affected by colonial expansion during the period. Observed ritual differences might also be due to other factors, for example, seasonal variation or, perhaps, reduced or unusually plentiful resources. Variation could also be due to observer error or oversight. A trait may be present in a linguistic group but not recorded, either because it was not observed or perhaps deemed uninteresting. Some societies with very low numbers of attributes (10 or

less) were already excluded for this reason. To further address the challenges of reporting variation, traits were only selected if they tended to be regularly recorded by the different authors. The main ordeals and permanent markings, for both men and women, were nearly always noted by ethnographers but the recording of ceremonial detail linked to them was inconsistent. For example, the process of tooth avulsion was commonly observed however related aspects, such as the person carrying out the procedure or what happened to the tooth, were inconsistently recorded. The colour of painting the novice or elder was usually noted as were elaborate hair designs and the use of human hair belts, but other body decorations were not consistently observed. Participation in male rites contained many areas of inconsistency, such as the kinship affiliation of guardians and relatives and the involvement of women and neighbouring groups. Consequently, only one trait was taken from this category (women's participation in fire ceremonies) for the phylogenetic analysis.

The recording of female rites (and women's involvement in male rites) is a particular issue in terms of missing data and inconsistent reporting. Since early ethnographers were predominantly male, they may not have focused on women's ceremonies or been told about them if they did. Although it seems reasonable to assume male initiations were longer and more elaborate (something also seen cross-culturally) we also know that female initiations took place. Therefore, it is likely the dataset has a bias towards male ceremonies and that female ceremonies are under-reported. The position is not straightforward however as Indigenous Australian women's openness to discuss ceremonies may increase with male age (Thomas 2007: 195) and, since male ethnographers were normally middle-aged, such interactions were probably a source of some information. For example, the notebooks of Mathews (who was 60 at the time) include many Aboriginal women's names, suggesting at least some dialogue took place (*ibid*). As noted above, a further aspect of women's involvement is within male initiation ceremonies, particularly at the earlier and later stages. Boy's initiations tend to feature broader community involvement than those for girls, often including significant roles for women (particular mothers and relatives of the male novice). In this study, both aspects of women's involvement were captured in ritual attributes: those linked to male initiation and those associated directly with female initiation. Since ritual studies have tended to focus heavily on male rites, one of the aims of this study was to include more aspects of women's involvement, albeit in the knowledge that under-reporting is likely to have occurred.

Taking account of all the above criteria, 27 commonly observed traits were selected from the full attribute list for the chapter 2 & 3 analyses (see Appendix 1a_27SelectedTraits). In some cases, a number of attributes were combined to form one generalised trait *e.g.* scarification, hair removal. Final traits for male initiation relate to: setting (1 trait), ceremony (11), physical ordeals (9) and women's participation (1). For female initiation, traits relate to: ceremony (1) and physical ordeals (4).

Initiation traits for chapter 4 analysis

For this chapter (hypotheses of ritual adaptation), traits were derived from the attribute dataset to meet the requirements of the theories tested. For initiation, these were elaborate ceremony, costliness of male rites and presence of female initiation. As discussed above, inconsistencies in reporting are likely to have resulted in missing data for some groups. If societies have been described by multiple authors this may also lead to a greater variety of attributes being observed, adding a further complication. To help address these problems, binary categories were used for the analysis. Whilst this approach has the disadvantage of flattening variation between societies, the major advantage is that differences in reporting will have much less impact. Whether a society is categorised as 0 ('low') or 1 ('high') is likely to be much less affected by inconsistencies in reporting. Binary categories also allow use of the discrete method in *Bayes Traits* (Pagel 1994) that enables mechanisms of causality to be examined (see chapter 4). Methods to estimate the split point for creating binary categories include using the mid-point of the measurement scale, the median of the data or splitting the data into three categories and discarding the middle category (Rucker *et al.* 2015). The latter method is adopted here because, by removing the more arbitrary classification of middle values, it preserves more of the statistical power of the continuous dataset (Gelman & Park 2009). Binary data is also required for the independent variables, those hypothesised to lead to ritual change, encompassing both ecological and sociological parameters. In most cases these were taken from alternative data sources, such as Binford (2001), but for warfare the existing data was inadequately detailed and therefore collected directly from ethnographies (discussed below). Binary categories for initiation trait values were defined as follows:

Elaborate ceremony. Values were required for two hypotheses. Firstly, that elaborate male initiation ceremonies will be associated with high population density. Secondly, that such ceremonies will be associated with societies supporting greater age-based control over wives, measured as a higher age difference between males and females at the time of marriage. To define the trait value, the number of different attributes used in the

setting and ceremony categories was summed for each linguistic group. A greater number of attributes indicates more effort required to create elaborate setting and staging, deliver more performance elements, decorate participants *etc*. The total number of possible attributes was 137 (setting 42, ceremony 95) with the median 20 per group (range 0-52). Splitting this into three categories for the 109 societies: 33 were categorised 0 (low ceremony < 16 attributes) and 38 categorised as 1 (high ceremony > 23 attributes) with the remaining 38 groups (16-23 attributes) not categorised (see Appendix 1a_Ceremony).

Girls' initiation. One hypothesis is tested using this trait; that ceremonies associated with the initiation of girls will be present where women's contribution to subsistence is above the median level for all groups. To define this trait value, the number of attributes used in these rites was summed for each group. There were 29 in total (ordeal 15, ceremony 14) with the median 2 per group (range 0-11). As only limited data is available for subsistence (see chapter 4) it was necessary to use the full ceremony dataset to maximise the number of matching societies. It is assumed that no or very few traits indicates lack of societal focus on female initiation. Data for the 109 societies was therefore divided into two categories; those at or below the median (≤ 2) were categorised 0 (minimal ceremony, 60 societies), and those above (≥ 3) categorised 1 (high ceremony, 49 societies). See Appendix 1a_GirlsInitiation.

Costly male rites. Values are required two hypotheses. That costly male rites represent 'hard to fake' signals of commitment to collective action associated with warfare and that painful rites are associated with harsh environmental conditions. Sosis *et al.* (2007) found an association between costly male rites and warfare cross-culturally, assessing costliness using graduate student scoring of ethnographic descriptions on a 1-4 scale. In this study, a more medically-orientated approach is applied, using physician assessments of the likely pain and longer-term health implications of individual procedures. This is expected to lead to a more accurate assessment of relative pain between societies and of the overall risks borne by individuals in order to become a societal member. Costly rites were defined as body markings or ordeals during initiation and 28 procedures of this type were identified. These were independently assessed by two experienced UK medical specialists (both orthopaedic consultants). Reviewers ranked separately, on a scale of 0-10, the likely painfulness of each procedure and its longer-term health risks (Appendix 1a_ScoreMarkingsOrdeals). Scores were summed and averaged across both specialists to give an overall costliness measure for each procedure. The total possible score was 244.5 with median 45.0 per society (range 0-134.5). Splitting the data distribution into three

categories, 36 societies were categorised 0 (low costliness < 36) and 34 categorised as 1 (high costliness > 61) with the remaining 39 groups (score 36-61) not categorised (Appendix 1a_CostlyRites).

Warfare

Archaeological evidence from skeletal remains, including depressed fractures of the crania, parry fractures of the arm bones and embedded spear tips, suggests violence and warfare was widespread in Aboriginal Australia during the Holocene (Webb 1995, Allen 2014, Pardoe 2014). Early ethnographic accounts also reference violent encounters between Indigenous Australian groups. Whilst these observations may relate to pressures brought about by colonial expansion, and may suffer from ethnocentric bias, they demonstrate some consistency in their descriptions of two main types of combat (Wheeler 1910, Basedow 1925, Allen 2014). Firstly, regulated settling of disputes that normally involves the exchange of spears and sometimes individual hand to hand fighting. Occasionally these exchanges escalated into fatal violence. Secondly, active raiding of other groups, often revenge attacks, which nearly always resulted in fatal encounters and regularly escalated into repeated cycles of violence. The more serious impact of the second form is supported by data from the *Yolngu* in Arnhem Land where, over a two year period, 3 deaths were recorded from regulated combat and 62 deaths from active raiding (Warner 1937). In this study I test whether costly male rites may be acting as signals of commitment to facilitate the collective action required in warfare. Since the existence of active raiding in a society carries a much greater risk of fatality, the presence of costly rites would be expected to be associated with active raiding if the hypothesis is supported.

To date, there has been no systematic analysis of Indigenous Australian conflict across the continent. In order to assess the presence of active raiding, ethnographic material was reviewed from broadly the same time period as initiation rites (1850-1910). Conflict was frequently recorded in the material already used to examine initiation ritual and this provided the major source of data. Another 20 sources were added to this from Greenway's (1963) *Bibliography of the Australian Aborigines* (index entry: 'Fighting, Killings, 'War' among Aborigines) and Allen & Jones's (2014) *Violence and Warfare among Hunter-Gatherers* (chapters 5 and 6 focus on Australia). The additional references and their allocation to linguistic groups are noted in Appendix 1a (References and Allocation worksheets). Reports of conflict were linked to a total of 63 linguistic groups, see Appendix 1a_Warfare. Sources were reviewed for specific references to active raiding *i.e.*

expeditions to other residential camps for the purposes of killing one or more of their party. Reasons for these raids include revenge for murders or unexplained deaths and disputes over women or territory. 37 groups met the criteria for active raiding and were allocated to binary category 1. Reports linked to the remaining 26 groups contained descriptions of violence that featured regulated combat only (spear exchanges, orchestrated individual fights *etc.*) and were allocated to binary category 0. This was the case even if fatalities were recorded because it is the presence of active raiding which carries the greater risk for group members. Since violent events were actively examined in these 26 societies the assumption is that, if active raiding did exist, it is unlikely to have been overlooked by the ethnographer. Defining societies by whether active raiding was recorded or not should therefore provide a good indication of the relative risks of warfare between them. The geographic distribution of the 37 groups with active raiding and the 26 without is illustrated in figure 1.2. It further supports the accuracy of the categorisation because active raiding groups tend to be clustered together. This makes intuitive sense because they are likely to be caught up in cycles of violence with each other.

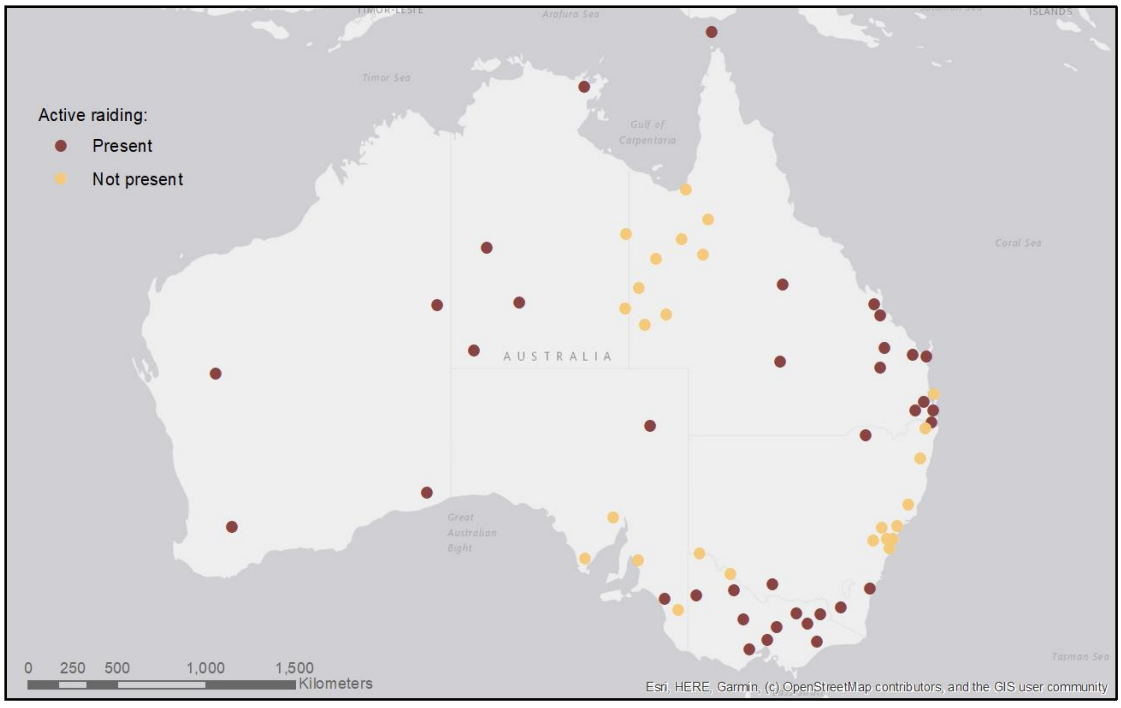


FIGURE 1.2 LOCATION OF 63 PAMA-NYUNGAN SOCIETIES WITH WARFARE DATA INDICATING WHETHER ACTIVE RAIDING IS PRESENT OR NOT.

Mortuary Ritual

General perspectives

Rituals linked to death and the disposal of the deceased are present in all societies. Whilst such rites vary a great deal they share common characteristics. There is usually a collective element involving close relatives of the deceased but also those from the wider social group. Symbolic elements are expressed, for example, through the appearance and activities of the mourners and the treatment of the corpse and its disposal. The careful preparation of the body is frequently linked to ensuring the spirit of the deceased smoothly transitions to an afterlife. These common themes are considered in more detail below, followed by specific discussion of Australian mortuary rites and the methodology applied to data collection.

Collective. In social terms, mortuary rites disaggregate the individual from the collective and reaffirm the bonds of the new society (Durkheim 2001 [1912], Hertz 1960 [1907 & 1909]). A person's death is significant not just for those closest to them but for the wider community; the death of an important leader, for example, creates particular unrest and elaborate rites and wide participation are required to repair the social fabric. The link between death and social anxiety leads to negative associations with the dead including their body, artefacts and habitation and these objects maybe classified as polluting or taboo. The lifting of these prohibitions for relatives, and their re-integration into society, depends on their relationship to the deceased (Hertz 1960). Name and food taboos may also provide acts of purposeful avoidance that serve to maintain the memory of the dead, helping to mediate the grieving process (Hallam & Hockey 2018). Conceptions of an afterlife can make the necessary break with the deceased, but also prolong the relationship with them, easing acceptance of their death (Robben 2018). Rites that maintain the corpse in a liminal state, such as secondary burials, maintain the link with the dead for a longer period, which may assist the adjustment of the living (Walter 1999). Material items, including from the corpse itself, are often incorporated into rites, with the mutual constitution of object and deceased creating a focal point for memory and mourning (Hallam & Hockey 2018). Grave markings and memorials to commemorate the dead may be serving this purpose but could also be advantageous to the living, confirming their lineal descent from the deceased to legitimise claims over land and resources (Saxe 1970, Goldstein 1981). Rites themselves may have similar effects. The social order is threatened by the unpredictability of death and ritual responds to this challenge by structuring the process; making death a social fact rather than a biological one. Symbolic re-birth, through re-incarnation or entry to a new spiritual life, harnesses

death into a controlled cycle of regeneration. By belonging to the social group an individual can triumph over their own biology; a fact which reaffirms the group's power and legitimises its authority (Bloch & Parry 1982, Bloch 1989).

Symbolic. The death of a person causes anxiety and fear in others and until the corpse is properly (ritually) treated its spiritual essence remains, menacing the living with the threat of further death. Rites, including the treatment of the corpse, are constructed symbolically to ensure the journey of the spirit to the afterlife takes place in an ordered fashion, according to the eschatological beliefs of the society (Hertz 1960). In secondary rites, the corpse needs time to free itself of the putrescence of the flesh and become purified, clean bones; converting itself into a spirit worthy of the land of the dead (Hertz 1960). Conceptions of death and eschatology vary greatly between societies because death's aftermath is so elusive and unknown (Needham 1970). Similarly, the symbols in mortuary rites are often vague and indeterminate yet commonly connote mystery and power (Metcalf & Huntington 1991). Symbolic features such as percussive noise and colour and are common in funeral performances. Music such as drumbeats may suggest the heartbeat and rhythm of life, the delineating of sacred time or the presence of power and divinity (Needham 1964). Black, the colour of darkness and decomposition, often provides the funeral hue but other colours may be used in opposition to death including white, signalling purity or the colour of cleaned bones. Sexuality is a common theme in funeral rites and Bloch & Parry (1982) suggest this is because biological and social facts are opposed to one another. Rites and narratives often support the primacy of the social case. In Christianity, for example, St. Augustine emphasised Adam's sinful lust as the cause of Eden's decline. In other societies, the conflict over female sexuality leads to symbolic representations of the corpse as polluting flesh (female) and clean bones (male). In exogamous societies male kin and female non-kin live together (and *vice versa*) leading to conflict between the sexes and an increased use of corpse symbolism. Such societies may be more likely to ritualise separation of the flesh and bones of the corpse and perform secondary rites over later disposal of the bones.

Mortuary ritual in Australia

Mortuary rites reported in the ethnographic record vary across the continent, particularly in the way the corpse is prepared and the methods of its disposal. However, there are also common themes such as strong emotional and physical demonstrations of grief, including self-harming, special inquest rituals following death, taboos associated with naming the deceased, avoidance of food associated with the deceased's ancestral totem

and the requirement to maintain silence for a long period. A re-negotiation of kinship obligations commonly takes place at this time *e.g.* younger widows re-married to husband's brothers. Rites vary significantly according to the social status of the deceased with elaborate ritual accorded to adult males but minimal ceremony associated with infants and the old. Strangers and those that have broken tribal laws are usually deprived of any mortuary rites.

Collective. Ceremonies involve both close relatives and those from the wider community. Present day Indigenous funerals or 'sorry business' often have high attendances and play an important role in maintaining collective solidarity (Tonkinson 1991, Burbank *et al.* 2008). Practices documented in the ethnographic record suggest a number of regional differences. Ceremonies tend to be more complex in the north, particularly Arnhem Land, with elaborate song cycles, specially prepared grounds and grave posts, simultaneous performances at different locations and later secondary rites associated with disposal of the bones. Elkin (1979: 355) suggests the presence of secondary rites indicates that death has a high social significance, since they provide more time for individuals to adjust to the weakening of society that follows the loss of an important member. Desiccation of the body, sometimes as a result of tree or platform disposal, and often followed by these rites, is common in north Australia and parts of the south east. Since desiccation is also a regular practice in the Torres Strait, the practice may have spread south from there to other parts of the continent (Elkin quoted in Berndt & Berndt 1996: 460, Arthur & Morphy 2005: 98). Cannibalism is part of the disposal process in some areas and usually specific parts of the body are eaten with the aim of absorbing positive attributes of the deceased, as a show of respect or, in the case of children, to give the child an opportunity of re-birth. Cremation has a wide distribution but tends to be associated with a reduced amount of ritual action. For example, in the Murray River region it is considered a quick means of freeing and disposing of the spirit and is often used for still-born or unwanted infants (Elkin 1979: 357). Burial as a one-stage, or as part of a multi-stage process, is the commonest form of body disposal in central and southern Australia. The orientation of the grave (such as east/west or north/south) and the corpse position, such as extended (horizontal) or flexed (limbs tied together), varies considerably in the ethnography. Archaeological analysis of 1,512 burials from the Murray basin indicated groups had not maintained single modes of burial over time, suggesting these traits are fairly labile (Littleton 2007). In the same study, multiple burials at the same site were common and Littleton suggests this is due to favourable landscape features (such as proximity to water) and not linked to legitimising resource access for group members, as suggested by Saxe (1970) and Goldstein (1981) in their hypothesis. However, Pardoe (1988), in an

earlier analysis of the same region, did find some support for the Saxe-Goldstein theory. This question is examined in more detail in chapter 4.

Symbolic. In many societies, a distinction is made at birth between body (foetus) and spirit (animating the foetus) and this is actively referenced throughout life providing a consistent narrative for the journey of the spirit after death. Mortuary rituals are structured to maintain this orderly transition with the aim of keeping people safe from the spirit's negative effects and regenerating a new life for the deceased (Berndt & Berndt 1996: 471). Beliefs and eschatology vary but often assume the spirit is formed of component parts that follow different pathways after death. One remaining as a 'trickster' spirit in the land of the living, one travelling to the land of the dead and another merging with an ancestral being. In desert regions, one element may return to the place of spirit children in preparation for re-birth among the living. In other regions, each person has a mythic counterpart and the lands of the living and the dead are conceived as separate realms (*ibid*). Myths tackling the problem of 'how death came about' often feature the moon, and its cycle of renewal, as a symbol of regeneration. Preparation of the corpse, for burial or other disposal methods, takes various forms including wrapping the body, tying hands, fingers and toes, the removal of hair and nails *etc*. These are commonly explained as measures to prevent the corpse causing trouble for the living before it has been avenged (*ibid*). Inquests are held in most cases of adult death with a focus on placating the deceased's watchful spirit. They commonly involve divination, using evidence from the corpse which is considered to remain animated, and in possession of sufficient agency, to be able to indicate who was responsible for its death. Methods include examining corpse exudations, internal organs and previously-buried bones, questioning the corpse (noting whether bones crack, hair comes out *etc.* when the culprit is named), and examining signs on the ground such as insect or animal tracks near the body. These may be combined with individual views such as the culprit being named by elders or featuring in dreams (Elkin 1979: 345). Such rites may be helpful in diffusing anxiety by providing a sense of control over the event, and in managing grief by providing a focus for action and deflecting feelings of guilt (Berndt & Berndt 1996: 473). Identifying the culprit is not necessarily followed by actual revenge but where this occurs it can lead to repeated cycles of violence (see comments on warfare earlier).

Mortuary ritual data preparation

The only continent-wide analysis of Australian mortuary ritual is Meehan's *'The Form, Distribution and Antiquity of Australian Aboriginal Mortuary Patterns'* (1971). Betty

Meehan collected material from a wide range of ethnographic sources focusing, in particular, on practices which might leave a trace in the archaeological record. She first distinguished between the presence of simple (one stage) and compound (two or more stage) corpse disposal. Practices were defined as compound if there were at least 'several weeks' between each stage. These two methods were then further analysed. For simple disposal, whether this involved trees, platforms, cremation or burials *etc*. and then additional variants identified based on the preparation of the corpse, the grave, grave surroundings *etc.* Compound disposals were further analysed based on the first step of the practice, whether this was drying, elevation, burial *etc.* Using this approach 98 attributes were identified. Recording did not overlap so, for example, the presence of simple burial and burial as the first step in compound disposal were two separate observations. Mortuary practices did co-exist together in societies with the method adopted usually related to the social status of the individual. Sources included more recent ethnographic material than used for initiation ritual, however a greater proportion of observations came from earlier accounts. For example, there were 264 recordings of compound disposal (all variants) from 51 separate authors that had a mean average publication date of 1902 (*ibid*, table 10). Potential bias from later material does however need to be borne in mind, particularly the encouragement of simple burial and the discouragement of compound and tree disposal by Christian missionaries.

Mortuary ritual traits for chapter 2 & 3 analyses

Criteria were applied as discussed earlier with traits identified based on variability, independence, relevance and breadth. Many of the 98 attributes were too infrequent to be selected with just under half (43) reported in only a few unique Pama-Nyungan locations. Although some of these had relatively high numbers of references, they turned out to either be from similar locations, from non-Pama-Nyungan regions (Arnhem Land and Kimberley), or have an unidentifiable location. A further 14 attributes could not be clearly categorised, such as the types of individuals associated with different disposal practices, and other variants associated with corpse orientation, grave shape, fill and locality. 10 attributes linked to cannibalism were excluded because they were not always associated with mortuary practice. 5 attributes were excluded because they were allocated to other traits and 2 summary attributes were excluded (burial-all and compound disposal-all) as they were not independent of the more detailed attributes in these categories. Following these adjustments, a total of 24 traits were selected for phylogenetic analysis (Appendix 1b_24SelectedTraits). 8 traits were associated with corpse disposal method, 8 with grave markings and 8 with treatment of the body or

grave. Traits were well balanced in terms of relevance: disposal methods (particularly compound disposal) and grave markings are important topics in the literature linked to collective aspects of mortuary ritual. Traits associated with body and grave treatment contribute symbolic elements to the dataset as they usually concern the fate of the spirit; containing malevolent aspects and ensuring successful regeneration according to eschatological belief. This area is, however, somewhat under-represented and other symbolic material, such as the character of mourning ceremonies and special inquests, would have improved the overall breadth of the data.

As with initiation, assignment of traits to linguistic group used the *Austlang* database. Allocation from Meehan table reference to language is listed in Appendix 1b_Allocation. For example, reference 1 in Mee3 (Tree Disposal) was listed as Manning River, NSW and allocated to the nearest language *Katthang*. In cases of conflicting information the majority trait was counted. Thus, if it was recorded in 50% or greater of references allocated to the same language, it was counted as present. Whilst this approach reduces the amount of analysable data, it does ensure focus on the most prevalent mortuary traditions in a given location. All groups with at least one trait recorded as present were included in the dataset giving a total of 136 societies (Appendix 1b_MortuaryData). Their distribution is illustrated in figure 1.3. There is good geographical coverage of Pama-Nyungan groups which is similar to initiation practices (figure 1.1) but includes additional representation from Western Australia.

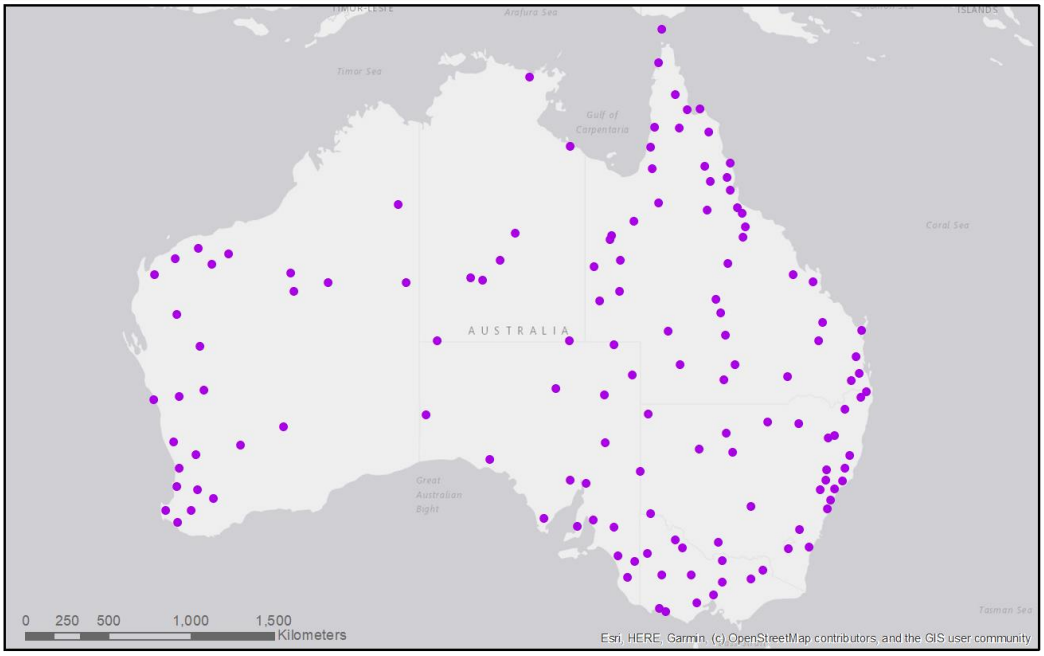


FIGURE 1.3 LOCATION OF 136 PAMA-NYUNGAN SOCIETIES WITH MORTUARY RITUAL DATA.

Mortuary ritual traits for chapter 4 analysis

Traits were derived from the dataset to meet the requirements of theories tested. For mortuary ritual, these were presence of compound or secondary disposal and presence of grave marking. These traits naturally lend themselves to binary categorisation enabling the same statistical approach to be employed as for initiation ritual, including the use of the Pagel discrete method to examine causality. For the independent variables, those hypothesised to lead to ritual change, the presence of patrimoieties was taken from *AustKin* (www.austkin.net) and the presence of partial sedentism from Binford (2001). Compound disposal data was taken directly from Meehan table 10 and the trait was present in 58 (out of 136) Pama-Nyungan societies (Appendix 1b_Allocation). Grave markings were defined using a composite category of traits associated with leaving a permanent or semi-permanent mark of the individual's resting place. 9 Meehan traits were linked to burial markings including carved trees, huts, posts, clearings *etc.* In addition, the presence of compound disposal was included as it suggests a longer-term maintenance of the dead's connection with the land (making 10 traits in all). To define the trait value, the same approach as initiation was used, with the data distribution inspected to determine category split points. This suggested 0 (absent) for groups with no markings (25 or 18% societies) and 1 (present) for those with 2 or more (53 or 39% of societies). Groups with only one type of marking were excluded (Appendix 1b_GraveMarkings).

Rock Motifs

General perspectives

Australia has many hundreds of sites containing rock paintings and engravings and they represent an important archive of Indigenous cultural history. Paintings involve the application of pigment, such as red and yellow ochres, to the rock surface. Engraving is done either by chipping away surface levels of rock or using a tool to incise markings. Although cave paintings and engravings can be ancient, such as those from Lascaux and Chauvet in France which maybe 30,000 years old, most Australian images were created more recently and can even be regarded as a contemporary practice in some areas. Layton (1992: 19) documented 40 reports of active rock painting and engraving between 1830 and 1986 across the continent. Paintings in a number of areas contain representation of Europeans and artefacts such as ships, horses and guns. The relatively recent age of many images means that something of their meaning and context has been

preserved, both through discussion with Indigenous people and comparison to ethnographic records. Although some images illustrate hunting success or the presence of certain species (*ibid*, 65) the vast majority are connected to religious belief in some way (Maynard 1975). They may be directly incorporated into rituals such as being re-painted during increase rites (Layton 1992: 47) or form part of ceremonial grounds (McBryde 1974). Images may also serve as religious iconography to illustrate legendary characters (Elkin 1949). New rock paintings were made to commemorate the *K.* mythical cycle that spread across the Northern Territories in contemporary times (Layton 1992: 128). Images often describe journeys dreamed and enacted by ancestors (*ibid*, 123). For the *Warlbiri*, the engraving of a python signifies a clan's totem but also illustrates the pattern of a long winding creek formed by this ancestral snake. In this way, the image serves to anchor the identity of individuals to both their ancestors and their country (Munn 1971). Images are often repeated in other media, such as body decorations, bark paintings and sand drawings, further enhancing these connections (Layton 1986). These media have provided the inspiration for many contemporary Indigenous artworks. Paintings and engravings made on rock surfaces may be sources of power in themselves, particularly where access is regulated and knowledge only passed to the initiated. They may also have a didactic role, encompassing both religious and secular aims. For example, depictions of journeys by Dreamtime beings may also indicate optimal walking tracks between water holes or foraging routes (Elkin 1934, Layton 1992: 72). Animal paintings can illustrate the abundance of species and the ways in which they should be killed and eaten (*ibid*, 74) but, when combined with particular infill patterns, take on a sacred role which also signifies clan membership and territorial allegiance. Images sometimes depict malevolent figures, such as the thin, animated *mimi* of west Arnhem Land, which are connected with spirits of the dead (*ibid*, 79). Some paintings, particularly hand stencils, may simply indicate presence at a site. These can provide a focal point for remembrance; when a person dies people visit their picture to mourn them (*ibid*, 75). The contextual information that facilitates interpretation of recent images is unavailable for older paintings, but supporting evidence also suggests they were often connected to religious belief. The absence of habitation debris at many older sites indicates they were more likely used for ritual purposes (*ibid*, 9). Ritual items, such as log coffins, head dresses and clap-sticks (used as musical accompaniment in ceremonies) feature in a number of older paintings (*ibid,* 59).

The strong, or even dominant, ritual component of Australian rock images suggests that analysis of their variation can represent a way of measuring ritual differences between societies. As these primarily relate to symbolic ritual elements, analysis provides a

complementary approach to the examination of initiation and mortuary ceremonies that are more focused towards ritual practice. A further complementary aspect is that rock images have a broader geographic distribution than ritual practices as their recording was not confined to areas that better survived the impact of colonial expansion. This advantage is tempered somewhat by differences in the availability of suitable surfaces. For example, fewer exposed rocky outcrops are present in low altitude areas and this generally leads to fewer images available for analysis.

Australian paintings and engravings tend to follow distinctive regional styles. For example, the rayed and mouthless heads of the *Wandjina* heroes in Kimberley (Crawford 1968), the delicate internal details of X-ray paintings in west Arnhem Land (Taçon 1989), the *Quinkan* trickster figures of Cape York (Layton 1992: 132) and the vibrant ochres and whites of concentric circles and parallel lines in the Western Desert (*ibid*, 1). Examples of images are included in figure 1.4. The geographically unified distribution of such identifiable styles points to their coherence as cultural traditions (*ibid*, 185). However, there are also similarities in content and form between the styles that are suggestive of a shared cultural history (*ibid*, 211) which are discussed below. These similarities can be modelled using phylogenetic analysis to examine whether they are indicative of possible historical relationships between regions. To date, there have been relatively few statistical analyses of Australian rock image variation, exceptions being Layton's analysis discussed below and a detailed study of Queensland images (Wade 2011). Outside of Australia, Lycett & Keyser (2017) analysed Blackfoot Indian rock art using statistical methods (principal component analysis) but the present study appears to be the first to use phylogenetic methods. Closest to this idea is probably the analysis of 'Clovis' projectile point variation to create parsimony trees of possible relatedness between Paleoindian societies (Buchanan & Collard 2007).

FIGURE 1.4 EXAMPLES OF DISTINCTIVE REGIONAL STYLES IN AUSTRALIAN CAVE PAINTINGS: WEST ARNHEM LAND, KIMBERLEY, CAPE YORK AND THE WESTERN DESERT.

Motifs as components of rock images

As discussed with ritual practices, phylogenetic methods can be applied to model history by breaking down the cultural artefact, in this case rock images, into relevant constituent components that demonstrate both continuity and variation across geographic space. Previous analyses of Australian rock images have identified motifs, or certain arrangements of shapes, which recur within stylistic regions that may signify the cultural group of the artist (Maynard 1977). The use of motifs as building blocks to assemble more complex meanings is supported by ethnographic analysis, in particular Munn's detailed accounts of *Warlbiri* imagery (1973). Researchers have also identified motifs that are similar between stylistic regions, which may be suggestive of a shared cultural history (Layton 1992: 211). These ideas have been the subject of a number of analyses attempting to isolate and classify recurring motifs. Generally, two modes of classification have been adopted (Clegg 1978). Some shapes, often termed figurative, appear to act as visual signifiers *e.g.* if a figure looks like a kangaroo it can be said to 'mean' kangaroo, and can be classified in such semantic terms. Other shapes appear to have symbolic rather than directly representational meanings which are either unknown or variable depending on the context. For example, the concentric circles used by the *Warlbiri* may signify either

camp sites or the tracks of totemic species (Munn 1973). These shapes are normally classified in formal terms *i.e.* according to the similarities and differences they have to other shapes. They are often termed geometric motifs and characterised by their simplicity of form, such as circles, arcs, dots and lines. Reference to ethnographic material suggests these two classifications reflect two different modes of representation: geometric motifs are 'birds-eye' views of marks left on the sand (such as by animals, humans or ancestral beings). Figurative motifs are representations of actual bodily forms (Layton 1992: 148). Whether motifs are classified in formal terms (and therefore geometric) or semantic terms (and therefore figurative) depends on the type of image and the contextual information available from Indigenous people and ethnographic reports.

Isolating and classifying motifs is a complex process; many images are ambiguous and difficult to interpret or obscured through weathering or overlaying with other designs. Much work has been undertaken to address these challenges, often focusing on specific designs. For figurative forms: the labelling of fish (Taçon 1988), macropods (kangaroos and wallabies) and birds (Officer 1984), animated human figures (Taylor 1987), snakes, reptiles and human-reptile figures (McBryde 1974) and mammals (McCarthy 1976). For geometric forms: the labelling of animal tracks (McDonald 1983), human footprints and arc designs (Tindale 1987), trident shapes (Clegg 1985) and circles, lines and dots (Forbes 1983, Nobbs 1984). Knowledge and familiarity are key to these interpretations *e.g.* the recognition of components of a footprint vs a series of shapes. Figurative motifs may incorporate different representational details and therefore hierarchical approaches that examine, for example, limb placement, presence of tail, width of torso *etc*. have been used by some authors to ensure consistency of classification (McCarthy 1976, Officer 1984).

Building on this body of research, Layton (1992) developed a core set of 38 motif archetypes, which tended to recur within and between regions, with the objective of quantitatively examining the coherence of previously identified stylistic traditions (*ibid*, 195). Layton's conclusions are discussed in chapter 2 and 3. Material was obtained from over 400 published and unpublished sources that featured photographs or line drawings of rock images (*ibid*, 249). Layton also made ten field trips to numerous sites over an eight year period (1974-1982) documenting their paintings and engravings. Altogether, data from 113 sites was recorded (in a few cases figurative and geometric images occurring at the same area were treated as separate sites). Development of the core motif set required a number of simplifications. Where specific forms were present *e.g.* particular

species of fish, reptile, bird, these were deemed present at only a generalised level. Items only rarely observed *e.g.* dingoes, bats, crocodiles, sharks, yams, bee's nests, were not reported separately but included within a catch-all category 'additional motifs' to give some extent of the (figurative) tradition at those sites. Motif definitions are set out in Layton's table 7.2 reproduced as figure 1.5 here. Examples of motifs are included in figure 1.6. Further details are provided in Layton's figures 6.1 to 6.3, 6.10, 7.1 and 7.2.

1	Dots and pits, incl. clusters & rows	20	Rake forms
2	Tridents and joined tridents	21	Stemmed circles
3	Kaluti (tree-like forms)	22	Parallel lines, including tally marks
4	Stars and radiating forms	23	Zig-zags and chevrons
5	Rectilinear mazes and grids	24*	Generalised human
6	Complete rings and enclosures	25*	Generalised bird
7	Arcs	26*	Animated human
8	Concentric arcs	27	Ladder forms
9	Bird footprints	28	Cross forms
10	Macropod footprints	29	Wishbone forms
11	Mammal footprints	30*	Generalised macropod
12	Undulating lines and snake forms	31*	Generalised fish
13*	Generalised mammal	32*	Ship
14	Human footprints	33*	Generalised turtle
15	Circles	34*	Moth or butterfly forms
16	Concentric circles	35	Barred rectangles
17	Barred circles and ovals	36	Cleland face (heart-shaped face-like form)
18	Curvilinear mazes	37*	Indeterminate lizard/human forms
19*	Generalised reptile	38*	Additional silhouette forms

*Defined as figurative forms; other forms are defined as geometric

FIGURE 1.5 MOTIF DESCRIPTIONS USED IN THE ROCK IMAGE DATASET (ADAPTED FROM LAYTON 1992).

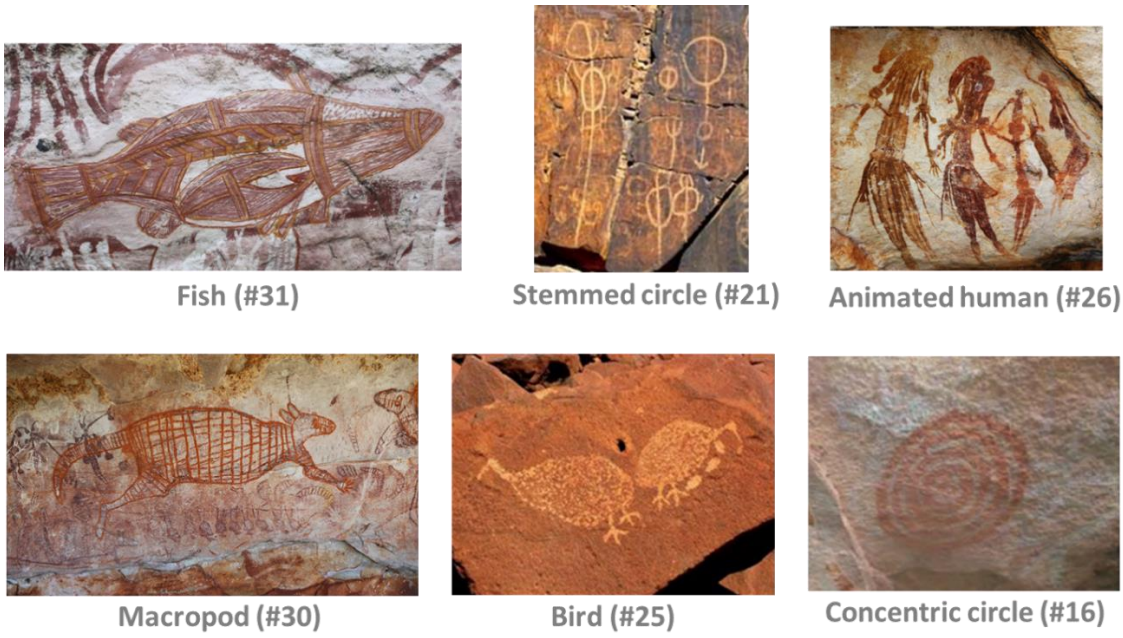


FIGURE 1.6 EXAMPLES OF MOTIFS RECORDED IN THE DATASET WITH REFERENCE NUMBERS USED.

Preparation of rock motif data for chapter 2 & 3 analyses

Layton's dataset of 38 motifs from 113 sites provides the material for these chapters. It also includes motif data from sites in northern Australia (Arnhem Land and Kimberly) that are outside the Pama-Nyungan language family; these are included in the historical modelling (chapter 2) but excluded in the comparison with linguistic history (chapter 3), since languages in these regions have not been incorporated into attested phylogenies. An important adjustment to Layton's dataset relates to dating of the material. Ritual traits collected to model initiation and mortuary history were collected over a similar and fairly recent timescale (1850-1910), however rock images were created at different times and this makes historical reconstruction more problematic. Paintings and engravings are difficult to date. Estimates based on adjacent archaeological deposits require the image to have been buried and paintings rarely survive this process (Layton 1992: 212). With engravings, there is no certainty they were made contemporaneously with adjacent material. However, radiocarbon techniques to obtain direct dates for rock images became available during the 1990s. These have become widely used although they rely on organic material being associated with the original image *e.g.* beeswax, charcoal or natural coatings such as wasp nests. Where such material is available, significant work has been, and is being, undertaken to establish dates for Australian rock images. Langley & Taçon (2010) reviewed 432 direct image dates obtained from 92 sites by a number of different researchers. 83% of images were dated after 6,000 BP and half of these were within the last 500 years. Whilst the availability of images is likely to be affected by taphonomic bias *i.e.* older images are less likely to have been preserved, the data does support the general idea that most Australian rock art is not of ancient origin. Older images are however present; the oldest direct date in their review was 29,700 BP from a painting at Walkunder Arch Cave, Queensland.

Ideally, I would like to use these image dates to calibrate Layton's dataset, however there are two problems with this. Firstly, dates are for single images rather than the collections of images from sites recorded by Layton. A relatively conservative approach has been adopted to address this: where a site is known to contain older images, all the data from that site has been removed. Since the study is comparing motif variation with language, a cut-off for site inclusion was set at 6,000 BP, which is the most recently estimated date for Pama-Nyungan linguistic expansion (Bouckaert *et al.* 2018). If language and motif change are linked, then images created after this date are likely to show evidence of this influence. This is still a simplification because within the 6,000 year period we may be comparing later language change with earlier motifs (and *vice versa*) however, to date,

insufficient dating information is available to undertake a more fine-grained analysis. The second problem is that the two groups of sites do not always overlap. Here, no adjustments are possible and older images may inadvertently be included if no dates are available for the site. This needs to be borne in mind when interpreting results. However, this is not expected to be a very significant problem as, to date, relatively few images have been found to be older than 6,000 BP, and sites that are known to be old tend to receive more attention from researchers, therefore images within them may have already been dated.

Using the Langley & Taçon data (obtained from P. Taçon), 4 sites were identified which contained more than 3 images greater than 6,000 BP. These corresponded to 6 different locations in the Layton analysis (#1, #23, #90, #91, #108, #109) and these were deleted from the image dataset (see figure 1.7). As most sites contained a range of dated images, the >3 cut-off was used so that the presence of isolated older images would not require site deletion when the majority were more recent. Further deletions were made to Layton's original list of 113 sites for other reasons: six sites did not contain any core motifs (#44, #50, #54, #55, #56, #157), two could not be located with certainty (#36, #57), there was insufficient data from Tasmania therefore the only site referenced (#112) was excluded, and one site (#58 Bolgart) was removed because it had the same data as #52 Bolgart. Altogether, 16 sites were deleted giving an adjusted dataset of 97 sites. Their geographical distribution is illustrated on figure 1.8 (note, some sites overlap so may not have a unique identified position).

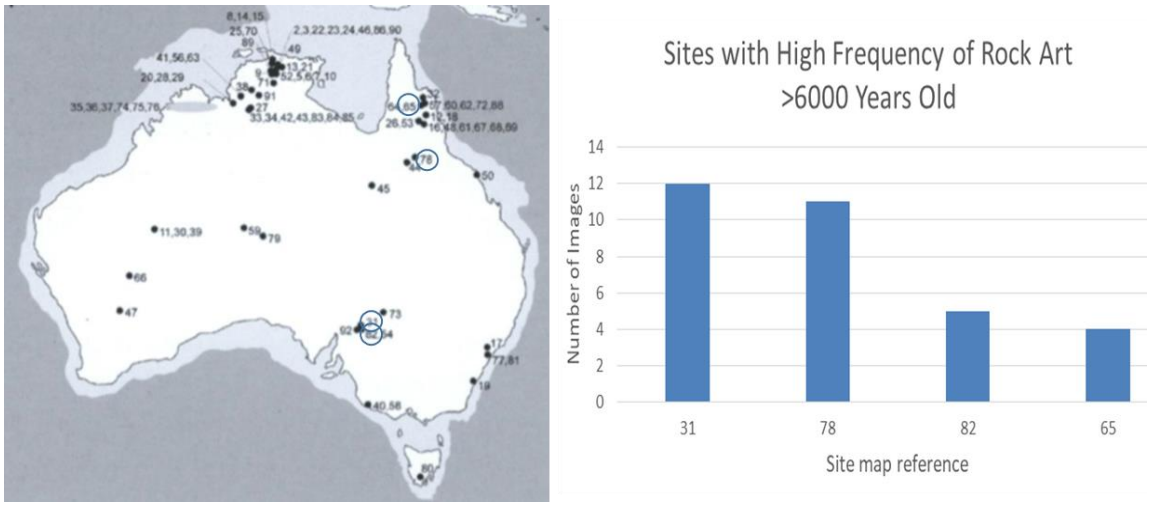


FIGURE 1.7 MAP INDICATING 92 SITES WITH DATED IMAGES FROM LANGLEY & TAÇON (2010). FOUR CIRCLED SITES (31, 78, 82 & 65) HAD HIGH FREQUENCY (>3) OF OLDER-DATED IMAGES (> 6,000 BP). THESE CORRESPONDED TO 6 SITES IN THE LAYTON ANALYSIS (1, 23, 90, 91, 108 & 109) WHICH WERE DELETED FROM THE DATASET.

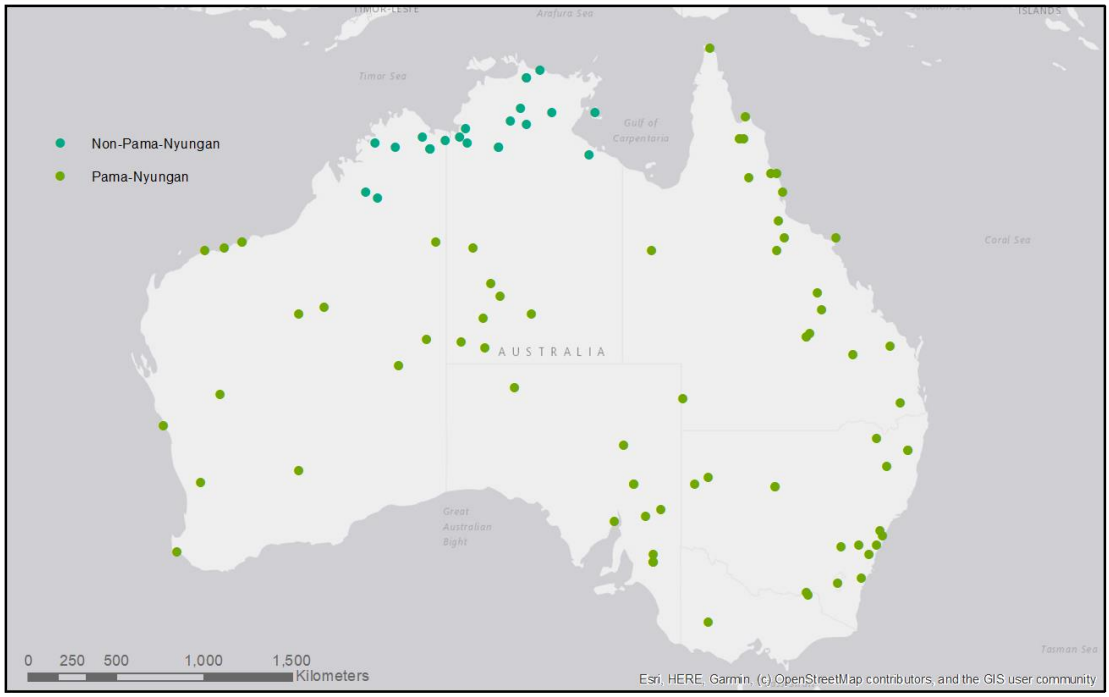


FIGURE 1.8 LOCATIONS OF 97 SITES (BOTH PAMA-NYUNGAN AND NON-PAMA-NYUNGAN) INCLUDED IN THE ROCK MOTIF DATASET.

To prepare this data for phylogenetic analysis, the locations of each site were established and matched to the closest language using *Austlang.* 74 sites matched to Pama-Nyungan languages and 23 to Non-Pama-Nyungan languages in Arnhem Land and Kimberley, see Appendix 1c_Allocation. Some neighbouring Pama-Nyungan sites had the same language allocation and, as with mortuary practice, a majority rule was used to determine motif presence/absence. Thus, if it was recorded in 50% or greater of sites allocated to the same language it was counted as present. Whilst this approach reduces the amount of analysable data, it does ensure focus on the main stylistic traditions. The difficulty of motif allocation means that miss-classifications may be still present in the data and, despite the removal of older-dated sites, some images outside the Pama-Nyungan timeframe may also remain. By using a majority rule, the occasional motif presence is de-emphasised if it does not occur widely across the language area. Combining sites with the same language resulted in a final dataset of 38 motifs across 49 Pama-Nyungan languages and the 2 Non-Pama-Nyungan regions, see Appendix 1c_RockMotifData. These data are used in the chapter 2 & 3 analyses. Chapter 4 is not relevant for rock images as there are currently no testable theories linking the use of particular motifs to ecological or sociological variables. There are, however, theories that link the development of

geometric motifs to Pama-Nyungan language expansion which are considered in chapter 3.

Conclusion

This chapter has detailed the methodology for creating an Australian ritual dataset utilising a large range of ethnographic material on initiation ritual, mortuary practices and rock motifs. This has been condensed into a form suitable for quantitative analysis by defining it in terms of traits that demonstrate breadth and variability across the continent, and allocating these to the most closely affiliated Pama-Nyungan language. The three datasets are analysed in the forthcoming chapters, applying statistical methods to examine the processes, and societal and ecological influences, shaping the diversity in ritual practices visible today.

Chapter 2: Modelling ritual history

Following development of an appropriate dataset, the next three chapters focus on its analysis. The approach begins broadly, examining, in this chapter, ritual diversity as a whole, followed by higher resolution analyses of individual traits in chapter 3, and comparison with ecological and sociological influences in chapter 4. In this way, the aim is to build up a picture of the different processes involved in the evolution of Pama-Nyungan ritual.

In the present chapter, phylogenetic methods are used to model the history of initiation, mortuary ritual and rock motifs. The objective is to determine whether such reconstruction is feasible and, if so, how their phylogenies compare. Comparison is also made to the language phylogeny to consider whether ritual could have been associated with Pama-Nyungan expansion. Finally, physical pathways of ritual change are modelled to examine their feasibility in the Australian context.

Cross-cultural studies of ritual indicate many similarities between societies, for example, the frequent use of rites for life transitions such as adulthood (Schlegal & Barry 1979) and death (Robben 2018), which suggest they may have a common purpose or origin. However, the large variation in symbolism, ceremony and participation between these rites, indicates other forces are also at work. As discussed in chapter 1, Australian ritual can also be characterised in this way. There are similarities *e.g.* initiation ordeals, but also many differences *e.g.* ceremony and body decoration. This combination of features, a common core with peripheral variations, suggest some type of evolutionary or 'descent with modification' process may be involved in ritual change. This inference leads to the proposed use of phylogenetic techniques for exploring models of ritual history. These methods assume that similarities between entities reflect their common inheritance, examining these to infer what their evolutionary history may have been. They were originally developed in biology to understand the evolution of species, and have more recently been applied to the study of cultural change (Mesoudi *et al.* 2004, Currie 2013, Gray & Watts 2017). Cultural traditions share some of the evolutionary features of species; they develop gradually over time with new elements being added or lost as they pass through generations. Consequently, phylogenetic methods have been productively applied to examining cultural histories such as language (Gray *et al.* 2009, Bouckaert *et al.* 2012, Currie *et al.* 2013), manuscripts (Barbrook *et al.* 1998), folk tales (Tehrani 2013) and

material objects (Tehrani & Collard 2002, Buchanan & Collard 2008, Jordan & Shennan 2009).

Why might ritual also be a suitable candidate for phylogenetic analysis? Rituals can be considered as integrated systems of traits (relating to symbols, ceremony and meaning) that only make sense together *e.g.* as part of a system of belief. In this way, they could be similar to languages, which are integrated systems of words, grammar and meaning whose elements only make sense as part of that system. Grammatically-specific words are a good example and this quality of specificity may make them particularly resistant to borrowing. Likewise, ritual traits concerned with symbolism may be highly specified to the cultural tradition and resistant to transmission between neighbours. However, some ritual traits could be subject to relatively high levels of borrowing. For example, people may seek ways of improving representations of complex meanings and beliefs by copying novel ideas from neighbours. These effects may impact some traits more than others. If particular traits are a core part of the tradition, they may be fairly resistant to change over time, whereas others may be more peripheral and subject to faster rates of mixing. Furthermore, societies may independently develop similar ritual traits to meet similar needs, especially if available materials and environments are also comparable. For example, body painting styles, corpse disposal methods and some rock motifs could fall into this category.

The integrated nature of ritual and its specificity to the cultural traditions of a society suggests that, like language, there are good reasons to believe that the observed patterns of similarity and variation between Australian ritual traditions reflect the action of a 'descent with modification' process. Here, phylogenetic techniques are used to explore how well ritual data fit this type of evolutionary model. It is unlikely, however, that such vertical transmission will have been the only driver or ritual change and horizontal transmission between neighbours, and possibly independent evolution, will almost certainly have been involved.

New ritual traditions could be acquired through imposition by dominant groups or assimilation with those considered more prestigious (Boyd *et al.* 2005: 321). Particular traits might be borrowed because they are novel or beneficial in some way. Repeated contact between groups, due to inter-marriage or exchange networks for example, may lead to a general drift towards ritual similarity, due to the need to co-ordinate practices or perhaps because of conformist bias (Boyd & Richerson 1985, Mesoudi *et al.* 2004). Whilst it is still possible to reconstruct robust cultural phylogenies in the presence of such horizontal transmission (Nunn *et al.* 2010, Greenhill *et al.* 2009), the degree to which this

is successful is likely to be highly dependent on the extent to which ritual forms have resisted such transmission. The effect of isolating mechanisms on cultural acquisition (and loss) has been considered by a number of authors including Durham (1992), Boyd *et al.* (2005) and Tehrani & Collard (2013). As discussed in the Introduction, Boyd *et al.* (2005) hypothesised that cultures, broadly defined as systems of socially transmitted information, could be classified into one of four types depending on the extent to which inheritance and mixing contributed to their evolution. They grouped these along a continuum of decreasing levels of phylogenetic stability:

1. All the elements that make up a culture cohere and resist recombination, therefore phylogenies are relatively easy to infer.

2. A conservative 'core tradition' in each culture is identifiable that is rarely affected by diffusion from other groups. However, peripheral elements may be heavily subject to cross-cultural borrowing. Phylogenetic reconstruction requires distinguishing between core and peripheral traits.

3. Cultures are best represented as packages of smaller elements. Each package is relatively unaffected by recombination but has its own history of inheritance. Reconstruction requires the identification of stable cultural domains and their separate phylogenies.

4. There are no observable entities of culture that are sufficiently coherent, or stable over time, for phylogenetic reconstruction to be useful.

Their classification provides a useful framework for structuring this analysis. It suggests a way to categorise each of the three ritual forms and to compare them. It also provides a way to think about the traits themselves; whether certain packages of traits might have their own histories or whether they might be core or peripheral to a cultural tradition. Here, 'peripheral' denotes traits heavily subject to cross-cultural influence, rather than suggesting unimportance. Such traits could be quite labile, easily incorporated in and out of ritual practice, or quite beneficial, readily transmitted to many societies because of their novel or innovative qualities (Rogers 2010 [1962]). Decorative items such as pearl shells were incorporated into the ritual practices of many Australian societies, including those thousands of kilometres from the shells' origin (Akerman & Stanton 1994). As with mythical narratives (discussed later) such diffusion may have happened quite recently (Haynie *et al.* 2014). In this analysis, ritual traits associated with ceremonial activity, such as body decoration and rock motifs, might be similarly affected by high diffusion levels. This topic is returned to in Chapter 3.

In the following analysis, phylogenetic methods are used to examine which Boyd *et al.* categories best characterise Australian rituals. If reconstruction is not possible the ritual may be type 4 (no coherence). If they have different reconstructed phylogenies they may be type 3 (separate histories). If some rituals vary together, or with language, then type 2 (core traditions) may be the best description. If all types vary together, and this variation is also aligned to language, then type 1 (full coherence) might the best characterisation of ritual, and potentially, Pama-Nyungan culture as a whole.

Two methods are used for phylogenetic analysis: *Neighbour Net* (Bryant & Moulton 2004) and Bayesian phylogenetic inference using the program *Mr Bayes v3.2* (Huelsenbeck & Ronquist 2001, Ronquist *et al.* 2012). Both methods assume that trait change has been driven by the branching process we would expect if ritual traditions have developed along an evolutionary or 'descent with modification' pathway. But, importantly, both methods can also accommodate the conflicting signals in relationships expected in these datasets. They can be used to create phylogenetic networks, as opposed to single bifurcating trees, which represent the range of possible relationships graphically, highlighting areas where reconstructed history is uncertain and other influences may have played a role (Huson & Bryant 2006). The two methods use different analytical approaches and are discussed in more detail later. Briefly, *Neighbour Net* assumes that distances between taxa, measured as similarities in character or trait presence, are representative of their relationship to each other and uses a clustering algorithm to group taxa together based on these distances. Bayesian approaches such as *Mr Bayes* use the character dataset directly, estimating the likelihood that a given phylogeny and model of evolution would produce the distribution of character or trait data. A powerful search algorithm is applied to find those trees with the highest likelihoods and a sample of these can be used to create a consensus network and single consensus tree. The use of two different phylogenetic approaches (*Neighbour Net* and Bayesian) provides more confidence in the relationships inferred from ritual variation and any conclusions drawn. Both methods generate summary statistics of phylogenetic fit that can be compared between ritual types and with other cultural datasets. Both networks can also be analysed using the same software platform *SplitsTree 4* (Huson & Bryant 2006) facilitating easier comparison between them.

The trees produced in the Bayesian analysis are used to examine a further aspect of ritual change; its geographic pathway across the Australian continent. The aim is two-fold, firstly to assess whether the proposed phylogenies represent feasible routes of cultural transmission and, secondly, to provide an additional way of examining correspondence between ritual forms and the Pama-Nyungan language expansion. Bouckaert *et al.* (2018)

recently completed an analysis of this expansion that enables us to compare physical pathways of change. The Bayesian inference model *Geo*, in *Bayes Traits v3* (Pagel & Meade 2006), is used for this analysis. A posterior distribution of ancestral node co-ordinates is derived for the phylogeny by modelling location as a continuous variable evolving through time along its branches. Similar approaches have been used to investigate the dispersal of pathogens (Lemey *et al.* 2009 & 2010, Bello *et al.* 2012), plants (Pirie *et al.* 2012) and insects (Sklenarova *et al.* 2013). They have also been used to examine linguistic expansions such as Arawak (Walker & Ribeiro 2011), Indo-European (Bouckaert *et al.* 2012) and Bantu (Currie *et al.* 2013), as well as Pama-Nyungan.

Data Preparation

A number of ethnographers have noted the transmission of ritual elements between neighbouring Australian societies during the colonial era (Layton 2003: 282). Gray (1978) observed that *Wadjari* speakers, dispossessed from the interior by Europeans, introduced circumcision and associated mythology to Carnavon, a coastal town 150km to the east. Rituals were adopted by existing Indigenous Australian residents, enhancing their community identity and solidarity in opposition to European settlement. Elkin (1952) noted influences from both north-eastern and southern mythology in the cave paintings at Beswick Creek in the Northern Territory. The latter related to the *K.* myth cycle[1] (associated with fertility) which diffused widely into the upper northern half of the Northern Territory (Berndt 1951a). This may also have been linked to European expansion; Berndt (1951b) compares it to a 'psychic wave revitalising the postulants'. Myth may become disconnected from ritual practices. The northward movement of *K.* mythology was not always accompanied by sub-incision, which it was associated with in the centre (Berndt & Berndt 1996: 169). Elkin (1961: 202, quoting Robertson Smith (1927: 18)) compared myth variability to ritual stability in his discussion of the *Y.* cycle. Similarly, Meggitt (1966: 197) noted the *G.* myth cycle adopted by the *Warlbiri,* which originated in the north-west, was not linked to their adoption of sub-incision which featured in pre-existing narratives. Thus, ethnography suggest a dynamic exchange of mythical elements, but perhaps a greater stability to the rites themselves. The severe dislocation caused by European expansion seems to have increased ritual transmission between neighbours in the Northern Territory areas featured in these ethnographies, and this may well have happened elsewhere across the continent. Whilst it represents a unique event, and one catastrophic for the Indigenous Australian people, it seems likely that more benign

[1] Mythical cycle names are abbreviated in the text and bibliography due to their secret-sacred nature.

influences, including exchange networks, marriage patterns, changing environments and internal conflict, could all have stimulated ritual diffusion in the past.

The likelihood that ritual elements (particularly those associated with mythical narratives) have been transmitted between neighbours suggests individual ethnolinguistic groups may not possess a sufficient number of traits resistant to diffusion (or other influences) for phylogenetic reconstruction to be feasible; particularly over the long timeframe of Pama-Nyungan language expansion. To address this, analysis has been undertaken at the higher entity level of language area. Whilst this approach flattens some of the variation in the dataset, reconstructing history at this level removes the effects of diffusion between close neighbours. In addition, preparation of the dataset indicated significant ritual differences between language areas, suggesting that, whilst borrowing across language area borders might still occur, this may be less frequent. For example, in South Australia, the *Kaurna* (from the *Yura* language area (defined later in figure 2.1)) practice scarification and circumcision, whereas their direct neighbours the *Ngaiawang* (from the *KulinNganyeric* area) have no permanent markings, and practice only hair removal as part of their initiation rites (see Appendix 1a_CostlyRites). As discussed later in this chapter, *YuinKuricWiradhuric* figurative rock motifs are distinct from the more geometric styles of neighbouring areas (*BandjaDuraWaka* and *KulinNganyeric*). These distinctions suggest there may be higher barriers to ritual transmission between language areas, perhaps because novel elements are less easy to incorporate when there are large differences in ritual traditions.

There are two further advantages to using language areas rather than individual linguistic groups. Firstly, as discussed in chapter 1, inconsistencies in ethnographic reporting may have resulted in missing ritual data for language groups. A trait may have been present but not recorded, either because it was not observed or perhaps deemed uninteresting. Whilst efforts have been made to reduce the impact of this, such as only selecting traits if they tended to be regularly recorded by different authors and excluding societies with very low numbers of attributes, inevitably some inconsistencies may remain. Using wider language areas, together with a majority rule for recording trait presence (see below), ameliorates the problem of using individual linguistic groups that may have been impacted by missing data.

Secondly, language areas can be more closely matched to the ritual dataset in numerical terms. Whilst there is no 'magic number' of taxa and characters that ensures the accuracy of a phylogeny (Heath *et al.* 2008) the number of ritual traits is relatively low for deriving a phylogenetic history. The number of individual societies is also high relative to this small

dataset. If these were used as the taxa the resulting character/taxon ratio would be unusually low (around 0.2), which would make phylogenetic reconstruction challenging because of the large number of possible tree topologies that might fit the dataset. In an analysis of 235 morphological character-derived phylogenies, Scotland *et al.* (2003), found an average of 2.4 characters per taxon. Here, limiting the taxa to language areas brings the character/taxon ratio up to between 1.7 and 2.5 (table 2.1), which is more in line with existing phylogenetic datasets.

Three criteria were applied to define the language areas. Firstly, that societies within the area were monophyletic in the language tree *i.e*. they shared a common ancestor. Secondly, that the number of societies within each was reasonably well balanced. Thirdly, that there were similar numbers of language areas for each ritual type, in order to simplify comparisons between them. Taking account of these criteria, 15 language areas were defined using the Pama-Nyungan consensus phylogeny (Bouckaert *et al.* 2018, supplementary information), see figure 2.1 (phylogeny) and figure 2.2 (map of language areas). These defined clades were well attested in the language phylogeny; 14 nodes had >90% posterior support and only was below this (*KalkaMayabic,* 58%). Most groups had 5-15 societies per area, with only 3 out of 15 groups having less than 3 societies. A summary of the language area data used for the analysis is shown in table 2.1.

	#societies	**#language area/region**	**#societies per area/region**	**#traits**	**#adjusted traits**	**Ratio: trait/area**
Initiation ritual	109	13	8.4	27	25	1.9
Mortuary ritual	136	14	9.7	24	24	1.7
Rock motifs	97	11*	8.8	38	27	2.5

*includes two non-Pama-Nyungan regions: Kimberley and Arnhem Land

TABLE 2.1 SUMMARY OF LANGUAGE AREA DATA.

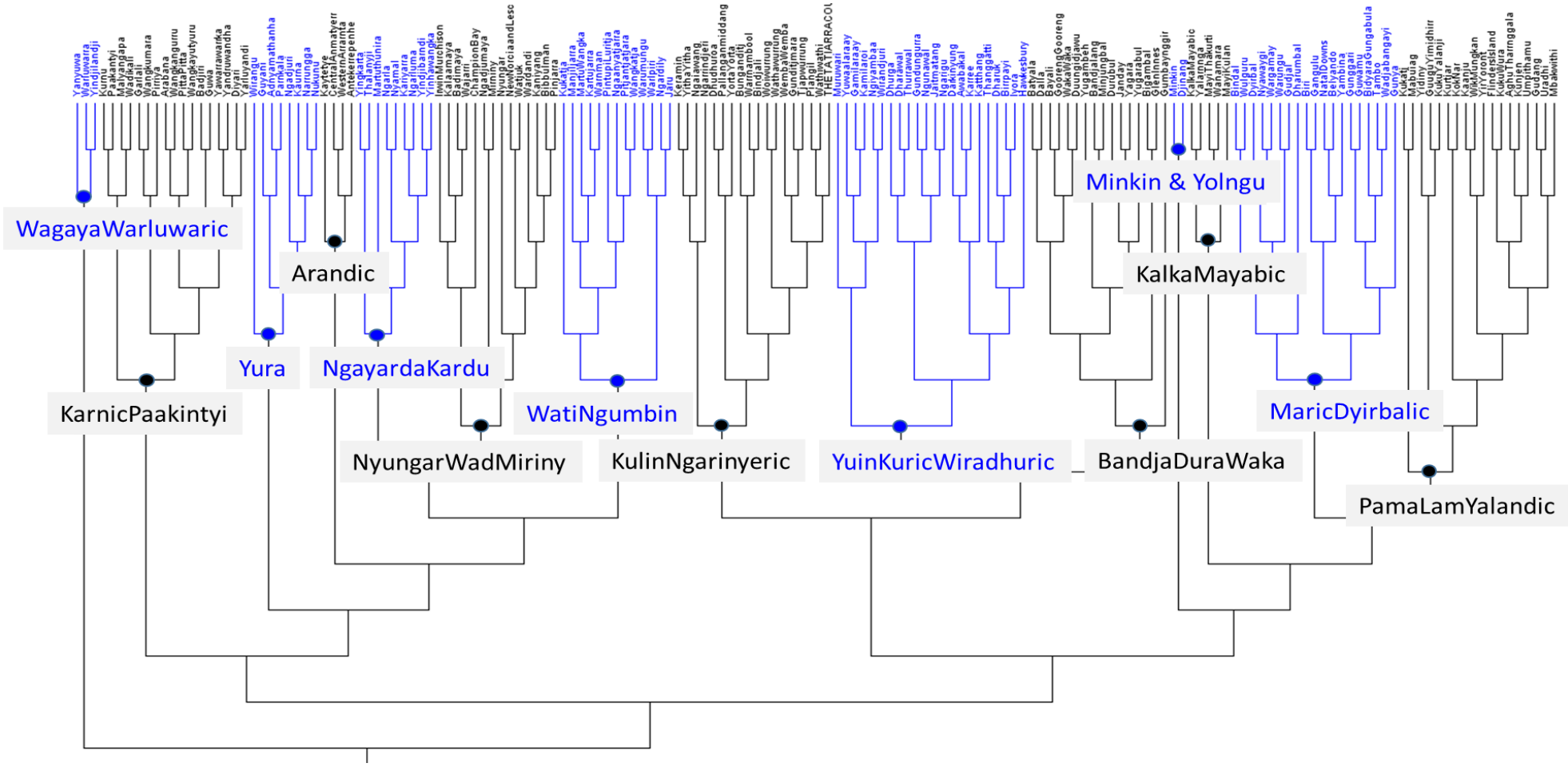


FIGURE 2.1 FIFTEEN LANGUAGE AREAS DEFINED BY SUB-DIVIDING THE PAMA-NYUNGAN PHYLOGENY INTO MONOPHYLETIC GROUPS (THOSE SHARING A COMMON ANCESTOR).

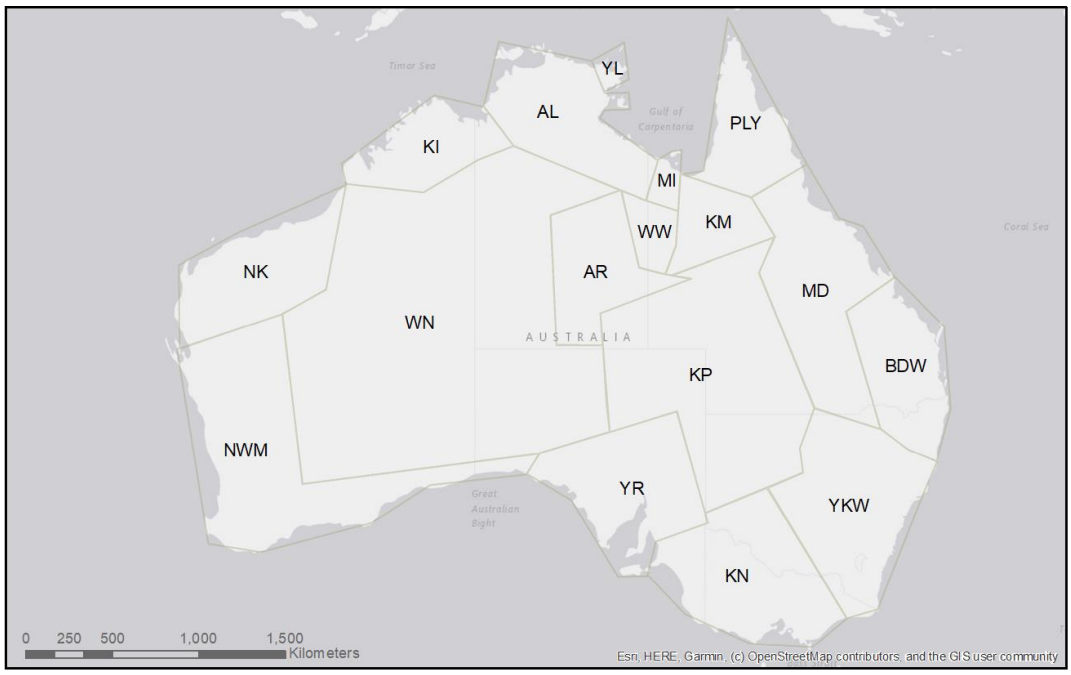


FIGURE 2.2 LOCATIONS OF FIFTEEN PAMA-NYUNGAN LANGUAGE AREAS DEFINED IN FIGURE 2.1: YL (YOLNGU), MI (MINKIN), PLY (PAMALAMYALANDIC), MD (MARICDYIRBALIC), BDW (BANDJADURAWAKA), YKW (YUINKURICWIRADHURIC), KN (KULINNGARINYERIC), YR (YURA), WN (WATINGUMBIN), NWM (NYUNGARWADMIRINY), NK (NGAYARDAKARDU), AR (ARANDIC), KP (KARNICPAAKINTYI), WW (WAGAYAWARLUWARIC), KM (KALKAMAYABIC). LOCATIONS OF TWO NON-PAMA-NYUNGAN REGIONS ARE ALSO SHOWN: KI (KIMBERLEY) AND AL (ARNHEM LAND).

To focus on the dominant ritual traditions practiced in each language area, traits that were recorded in 50% or more of the societies for each taxon were coded as present, while traits that were rare or unknown were coded as absent. For mortuary ritual, the data is thinly spread across a wide number of societies, therefore trait presence would have been very low using the majority rule. In this case, traits were recorded if they were present in any of the societies within the language area. For comparison, the average number of mortuary traits per society in the primary dataset was 4.2, versus 12.8 for initiation and 9.6 for rock motifs. Final trait numbers for the three analyses are noted in the #adjusted traits column in table 2.1. The dataset used for each ritual type is included in Appendix 2_RegionalData.

Method 1 – *Neighbour Net*

Neighbour Net (Bryant & Moulton 2004) assumes that distances between taxa, measured as similarities in character or trait presence, are representative of their relationship to each other and uses a clustering algorithm to group taxa together based on these distances. As *Neighbour Net* does not assume a strictly branching model of descent, groups of compatible taxa are able to overlap and intersect with each other which is

advantageous for capturing information on conflict (Huson & Bryant 2006). *Neighbour Net*, in common with other distance-based methods, summarises character variation in the form of a pairwise distance matrix. Although some information is lost in this process, simulation studies suggest the matrix preserves the majority of phylogenetically useful data (Bryant 2003) and produces accurate phylogenies (Roch 2010). *Neighbour Net* has been productively applied to phylogenetic analysis of conflicting signals in both biological and cultural systems (Morrison 2005, Hamed 2005, Kennedy *et al.* 2005, Gray *et al.* 2010, Walker & Ribeiro 2011, Chen *et al.* 2013 and Tehrani 2013).

The *Neighbour Net* (NN) algorithm is based on neighbour-joining (NJ) (Saitou & Nei 1987), arguably the most widely used distance-based method for inferring single bifurcating trees (Bryant & Moulton 2004). NJ starts with one node for each taxon and at each iteration the closest pair of nodes are selected and replaced by a new composite node. The matrix of pairwise distances is recalculated with this new node and the process repeated. When only two or three nodes remain, the amalgamation is reversed to create a tree hierarchy. The NJ algorithm resolves conflicts by only selecting one node per position and therefore produces a single bifurcating tree. In NN the objective is to retain and visualise these conflicts and to do this the algorithm works slightly differently. When a node pair is selected it is not combined and replaced immediately. Instead, the algorithm waits until the nodes are paired a second time, then the three linked nodes are replaced with two nodes and the distance matrix is recalculated. As the algorithm progresses, some node pairs will have been identified as neighbours but not amalgamated and this simple change generates a collection of splits instead of a single tree. Each split corresponds to a collection of parallel edges, all with the same length, and removing them divides the network into two connected groups of taxa. When these splits are incompatible with each other the network becomes reticulate or box-like. More boxed areas indicate more conflict in the dataset as to how taxa should be grouped together. Lines, or edges, between the taxa represent the distance between them computed using a variant of the least squares formula also used for NJ. Although there is no temporal component (since no evolutionary model is employed), the edge lengths are indicative of the amount of trait change between associated taxa.

Splits graphs do not provide an explicit history of reticulations (Strimmer *et al.* 2001) but by identifying areas of conflicting signal they can help identify taxa requiring closer examination. Network regions that are more box-like may indicate, for example, greater levels of horizontal transmission. To provide a numerical measure of conflict a delta value can be calculated from the distance matrix for each taxa and for the dataset as a whole

(Holland *et al.* 2002, Gray *et al.* 2010). The measure quantifies how far the distance matrix is from being additive in which case it could be perfectly represented by a bifurcating tree. Subsets of four taxa (quartets) from the matrix are scored based on the differences in distance between pairs of taxa within the quartet. A value of 0 indicates the distance data is additive and therefore the quartet is perfectly treelike. Progressively higher values up to 1 indicate it is less so. The delta value for each taxa is the average of all quartets that contain it, and for the dataset is the average of all taxa. Q values can also be calculated from the distance matrix that use a slightly different calculation method to measure departure from a strict tree (Gray *et al.* 2010).

Two caveats need to be borne in mind when interpreting delta and Q values. Firstly, no methodology is currently available for calculating their statistical significance (Gray *et al.* 2010). Secondly, in simulation studies, delta values were found to vary depending on tree topology (Holland *et al.* 2002). In balanced trees, values were similar across taxa because their tree positions are similar relative to each other. In unbalanced trees, delta values were higher for taxa at the end of long branches and in the middle of trees (because of their inclusion in more quartets). Tree topology is also sensitive to missing data (affecting the way the tree is pruned) which in turn can affect delta values. Since the calculation method is similar, Q values are likely to be affected by tree topology in a similar way. Because of these issues, it is not easy to set threshold values over which datasets might be deemed treelike. For comparison, a delta score of 0.30 was obtained for a dataset of variants of the folktale Little Red Riding Hood and supporting analysis suggested the data was relatively treelike (Tehrani 2013). Using similar sized language datasets, Gray *et al.* (2010) obtained a delta score of 0.33 for Austronesian languages and 0.21 for Indo-European and they suggest higher rates of borrowing between Austronesian languages led to greater conflicting signal. Here, we are also using similar sized datasets (for each ritual) therefore delta and Q scores are expected to provide useful *relative* information on tree likeness and, potentially, particular taxa that might be associated with conflict.

Results – *Neighbour Net*

The three ritual networks were generated using *Neighbour Net v4.14* in *SplitsTree 4*[2] (Huson & Bryant 2006) and are shown in figure 2.3. Areas that are more boxed or reticulate indicate more conflict in the dataset as to how taxa should be grouped. Visually, all three datasets show a fair degree of conflict, mortuary ritual has the most and rock motifs the least, but all also have some tree-like branching structure. The three networks show some alignment to the geographic locations of language areas (figure 2.2), with a number of near-neighbour pairings indicating close ritual similarities that might be expected based on their proximity. In comparison, randomised data would arrange groups equidistantly from each other in no particular order.

For all three forms, there is some indication of a division between two sets of groups (the dashed lines in figure 2.3) that suggests a divergence in their ritual traditions. The patterns of division are however quite different. Initiation has an east/west orientation, mortuary ritual is north/south and rock motifs are north & east/south & west. The rock motif network has the least conflict between regions, but there is a clear geographic outlier with YKW, a south-east region, clustered with groups located in the north of the continent.

[2] Datatype set as *standard* (morphological data), distance method as *uncorrected_P* (P=proportion of positions at which two taxon sequences differ), distance transformation as *ordinary least squares*, and drawing algorithm as *equal angle*. These are also the default settings for constructing networks in *Neighbour Net.*

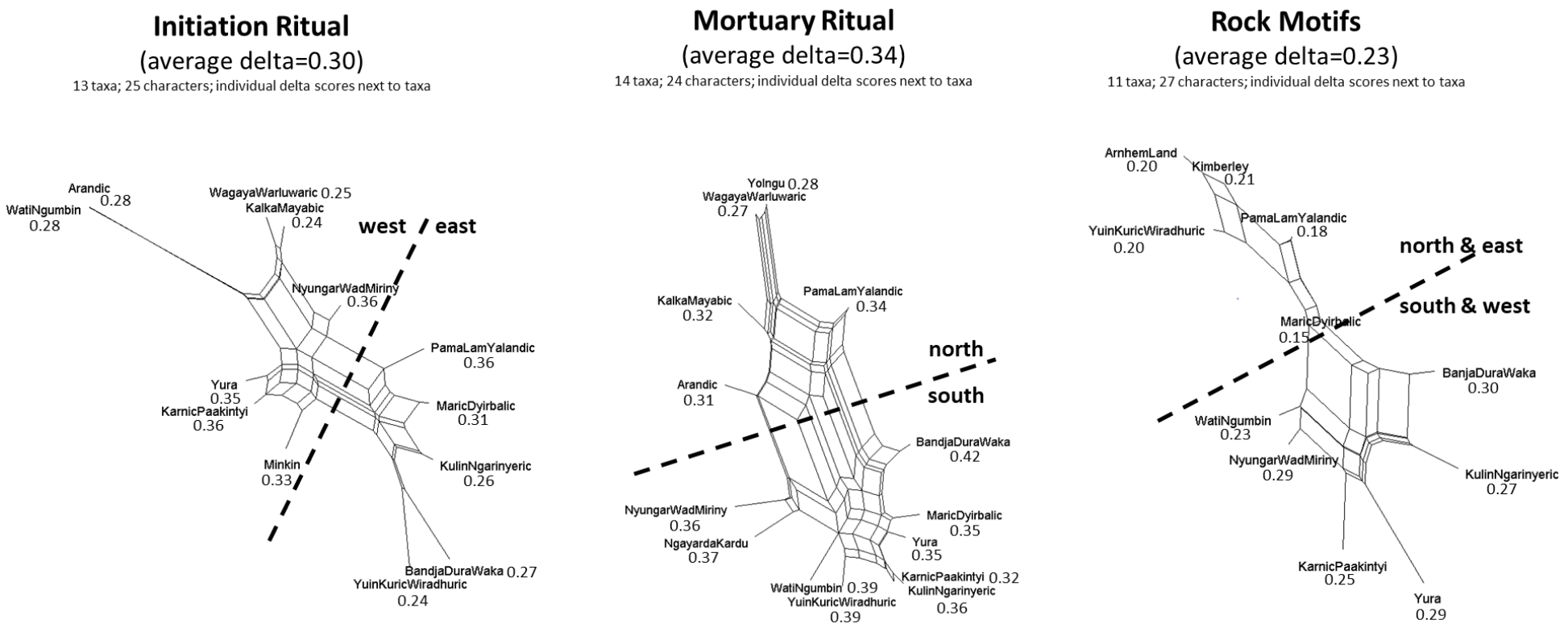


FIGURE 2.3 NEIGHBOUR NET GRAPHS AND DELTA VALUES (AVERAGE AND BY TAXA) FOR INITIATION, MORTUARY RITUAL AND ROCK MOTIFS. ALL THREE NETWORKS SHOW SOME ALIGNMENT TO THE GEOGRAPHIC LOCATIONS OF LANGUAGE AREAS (FIGURE 2.2), WITH A NUMBER OF NEAR-NEIGHBOUR PAIRINGS INDICATING CLOSE RITUAL SIMILARITIES THAT MIGHT BE EXPECTED BASED ON THEIR PROXIMITY. FOR ALL THREE FORMS, THERE IS SOME INDICATION OF A DIVISION BETWEEN TWO GROUPS (REPRESENTED BY THE DASHED LINES) THAT SUGGESTS DIVERGENT RITUAL TRADITIONS. THE ROCK MOTIF DELTA VALUE OF 0.23 INDICATES THIS DATASET HAS THE LEAST CONFLICT AND IS THEREFORE MOST TREE-LIKE. VALUES FOR INITIATION (0.30) AND MORTUARY (0.34) ARE HIGHER, INDICATING LESS PHYLOGENETIC STRUCTURE IS PRESENT.

Examination of delta scores largely confirms these visual observations. The rock motif value of 0.23 suggests it has the least conflict and is therefore the most tree-like. Values for initiation (0.30) and mortuary (0.34) are higher, indicating less phylogenetic structure is present. Figures are within the range reported by Tehrani 2013 (0.30) and Gray *et al.* 2010 (0.21 & 0.33) for folktale and language datasets respectively. Q values had similar trends; mortuary ritual was the highest (least tree-like) at 0.10, with initiation and rock motifs both lower at 0.06. Delta and Q values for the nine taxa shared by each of the ritual datasets are represented graphically in figure 2.4. Individual values tend to reflect the average delta scores for each of the datasets. No consistently high delta or Q values are identifiable suggesting no particular taxa are associated with higher levels of conflict.

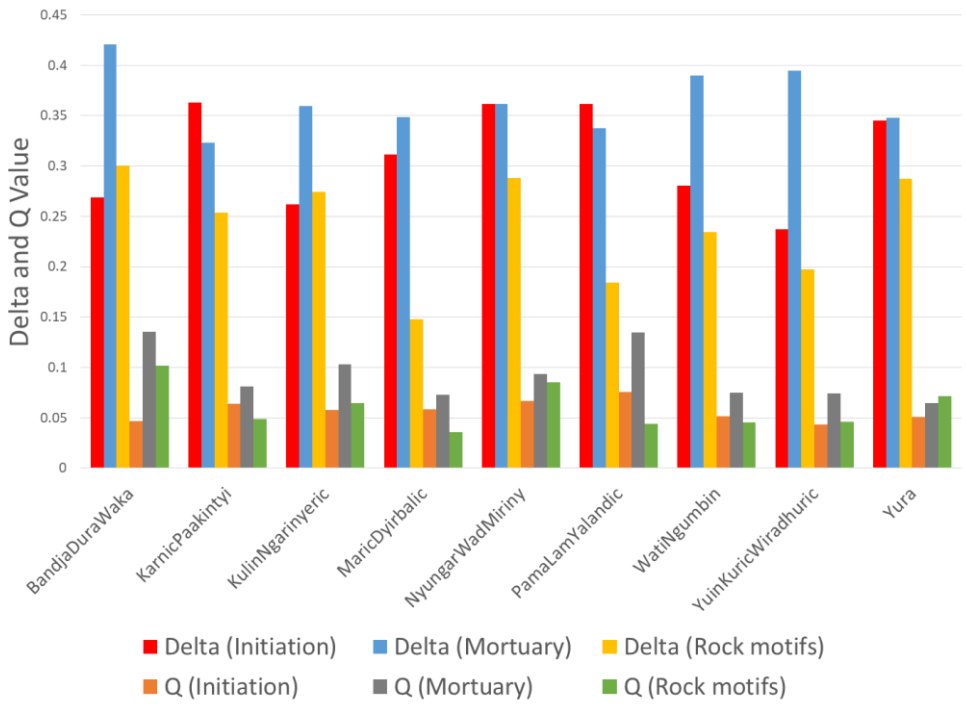


FIGURE 2.4 COMPARISON OF DELTA AND Q RESIDUAL VALUES FOR EACH TAXA BY RITUAL TYPE. DASHED LINES REPRESENT AVERAGE DELTA VALUES (SEE ALSO FIGURE 2.3). NO CONSISTENTLY HIGH DELTA OR Q VALUES WERE IDENTIFIABLE SUGGESTING NO PARTICULAR TAXA ARE ASSOCIATED WITH HIGHER LEVELS OF CONFLICT ACROSS THE DATASETS.

The network structure, delta and Q values suggest datasets for rock motifs and possibly initiation are relatively tree-like, but that much less phylogenetic structure is present for mortuary ritual. In Boyd *et al.* terms, ritual is not a coherent type 1 process as the different rituals do not have a similar phylogenetic structure. The phylogenetic results for rock motifs, and possibly initiation, suggest they are either type 2 (core/peripheral) or type 3 (separate phylogenies). The lack of phylogenetic structure for mortuary ritual suggests it is type 4 (no coherence).

Method 2 – Bayesian phylogenetic inference

Bayesian approaches use the character dataset directly to infer phylogenetic relationships rather deriving them from a distance matrix. A powerful search algorithm is used to find trees, and associated model parameters, with the highest likelihood of producing the distribution of character data according to the evolutionary model selected. The program *Mr Bayes V3.2* (Huelsenbeck & Ronquist 2001, Ronquist *et al.* 2012) was used for this analysis. Bayesian methods are very flexible; different evolutionary models can be used to infer phylogenies and their parameters estimated. They are particularly effective when the amount of evolutionary change varies between different characters or tree regions, since parameters such as branch lengths and character substitution rates, can be specifically modelled in the analysis (Huelsenbeck et al. 2001). The Bayesian approach has been widely adopted in biological phylogenetics (Huelsenbeck & Ronquist's 2001 paper has over 20,000 citations) and more recently in cultural analysis, such as inference of language family trees (Gray *et al.* 2009, Bouckaert *et al.* 2012 and Currie *et al.* 2013), folk tales (Tehrani 2013) and material culture (Matthews et al. 2011).

In common with other platforms, *Mr Bayes* employs a Markov Chain Monte Carlo (MCMC) algorithm to perform the tree search (Nunn 2011: 36). This starts with a random tree, changes this randomly and then computes the new likelihood. If this is higher the tree is accepted, if lower it is accepted probabilistically in proportion to the difference in likelihoods. The process is iterated to create a chain of trees which, when run long enough, reaches a stable distribution when the average likelihood is not increasing. Separate tree chains are initiated from different starting points to check they converge and are not settling on a local likelihood peak. Trees are discarded from the initial 'burn in' period before stability is reached and then sampled along the chain at equal intervals to create a set of trees (or 'posterior distribution') used for further analysis. Because the sampled distribution contains multiple trees it captures both high and low probability nodes, thus reflecting the conflict in phylogenetic relationships inferred from the dataset.

The tree distribution is visualised using a consensus network (Holland & Moulton 2003). Each tree branch is coded as a 'split' (partition of the taxa into two groups) so that the tree becomes a series of splits. The posterior sample of trees is therefore redefined as a collection of multiple splits that can be represented as a network. Infrequent splits are removed from the sample to improve clarity. In this case, only splits occurring in at least 10% of the tree distribution were displayed (Holland *et al.* 2004). Regions in the network

with compatible splits have a branching tree-like structure whereas areas where the splits are incompatible are more box-like.

A majority-rule consensus (MRC) tree was also used to summarise the tree distribution. This includes clades supported in at least 50% of the posterior sample and is the default option in *Mr Bayes v3.2* (Ronquist *et al.* 2012). MRC trees have been shown to outperform other methods, such as maximum clade credibility (MCC), in summarising diffuse posterior distributions, presenting a more conservative summary of topology and inclusion of fewer incorrect clades (O'Reilly & Donoghue 2018). Consensus posterior support values can also be used to assess confidence in tree topology with the number of highly supported nodes providing a measure of overall phylogenetic fit. Studies using different tree building methods *e.g.* Parsimony, Maximum Likelihood, have commonly used 70% as a threshold for demonstrating confidence in the existence of the clade, using support values calculated with the bootstrap method (Soltis & Soltis 2003). In simulation studies some authors conclude that Bayesian posterior support values are equivalent to these bootstrapped values, whilst others have suggested higher thresholds are required to demonstrate phylogenetic signal (Alfaro *et al.* 2003). Such studies commonly use large DNA character sets and threshold Bayesian support values are found to be much lower when the number of characters is below 100 (Alfaro *et al.* 2003, O'Reilly & Donoghue 2018). Here, datasets of only 24-27 characters are used therefore nodal support values above 70% are likely to provide evidence of phylogenetic fit.

Whilst MRC is a conservative method for producing consensus trees, using one tree to represent the posterior sample still represents a significant approximation. To provide additional confidence in the validity of the ritual consensus trees an additional test was conducted using the *PAUP* software package (Swofford 2002) to assess whether they were statistically different from those generated randomly. The test, T-PTP (Topology dependent – Permutation Tail Probability), examines how frequently the length of a selected tree occurs in random permutations of the data (Faith & Cranston 1992). Tree lengths are calculated on a parsimony basis, measuring the number of character changes that would be required to generate the tree topology. Trees requiring fewer changes are assumed to be better representations of historical relationships. Whilst this may not always be the case, the method represents a useful way of testing whether derived trees are statistically different from those obtained randomly.

Mr Bayes – model selection

Analysis using *Mr Bayes* requires selection of an appropriate evolutionary model that best aligns with what is known about the underlying data. Two model variants were evaluated to determine which had the best statistical fit to each of the ritual datasets. Firstly, instead of applying a net substitution rate for trait gain, separate rates were modelled for trait acquisition (0 to 1) and loss (1 to 0). Transmission of cultural traits requires persistence between generations which may fail to occur because the trait has been lost, forgotten or modified (Boyd & Richerson 2005: 57). In language, for example, cognates can be lost relatively easily, but the innovative events that produce them are rare (Atkinson *et al.* 2005). Consequently, we might expect ritual traits to have a materially faster rate of loss than gain. The second variant allowed substitution rates to vary by trait. Traits linked to environmental or functional needs may change at a slower rate than those more symbolically or socially orientated (Rogers & Ehlrich 2008, Currie & Mace 2014). Rates may also be affected if routes of social transmission vary between traits (Aoki *et al.* 2011). *Mr Bayes* also allows various clock models to be specified for the phylogeny that model rates of trait change over time. Since we have no prior information to indicate how this might vary for ritual, all models were set as unconstrained. In this case, resulting tree branch lengths are proportional to the number of expected changes per trait rather than being proportional to time.

The two model variants encompass four parameter combinations:

1) Substitution rate as net or separate. Set by coding *datatype* in the nexus file as either *standard* (net rate) or *restrictive* (separate rates). Restrictive models were first developed for DNA sites acted on by restriction enzymes.

2) Substitution rates as fixed or variable by trait. Variable rates are drawn from a gamma (skewed) distribution considered to be a well-approximated model of evolutionary rate variation (Yang 1993).

For model selection, two MCMC chains were run for one million iterations with the first 25% discarded as 'burn in', and tree and parameter samples taken every 500th iteration, to produce a posterior distribution. For each model, the log likelihoods reported are the averaged harmonic means of the sampled marginal log likelihoods from each of the two runs. Likelihood differences between the chains were measured using the *Mr Bayes* statistic *average standard deviation of split frequencies* and, for all the 1) and 2) model variants, this was close to or below the 0.01 value conventionally accepted as a

convergence threshold. To account for run to run variation, each analysis was repeated 5 times per model variant, and the mean likelihood reported. The threshold used for model selection is that the more complex model (in terms of additional parameters used) should represent at least a 2.0 log likelihood improvement over the simpler (lower parameter) model (Raftery 1996).

Mr Bayes – model selection results

Results for each of the three ritual forms are detailed in table 2.2 below. Allowing separate gain/loss substitution rates for rock motifs resulted in an 8.0 log likelihood improvement over the net rate model (significantly greater than the 2.0 log threshold), but there were no improvements for initiation or mortuary ritual (both were 2.0 log units worse than the net model). Sampled substitution rate values for rock motifs were higher for motif loss (1 to 0 = 0.83 mean) than gain (0 to 1 = 0.17 mean) suggesting novel motif images are easier to lose than acquire which was in line with expectations. The more symbolic nature of rock motifs may result in lower persistence, and therefore more materially higher loss rates, than seen with initiation and mortuary traits. For all three ritual forms there was no significant difference between models with fixed or variable substitution rates across all traits. In this case, the requirement to estimate a large number of additional parameters (for between 24 and 27 traits) was not compensated for by any significant improvement in the model's fit to the data. The finding suggests that there is no material difference between different traits in their rates of gain/loss (either net or separated). Model A was therefore optimal for initiation and mortuary ritual and model C for rock motifs.

Model:	**A**	**B**	**C**	**D**
Substitution rate gain/loss:	Net	Net	Separate	Separate
Substitution rate by trait:	Fixed	Variable	Fixed	Variable
Initiation ritual	157.97*	158.22	160.01	160.23
Mortuary ritual	188.78*	187.13	190.86	189.80
Rock motifs	155.30	155.44	147.32*	148.38

TABLE 2.2 NEGATIVE LOG LIKELIHOOD VALUES BY MODEL FROM *MR BAYES*; * OPTIMUM MODEL.

Results – *Mr Bayes*

Consensus networks generated from the posterior tree distributions for the selected models are shown in figure 2.5. Areas that are more boxed or reticulate indicate more conflict in the dataset as to how taxa should be grouped together. All three datasets demonstrate a clear separation into two distinct groups, but within these groups there is a fair degree of conflict, mortuary ritual has the most and initiation the least. As in *Neighbour Net*, all three networks show some alignment to the geographic locations of language areas (figure 2.2) which might be expected based on their proximity. In the rock motif network, YKW, a south-east language area, is a clear geographic outlier as it is grouped with areas in the north. The patterns of separation (dashed lines in figure 2.5) suggest a marked divergence in ritual traditions, however these vary depending on the ritual type. Initiation is east/west, mortuary ritual north/south and rock motifs are north & east/south & west.

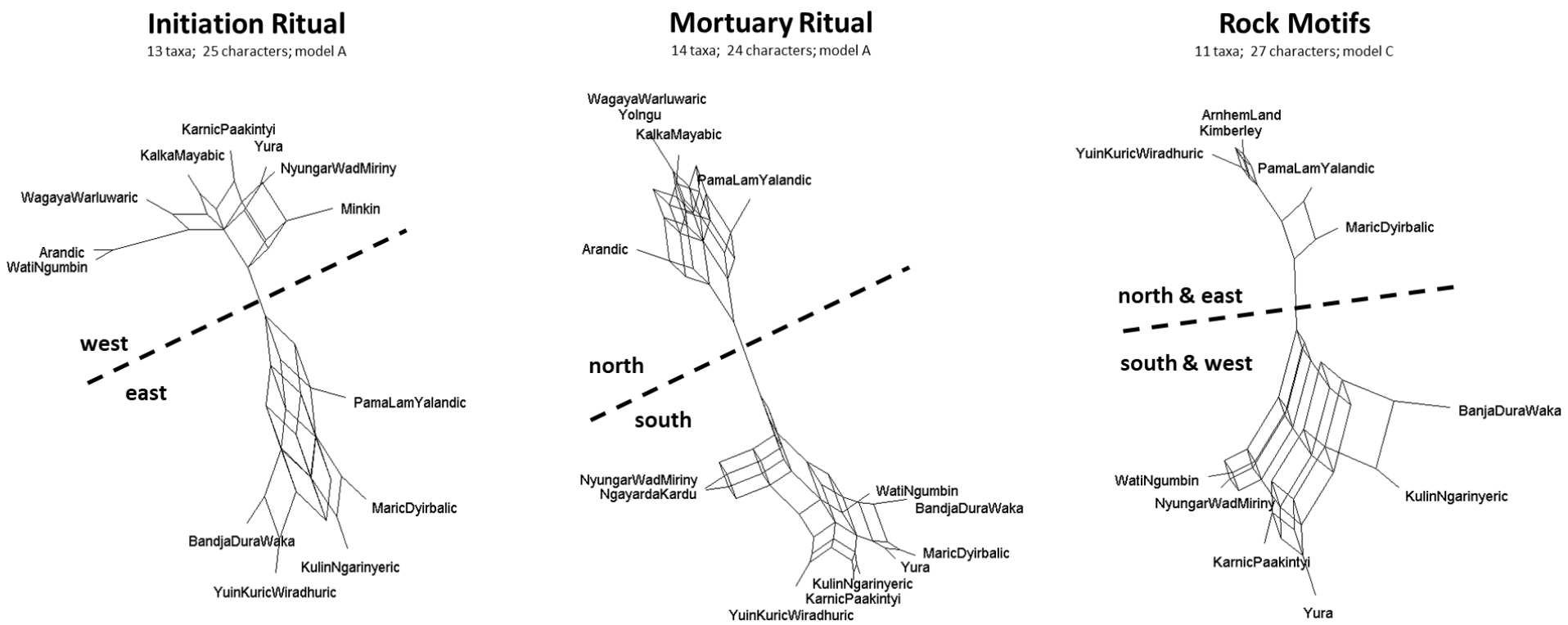


FIGURE 2.5 BAYESIAN CONSENSUS NETWORKS FROM *SPLITSTREE 4* CONSTRUCTED FROM A 1,501 TREE SAMPLE PRODUCED USING *MR BAYES V3.2.* TREES WERE OBTAINED FROM THE FIRST CHAIN OF THE 5TH RUN (SEE TEXT) AND REPRESENT 75% OF THE POSTERIOR SAMPLE (FIRST 25% DELETED AS BURN-IN). THE THRESHOLD FOR NODE INCLUSION WAS SET AT 10% POSTERIOR SUPPORT. MODELS USED WERE SELECTED BASED ON LIKELIHOOD VALUES; FOR INITIATION AND MORTUARY RITUAL, MODEL A (NET SUBSTITUTION RATE, FIXED ACROSS ALL TRAITS) AND FOR ROCK MOTIFS, MODEL C (SEPARATE SUBSTITUTION RATES, FIXED ACROSS ALL TRAITS). ALL THREE NETWORKS SHOW SOME ALIGNMENT TO GEOGRAPHIC LOCATIONS (FIGURE 2.2) AND A DIVISION BETWEEN TWO GROUPS (REPRESENTED BY DASHED LINES) THAT SUGGESTS DIVERGENT RITUAL TRADITIONS.

Majority-rule consensus trees were generated from the posterior sample and are illustrated in figure 2.6. These are shown as rooted to provide an indication of the direction of ritual change and simplify the comparison of tree topologies between ritual types. The tree sample contains unrooted trees because the branch length evolutionary rate was unconstrained in the model, therefore there is no known rate of change that would enable the mid-point of the tree to be estimated as its root. Trees are rooted using the conventional assumption that language and culture are closely related, therefore the oldest linguistic area is adopted as outgroup (Pagel & Mace 2004, Gray & Watts 2017). For initiation and mortuary ritual, *WagayaWarluwaric* was set as the outgroup as opinion seems to converge that Pama-Nyungan language expansion likely originated in this region (Bowern & Atkinson 2012, Bouckaert *et al.* 2018). For rock motifs, a topology constraint was applied to group all Pama-Nyungan taxa into one clade, effectively setting both Arnhem Land and Kimberley as outgroups. Languages in these (Non-Pama-Nyungan) regions are hypothesised to have originally shared a common ancestor with Proto-Pama-Nyungan languages (McConvell & Bowern 2011) so are presumed to be outgroups.

There was support for at least some nodes across all three ritual types in the consensus trees. Mortuary was the weakest with only 2 nodes above the 70% threshold indicating confidence in the presence of a clade. Rock motifs had 4 clades above 70% and initiation 5 above or equal to 70%. The separation into two distinct groupings visible from the consensus network analysis is reflected in the consensus trees. Initiation has a node with 91% support encompassing eastern regions, mortuary an 88% node grouping southern regions and rock motifs a 92% node including south & west groups.

The character datasets used to generate the phylogenies may comprise traits with and without phylogenetic signal. To determine whether allowing phylogenetically active and non-active traits to have different evolutionary parameters might improve the reconstruction, data were partitioned in the Bayesian analysis using the chapter 3 results that assessed phylogenetic signal relative to language. All initiation traits had phylogenetic signal so this did not change the analysis. 15 out of 26 mortuary traits and 9 out of 37 rock motifs had phylogenetic signal (see table 3.2). Both of these datasets were partitioned into two groups (after adjustment to account for the slightly different total trait numbers in chapter 3) to allow substitution rates and/or tree topology to vary depending on whether traits had phylogenetic signal or not. Likelihood values were then examined relative to the values for the un-partitioned models in table 2.2. No differences above the 2.0 log threshold were observed and the separate partitioned topologies were close to star-like formation, with few clades resolved. Traits showing evidence of variation

with language do not therefore appear to have different evolutionary histories compared to those which show no variation. However, it is also possible that the resultant reduced character datasets for each partition are simply too small to generate meaningful phylogenetic information.

Finally, consensus trees were tested using T-PTP (Topology dependent – Permutation Tail Probability) in *PAUP* (Swofford 2002) to assess, based on parsimony criteria, whether they were statistically different from those generated randomly. In comparison with 1,000 randomly generated trees, all three consensus trees had p values of 0.01, well below the $p<0.05$ threshold required for demonstrating significance.

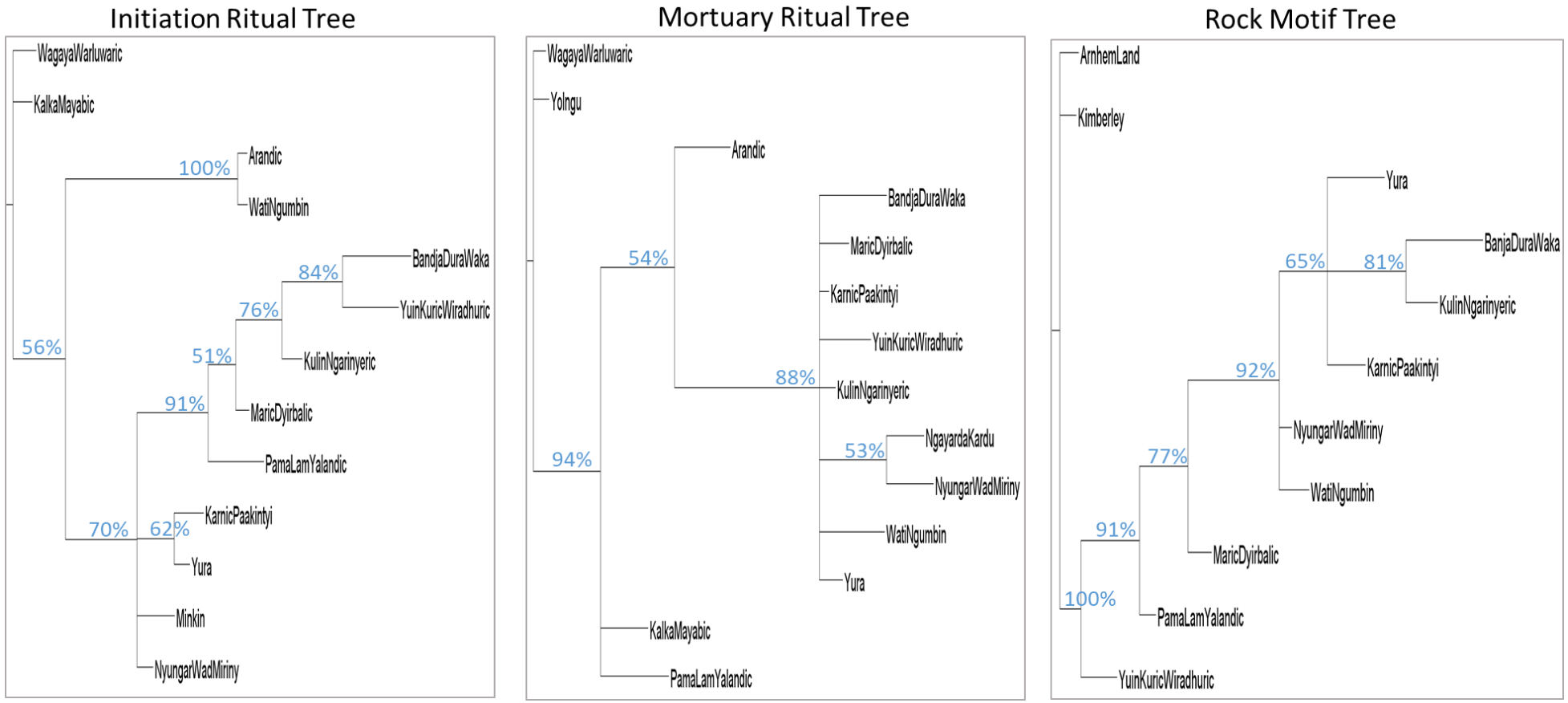


FIGURE 2.6 MAJORITY-RULE CONSENSUS TREES (ONLY NODES ABOVE 50% POSTERIOR SUPPORT ARE INCLUDED) DERIVED FROM 1,501 POSTERIOR TREE SAMPLES GENERATED FOR EACH RITUAL TYPE (SEE FIGURE 2.5). TREES SHOWN ARE PHYLOGRAMS (BRANCH LENGTHS ARE PROPORTIONAL TO THE EXPECTED NUMBER OF CHANGES PER TRAIT). THERE WAS SUPPORT FOR AT LEAST SOME NODES ACROSS ALL THREE RITUAL TYPES. MORTUARY WAS THE WEAKEST WITH ONLY 2 NODES ABOVE 70% (THRESHOLD INDICATING CONFIDENCE IN CLADE PRESENCE), ROCK MOTIFS HAD 4 CLADES ABOVE 70% AND INITIATION HAD THE STRONGEST SUPPORT WITH 5 CLADES ABOVE OR EQUAL TO 70%.

In summary, *Mr Bayes* results suggest that initiation and rock motif datasets are quite tree-like, with a number of consensus tree clades above 70% posterior support, but that mortuary ritual is much less so. In addition to well-supported nodes, phylogenies that represent good models of trait change are likely to have a well characterised hierarchical structure. Both initiation and rock motifs demonstrate this, with well supported sub-groupings deeper in the tree, however mortuary ritual has much less evidence of hierarchy. Summary phylogenetic statistics for *Mr Bayes* in comparison to *Neighbour Net* and PAUP, are shown in table 2.3.

Method	Phylogeny Type	Phylogenetic Statistic	Initiation Ritual	Mortuary Ritual	Rock Motifs
Neighbour Net	Distance Network	Average delta value	0.30	0.34	0.23
		Average Q value	0.06	0.10	0.06
Mr Bayes	Bayesian consensus tree	Number of clades ≥ 70% support	5	2	4
PAUP	Bayesian consensus tree	T - PTP test using parsimony criteria	0.01	0.01	0.01

TABLE 2.3 SUMMARY OF PHYLOGENETIC STATISTICS BY RITUAL TYPE.

Neighbour Net analyses suggested there was phylogenetic structure for rock motifs, possibly initiation, but not mortuary ritual. *Mr Bayes* results support these findings for rock motifs and mortuary ritual, but provide more conclusive evidence of phylogenetic structure for initiation. Both analyses separate each ritual into two regional groupings, but this separation is more delineated in *Mr Bayes*. Thus, although there are small differences between the two sets of results, the broad conclusions are similar. Since the methods had quite different analytical starting points, such a consensus suggests we can be reasonably confident in the conclusions drawn. In Boyd *et al.* terms, ritual does not seem to be a fully coherent type 1 process as rituals do not have similar phylogenetic relationships. Rock motifs and initiation do have phylogenetic structure, however, suggesting they may be either type 3 processes (individual phylogenetic histories), or type 2 (core vs peripheral) if their variation is aligned to other cultural elements such as language. Mortuary ritual is a more ephemeral type 4 process with insufficient coherence as a cultural entity for phylogenetic methods to be useful. I do not use this model in

further analysis in the chapter, although the north/south distinctions highlighted in the results are considered later.

Comparisons of ritual and language

In this section, initiation and rock motif phylogenies are compared to the Pama-Nyungan language tree. If they are similar, it would suggest the ritual is integrated within population history and may be a core element of Pama-Nyungan culture. In Boyd *et al.* terms it would be a type 2 process. Such a finding would also support the hypothesis that ritual could have played a role in Pama-Nyungan expansion. If ritual and language phylogenies are different, it would suggest the ritual is a type 3 process; a stable cultural domain with its own, independent pattern of inheritance.

Initiation and rock motif consensus trees were used for the analysis (figure 2.6). For comparative purposes, phylogenies were aligned to include the nine language areas present across both trees, and the language tree (figure 2.1) was pruned to include these same nine regions. Trees were compared using the Robinson-Foulds (RF) metric, one of the most widely used methods for calculating phylogenetic distance (Robinson & Foulds 1981, Bogdanowicz & Giaro 2013, Kuhner & Yamoto 2015). The RF algorithm counts the number of branch partitions that appear in one tree, but not the other, scoring 1 for each unmatched partition. The fewer the unmatched partitions, the greater the similarity between trees. For the RF calculation, two polytomies (nodes with > 2 descendants), in each of the initiation and rock motif trees, were resolved by including nodes with slightly lower posterior probabilities (30-40%). The calculation was implemented in R using the *cospeciation* function from the *phytools* package (Revell 2012). To assess statistical significance, the RF score was compared to a null distribution of RF values obtained from 1000 randomly simulated trees. Results are shown in table 2.4. An alternative comparison metric was also tested, Subtree Prune and Re-graft (SPR), which counts the number of operations required to explain the difference between trees (Goloboff 2008), and this returned similar relative p-values.

	RF score	Mean RF score from null distribution	P value vs null distribution
Initiation vs Language	4	10.2	0.012*
Rock motif vs Language	12	11.4	1.000
Initiation vs Rock motif	12	11.7	1.000

TABLE 2.4 COMPARISON OF PHYLOGENIES USING RF ALGORITHM (ROBINSON & FOULDS 1981); *P<0.05.

The initiation phylogeny was similar to language based on the RF metric and this result was statistically significant ($p<0.05$). In contrast, the rock motif phylogeny had no similarity to language based on the RF score and, unsurprisingly given this result, was not similar to initiation. Both comparisons returned RF scores close to the null distribution obtained from random trees. The three tree comparisons are illustrated in figures 2.7 to 2.9. Rotating the taxa to align the tips of the trees (without changing their topology) leads to a match between language and initiation, but is much more 'tangled' in the other two cases. Whilst initiation and language trees are similar, they are not the same. The eastern clade is consistent but the western clade has a different internal structure. This could be driven by the relative homogeneity of western languages compared to more heterogeneous initiation practices. For example, *WatiNgumbin* rituals have a number of costly elements and this is an isolated taxa in the initiation tree. There may have also been greater ritual diffusion between some neighbours *e.g. Yura* & *KarnicPaakintyi* are more closely linked in initiation than language. The *Neighbour Net* graph (figure 2.3) was quite reticulated in the western half of the tree and the *Mr Bayes* consensus nodes for initiation had less posterior support (56%, 70% & 35%) than approximate corresponding nodes for language (75% & 98%, from Bouckaert *et al.* 2018: figure 2).

The close association between initiation and language suggests it might represent a core element of Pama-Nyungan culture, akin to a type 2 core process in Boyd *et al.* terms. In contrast, the rock motif phylogeny demonstrates no coherence with language so is more likely to be a type 3 process; a stable cultural domain with an independent history.

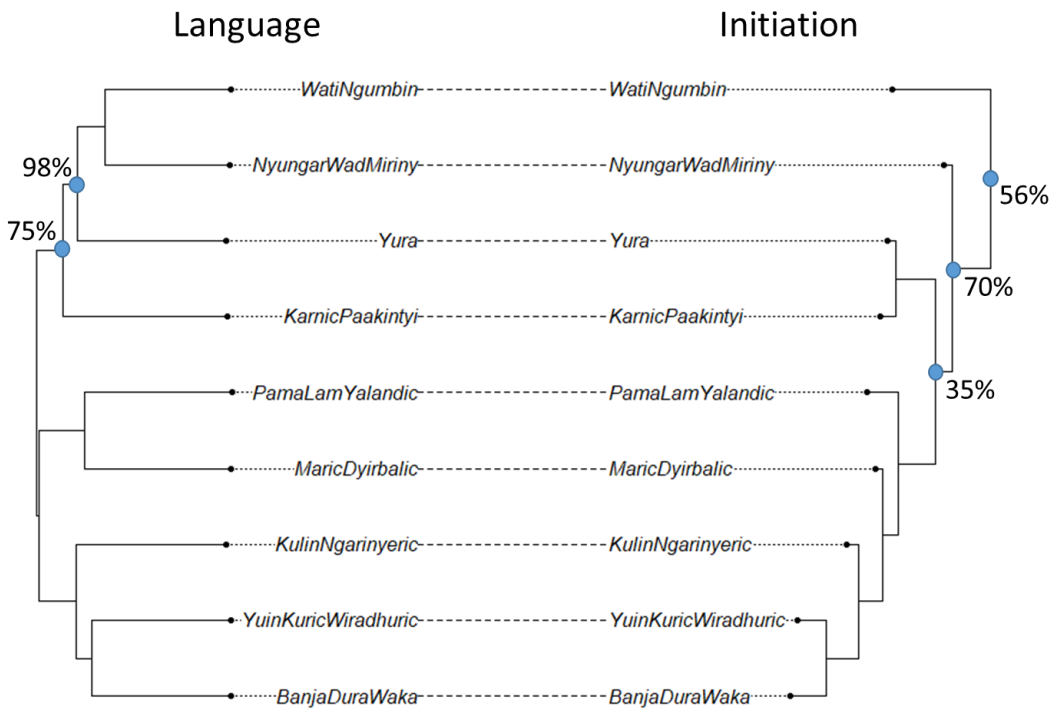


FIGURE 2.7 PAMA-NYUNGAN LANGUAGE TREE COMPARED TO INITIATION CONSENSUS TREE USING *COSPECIATION* IN R. ROTATING TAXA TO ALIGN THE TIPS SUGGESTS ALIGNMENT BETWEEN LANGUAGE AND INITIATION, ALTHOUGH THERE ARE DIFFERENCES IN THE DEEPER TREE STRUCTURE (PARTICULARLY IN THE UPPER (WESTERN) HALF). POSTERIOR SUPPORT VALUES ARE INCLUDED FOR SELECTED NODES (DISCUSSED IN THE TEXT).

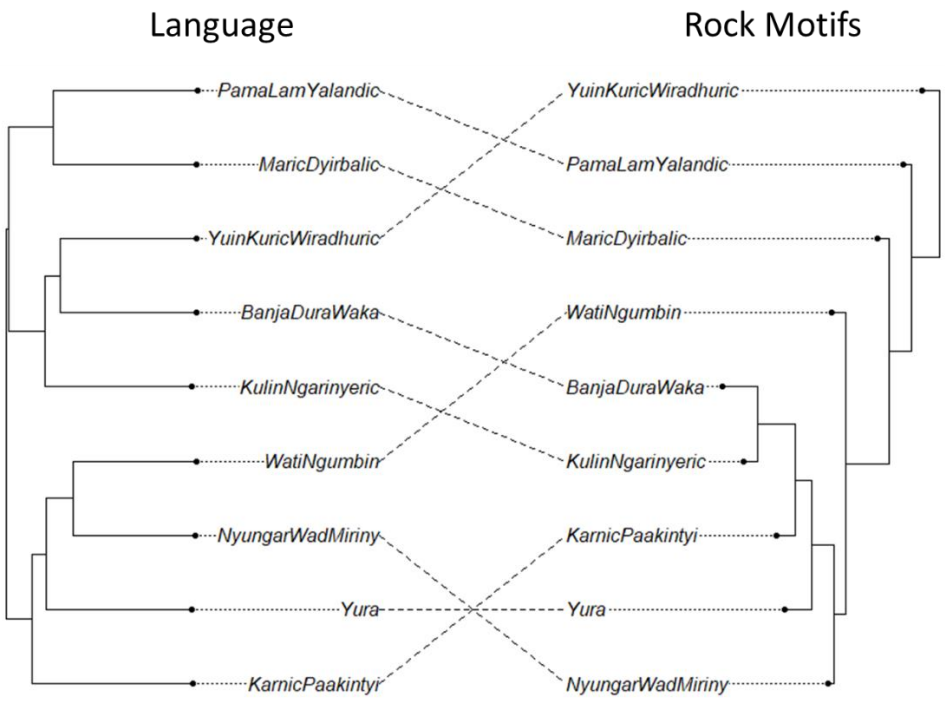


FIGURE 2.8 LANGUAGE TREE COMPARED TO ROCK MOTIF CONSENSUS TREE USING MATCHED PHYLOGENIES. ROTATING TAXA TO ALIGN THE TIPS DOES NOT SUGGEST ALIGNMENT BETWEEN THE TWO.

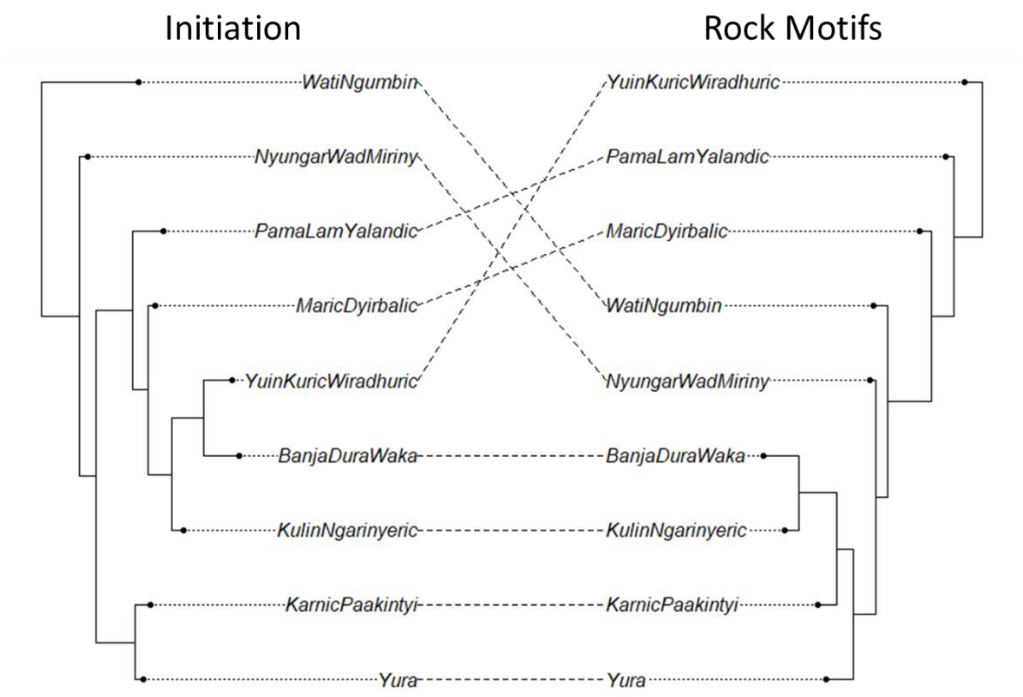


FIGURE 2.9 INITIATION AND ROCK MOTIF TREES COMPARED. ROTATING TAXA TO ALIGN THE TIPS DOES NOT SUGGEST ALIGNMENT BETWEEN THE TWO.

Examining pathways of ritual change

Results so far suggest that Australian ritual fits the Boyd *et al.* hypothesis of cultural types quite well with initiation a type 2, rock motifs a type 3 and mortuary ritual a type 4 cultural process. I next assess how these ritual histories might be represented as pathways of change across the Australian continent. The aim is two-fold, firstly to assess whether the proposed phylogenies represent feasible routes of cultural transmission and, secondly, to provide an additional way of examining correspondence between ritual forms and the Pama-Nyungan language expansion. Bouckaert *et al.* (2018) recently completed an analysis of this expansion, giving us the opportunity to compare physical pathways of change between the two. Such derived pathways may represent physical movements of people bringing new beliefs and ritual practices, or routes of cultural transmission brought about through the exchange of ideas. In language, for example, Bouckaert *et al.* suggest that Pama-Nyungan expansion took place mainly through absorption of cultural innovations into existing groups, rather than through replacement of existing populations.

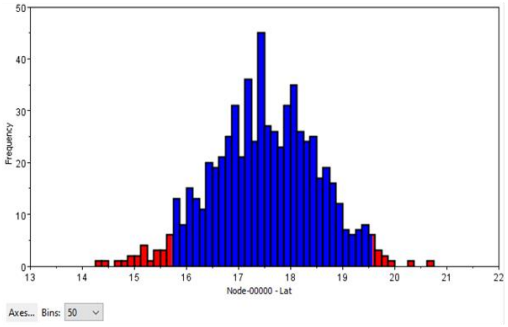
The Bayesian inference *Geo* model in *Bayes Traits v3* (Pagel & Meade 2006) was used to derive locations of ancestral (intermediate) nodes in the ritual phylogenies. Phylo-

geographic models treat location as a continuous variable that evolves through time along the branches of the tree. In applying these methods to ritual change, the assumption is that hierarchical relationships represented by the phylogeny reflect the movement of rock motif styles and initiation practices into new areas. Various approaches have been used to simulate the process of geographic change and models can become quite complex and highly specified to the dataset (Pirie *et al.* 2012). Here, the primary objective is to make comparisons between cultural types and the standardised approach applied in *Geo* is considered sufficient. To estimate the location of intermediate nodes, *Geo* uses an adapted version of the Brownian Motion (BM) model of evolutionary change widely applied in ancestral state reconstructions of continuous traits (Nunn 2011: 101). In the BM model, trait change is drawn from a normal distribution with variance proportional to branch length. This relationship (between branch length and trait change) is assumed to be constant throughout the phylogeny.

To estimate intermediate node locations, the latitude and longitude of the taxa at the tips of the phylogeny are first inputted as starting points. An MCMC chain then applies the BM model assumptions to search (simultaneously) for combinations of intermediate node locations that have the highest likelihood of producing the taxa tip data *i.e.* the locations. Values are sampled along the chain at equal intervals to create a posterior distribution of co-ordinates for each ancestral node. Initiation and rock motif majority rule consensus trees were used for the analysis and the nodes added to resolve polytomies for the RF distance calculation were retained to improve *Geo* model resolution. Starting co-ordinates for each language area were calculated by averaging latitude and longitude positions for each ethnolinguistic group (initiation) and each archaeological site (rock motifs) using an appropriate spherical geometric method (www.geomidpoint.com). *Geo* was run using an MCMC chain of 1m iterations with the first 25% discarded as burn-in and samples taken every 1000th iteration. *Tracer v1.5* (Rambaut & Drummond 2007) was used to analyse the sample output. Example results from node 0 for rock motifs are shown in figure 2.10. Mean latitude was 17.5 with 95% Highest Posterior Density (HPD) boundaries between 15.7 and 19.6. Mean longitude was 132.8 (95% HPD 130.7-134.8). The wide confidence intervals reflect a fairly high level of uncertainty in these estimates. This was also seen for the other nodes, and for initiation, and is probably related to the wide geographic range being covered with only a small number of estimated nodes.

Rock motifs: node 0 latitude data

Summary Statistic	
mean	17.5121
stderr of mean	4.1659E-2
median	17.491
geometric mean	17.4823
95% HPD lower	15.7265
95% HPD upper	19.5793
auto-correlation time (ACT)	1092.4891
effective sample size (ESS)	594.9716



Rock motifs: node 0 longitude data

Summary Statistic	
mean	132.7758
stderr of mean	4.2156E-2
median	132.7234
geometric mean	132.7716
95% HPD lower	130.7309
95% HPD upper	134.7565
auto-correlation time (ACT)	1028.8627
effective sample size (ESS)	631.7656

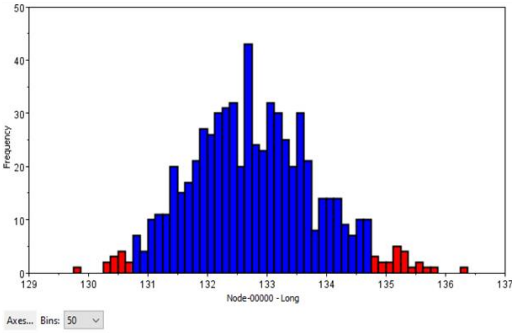


FIGURE 2.10 ROCK MOTIFS NODE 0 OUTPUT FROM *GEO* MODEL (*BAYES TRAITS V3*) ANALYSED IN *TRACER V1.5.* MEAN LATITUDE (TOP) WAS 17.5 WITH 95% HIGHEST POSTERIOR DENSITY (HPD) BOUNDARIES BETWEEN 15.7 AND 19.6. MEAN LONGITUDE (BOTTOM) WAS 132.8 (95% HPD 130.7-134.8). THE WIDE CONFIDENCE INTERVALS REFLECT A FAIRLY HIGH LEVEL OF UNCERTAINTY IN ESTIMATES. THIS WAS ALSO SEEN FOR OTHER NODES AND FOR INITIATION (SEE TEXT).

Mean node values from the posterior distribution were plotted and joined to describe possible pathways of initiation ritual and rock motif spread on figures 2.11 and 2.12. The main difference between the two ritual forms is the pathway to the south. For initiation, there are two routes: one from the centre to southern regions (KP & YR) and one from north-east to south-east (KN, YKW & BDW). For rock motifs there are also two routes but they are different. One is via an early split to YKW and one leads back from the Western Desert to the remaining southern groups (KP, YR, KN and BDW). The main similarities between the two rituals are their central north-east origin, a route doubling-back from the desert (albeit along different paths) and the fact that routes to both north-east and south-east are inland from the centre of the continent, rather than taking place via the coast.

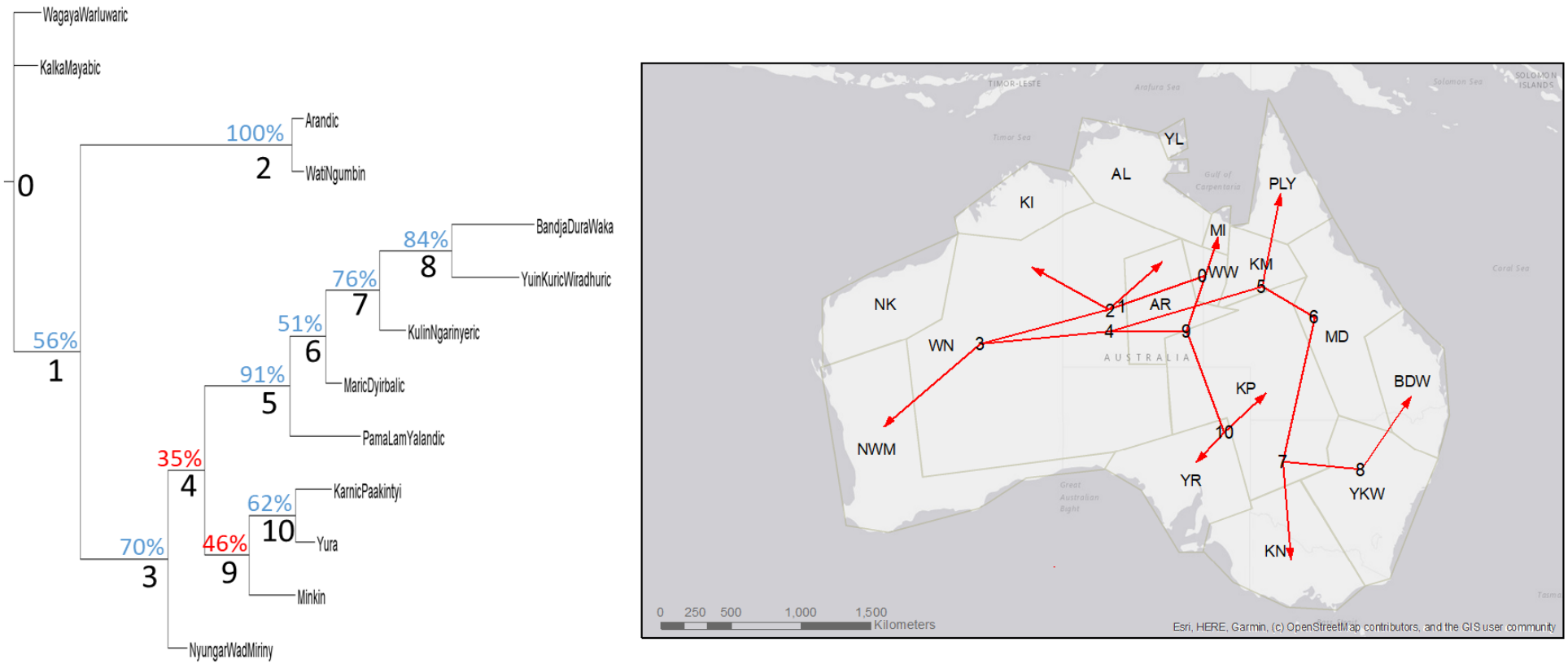


FIGURE 2.11 POSSIBLE PATHWAY OF INITIATION RITUAL CHANGE (IN RED, SHOWN ON RIGHT) USING ANCESTRAL RECONSTRUCTION OF NODE LOCATIONS ESTIMATED USING *GEO* IN *BAYES TRAITS V3*. NUMBERS AT EACH NODAL SPLIT ON THE PATHWAY CORRESPOND TO NODE NUMBERS ON THE CONSENSUS INITIATION TREE (SHOWN ON LEFT). THIS TREE IS FROM FIGURE 2.6 WITH INCLUSION OF TWO ADDITIONAL NODES WITH POSTERIOR PROBABILITY <50% (INDICATED IN RED).

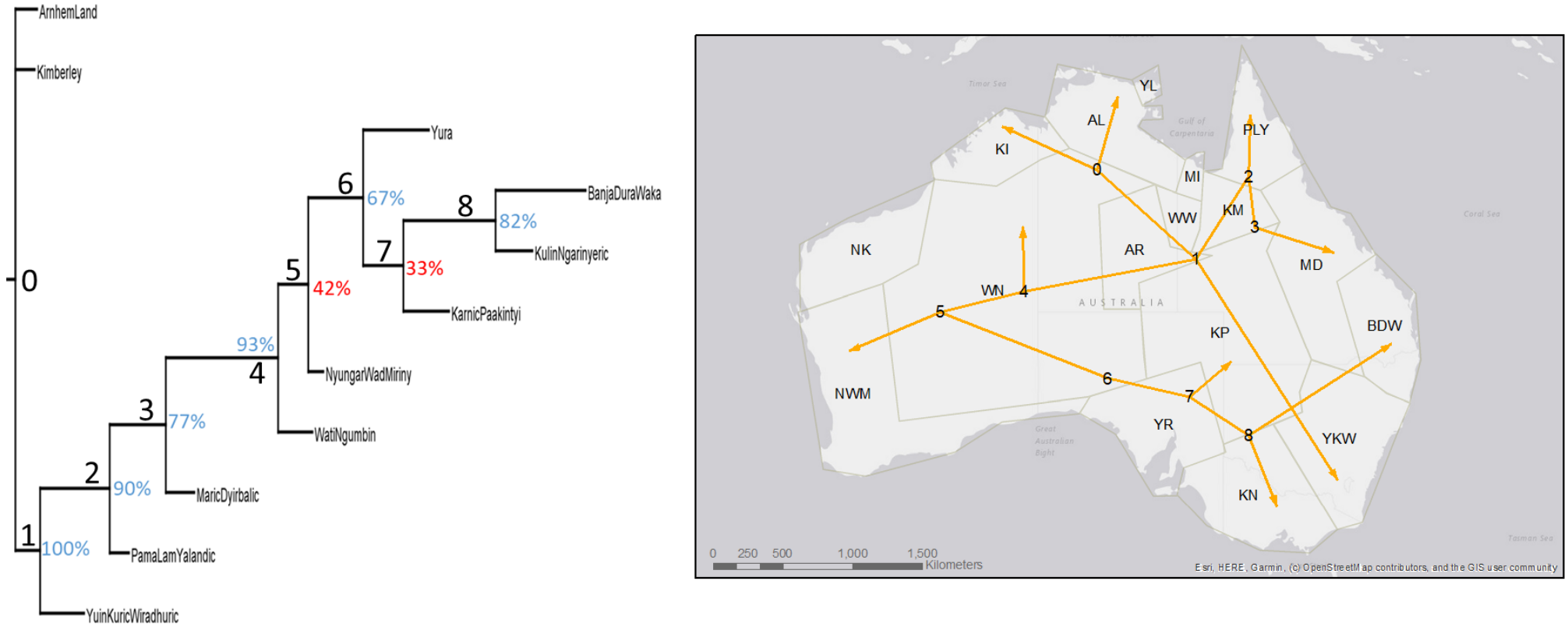


FIGURE 2.12 POSSIBLE PATHWAY OF ROCK MOTIF CHANGE (IN ORANGE, SHOWN ON RIGHT) USING ANCESTRAL RECONSTRUCTION OF NODE LOCATIONS ESTIMATED USING *GEO* IN *BAYES TRAITS V3.* NUMBERS AT EACH NODAL SPLIT ON THE PATHWAY CORRESPOND TO NODE NUMBERS ON THE CONSENSUS INITIATION TREE (SHOWN ON LEFT). THIS TREE IS FROM FIGURE 2.6 WITH INCLUSION OF TWO ADDITIONAL NODES WITH POSTERIOR PROBABILITY <50% (INDICATED IN RED).

Comparison was made with Bouckaert *et al.*'s 2018 analysis of the Pama-Nyungan language expansion. This used a Bayesian ancestral state model developed on a different software platform (BEAST) using a more complex evolutionary model and larger, sampled phylogeny. A schematic representation of the main pathways reported in the paper is included in figure 2.13, together with the initiation and rock motif pathways previously described. Initiation and language have some similarities, as might be expected given their similar phylogenies. Although the phylogeny created from rock motif data was quite different, comparison of all three pathways suggests some general correspondence in the patterns of cultural change. In particular, a central north-east origin, a northerly route across the Western Desert, and a central (north to south) axis that leads separately and overland to north-east and south-east regions, without use of the coastal route.

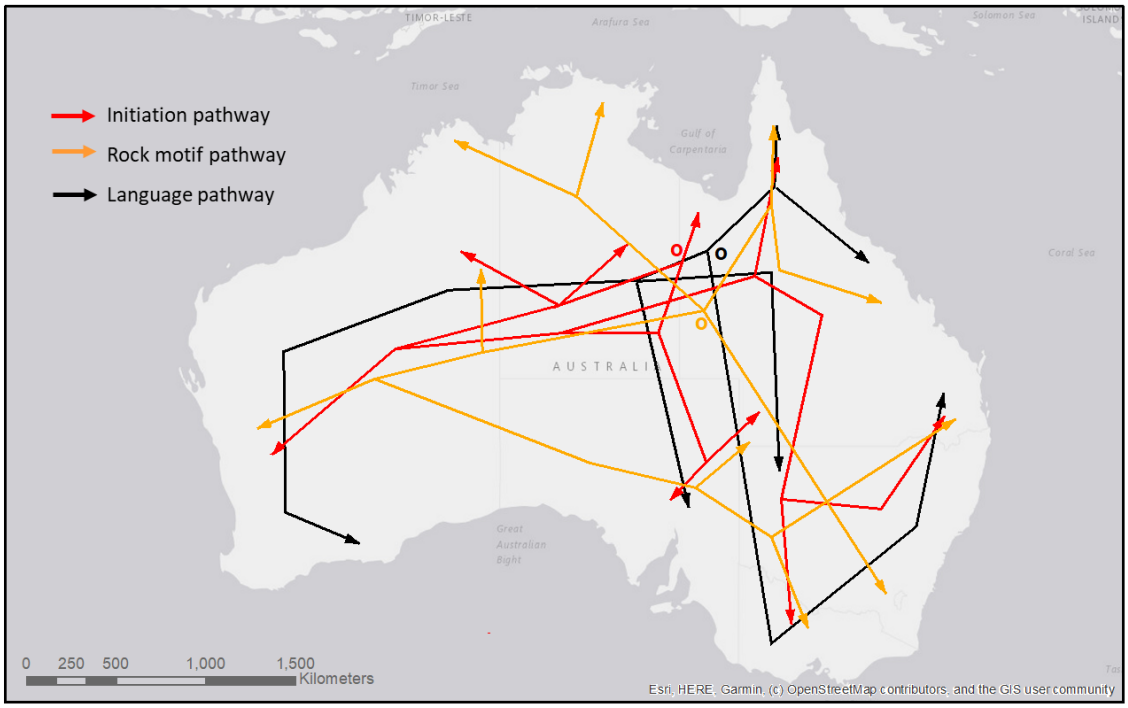


FIGURE 2.13 COMPARISON OF INITIATION, ROCK MOTIF AND LANGUAGE PATHWAYS. INITIATION AND ROCK MOTIFS FROM FIGURES 2.11 AND 2.12. LANGUAGE PATHWAY ADAPTED FROM BOUCKAERT *ET AL.* (2018). ORIGIN LABELS (O) MARK POTENTIAL STARTING POINTS FOR PAMA-NYUNGAN RITUAL AND LANGUAGE EXPANSION BASED ON THEIR PHYLOGENIES.

How feasible are these pathways as routes of cultural transmission? Australia is the driest inhabited continent on earth and the distribution and connectedness to water, particularly in the desert interior, has likely played a pivotal role in shaping patterns of cultural and population change. Bird, O'Grady & Ulm (2016) mapped the spatial distribution and permanency of standing water in Australia using the Water Observations

from Space (WOfS) dataset (www.ga.gov.au). Taking account of different terrain costs, they calculated connectivity lines of least-cost distances between water bodies to derive *distance to water* values by location. This data (obtained from D. O'Grady) is included in figure 2.14 and overlaid with the modelled ritual and language pathways. All pathways model a northerly route across the Western Desert which appears feasible based on water availability. Ethnography suggests groups occupying desert regions could not survive in areas 100km or more from water; effectively 2 days walk (Layton 1986). The overland route to the south is also feasible, although the north-south route would need to be more easterly for language and initiation, to avoid the central desert area.

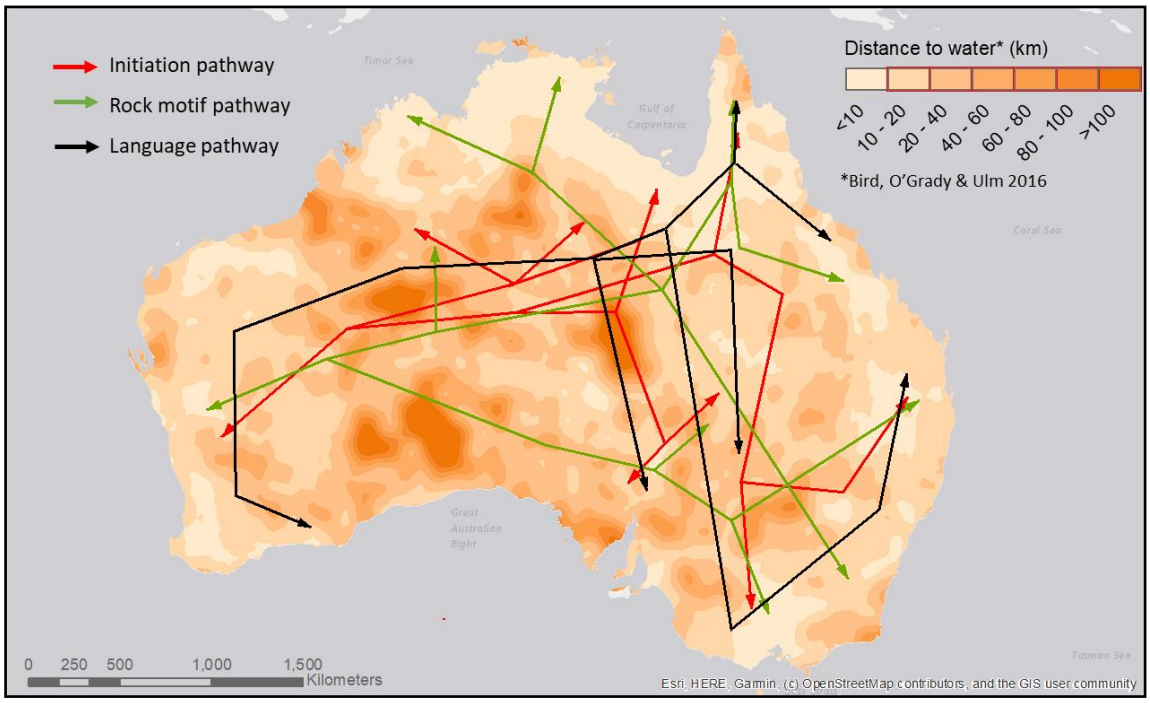


FIGURE 2.14 MODELLED PATHWAYS OF RITUAL AND LANGUAGE CHANGE COMPARED TO WATER AVAILABILITY USING THE WATER OBSERVATIONS FROM SPACE (WOFS) DATASET (BIRD, O'GRADY & ULM 2016).

Discussion

The meaningful phylogenetic signal obtained for initiation ritual and rock motifs suggests such models can provide a useful way of interpreting ritual history. Whilst horizontal transmission of ritual elements is known to have occurred (as discussed earlier), the creation of regional language areas appears to have provided sufficient boundaries for phylogenetic structure to be preserved. Australian ritual seems to fit Boyd *et al.*'s hypothesis of cultural types quite well. The similarity of initiation ritual to language suggests it is a type 2 'core' process that might have played a role in Pama-Nyungan expansion. Rock motifs have an independent phylogeny and more appropriately characterised as type 3. Mortuary ritual has little phylogenetic structure, suggesting it is type 4. Why might rituals have such different characteristics and what can this tell us about the development of ritual diversity in Australia?

One theme emerging from the analysis is the identification of two distinct traditions for each of the ritual types. These are illustrated in figures 2.15 to 2.17. For initiation, the east/west division appears best explained by a similar division in language. The correspondence between the two was clearly visible in comparison of the phylogenies (figure 2.7), leading to its identification as a type 2 'core' process integrated within population change. Mortuary rituals appear to have a north/south division (figure 2.16) but there is little support for further hierarchical structure, leading to its identification as a type 4 process. Mortuary rituals may be quite labile, with a mix of practices used in a region that depend, for example, on the social status of the deceased. However, the north/south split warrants further examination. Compound disposals (initial rites followed by a much later disposal ceremony) are more common in the north, and also practiced in south east Asia including parts of Indonesia. Some authors suggest the tradition diffused from there to Australia (Elkin quoted in Berndt & Berndt 1996: 460, Arthur & Morphy 2005: 98, Meehan 1971: 281) and identification of a north/south split in this analysis lends weight to this idea. This, together with lack of phylogenetic support elsewhere in the results, may indicate that diffusion, rather than inheritance, has been the main process shaping mortuary ritual variation.

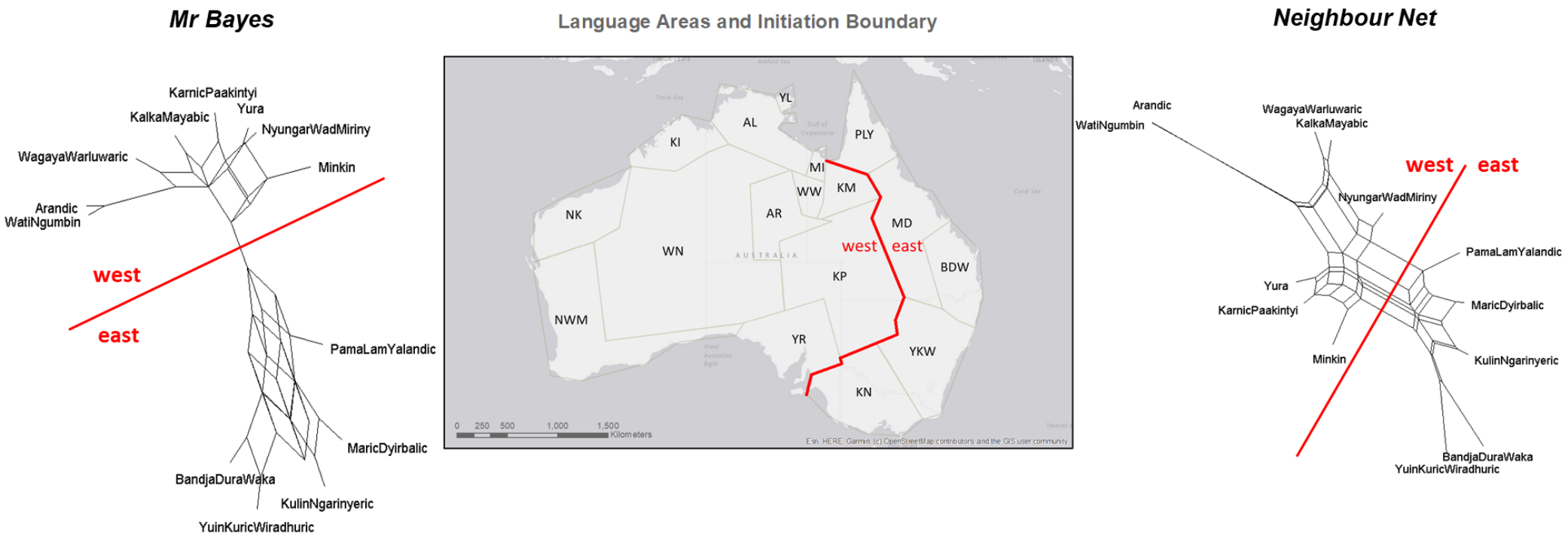


FIGURE 2.15 INITIATION: COMPARISON OF *MR BAYES* CONSENSUS NETWORK (ON LEFT, FROM FIGURE 2.5) AND *NEIGHBOUR NET* GRAPH (ON RIGHT, FROM FIGURE 2.3) RESULTING IN SUGGESTED BOUNDARY (RED EAST/WEST LINE ON LANGUAGE AREA MAP) BETWEEN DIVERGENT INITIATION TRADITIONS.

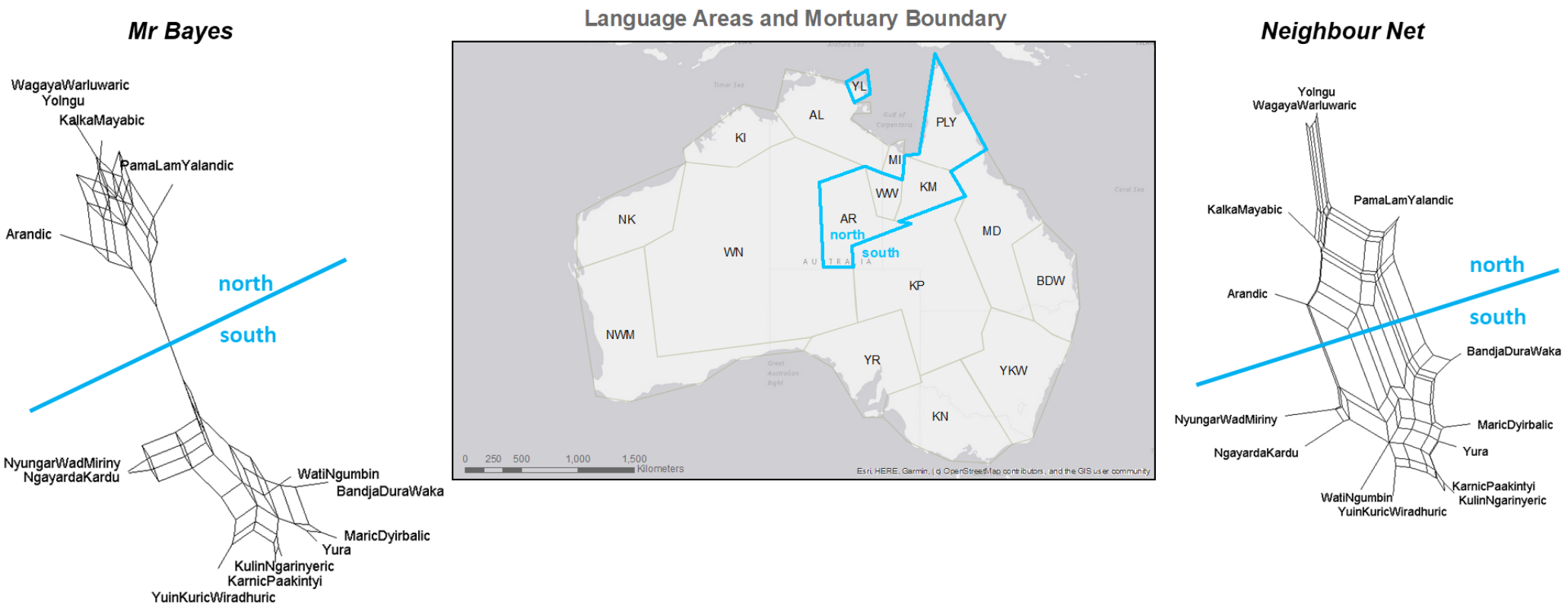


FIGURE 2.16 MORTUARY RITUAL: COMPARISON OF *MR BAYES* CONSENSUS NETWORK (ON LEFT, FROM FIGURE 2.5) AND *NEIGHBOUR NET* GRAPH (ON RIGHT, FROM FIGURE 2.3) RESULTING IN SUGGESTED BOUNDARY (BLUE NORTH/SOUTH LINE ON LANGUAGE AREA MAP) BETWEEN DIVERGENT MORTUARY RITUAL TRADITIONS.

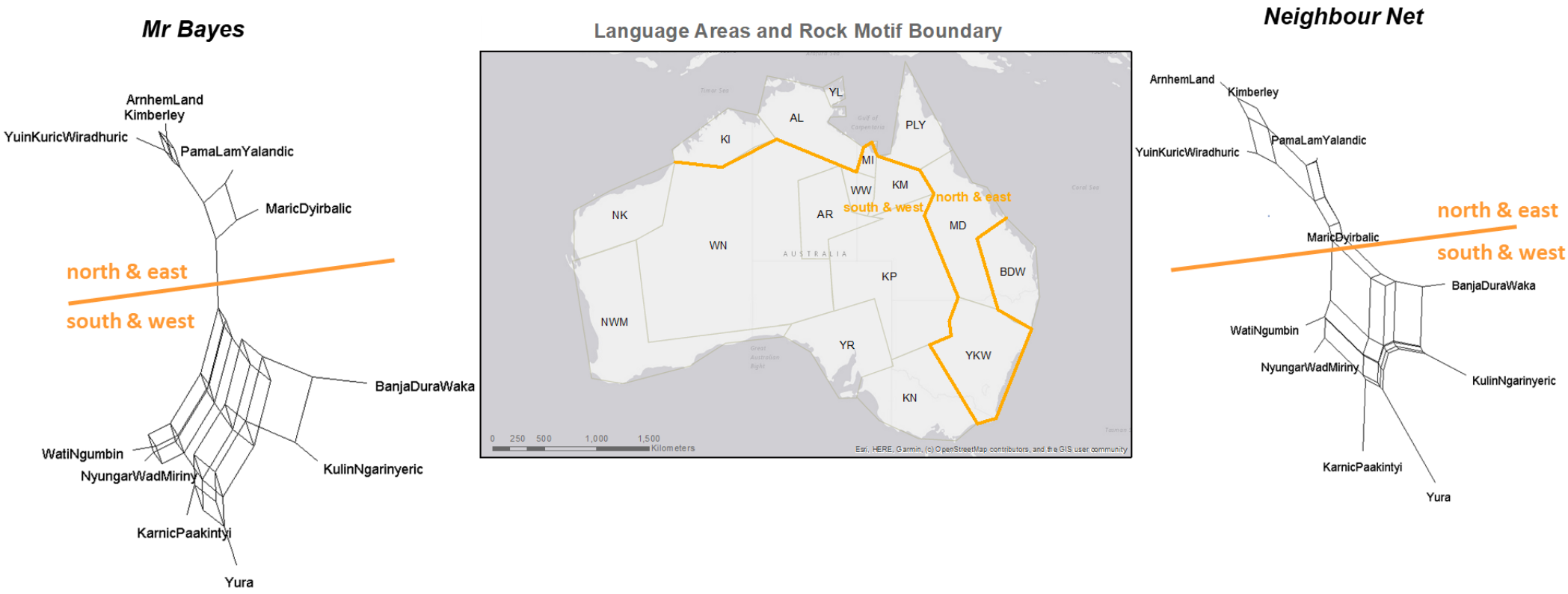


FIGURE 2.17 ROCK MOTIFS: COMPARISON OF *MR BAYES* CONSENSUS NETWORK (ON LEFT, FROM FIGURE 2.5) AND *NEIGHBOUR NET* GRAPH (ON RIGHT, FROM FIGURE 2.3) RESULTING IN SUGGESTED BOUNDARY (ORANGE NORTH & EAST/SOUTH & WEST LINE ON LANGUAGE AREA MAP) BETWEEN DIVERGENT ROCK MOTIF RITUAL TRADITIONS.

The north & east/south & west division identified from rock motif data (figure 2.17) may reflect separate traditions of representation. Regions in the north have a greater presence of figurative motifs, such as human forms, whereas those in the south contain more abstract, geometric images. Potentially then, the geometric representation gradually replaced the figurative one as part of a process of wider cultural change. Such a conclusion might support the idea, theorised by some authors, that geometric forms were linked to Pama-Nyungan expansion, with abstract motifs representing more complex forms of social organisation (Munn 1973, Layton 1992, Lourandos 1997). However, there is no correspondence between rock motif and language phylogenies to support this association (figure 2.8) and the independence of the rock motif phylogeny led to the conclusion it is a type 3 process with its own separate history.

Why might rock motifs have an independent history? Although they cannot be demonstrably linked to language change, at least some of their phylogenetic structure has been preserved. This may be because motifs, like linguistic cognates, are essentially neutral traits. Both have less susceptibility to the forces of borrowing and adaptation and this helps to preserve their shared history (Boyd *et al.* 2005: 319). It is not clear what processes may have shaped motif development but the pathway analysis may be provide some insight. The overland route to the south (figures 2.13 & 2.14) seems to be a route of cultural transmission common to rituals and language. Exchange networks have been documented by a number of authors (McCarthy 1939, Peterson 1976, McBryde 1984) and a central north/south axis appears to have been frequently (though not universally) used as a conduit for items such as axe heads, red ochre, *pituri* ('native tobacco') and decorative shells (see figure 2.18). Novel rock motifs may also have been transmitted along this route using pathways perhaps more aligned to exchange than to population movement.

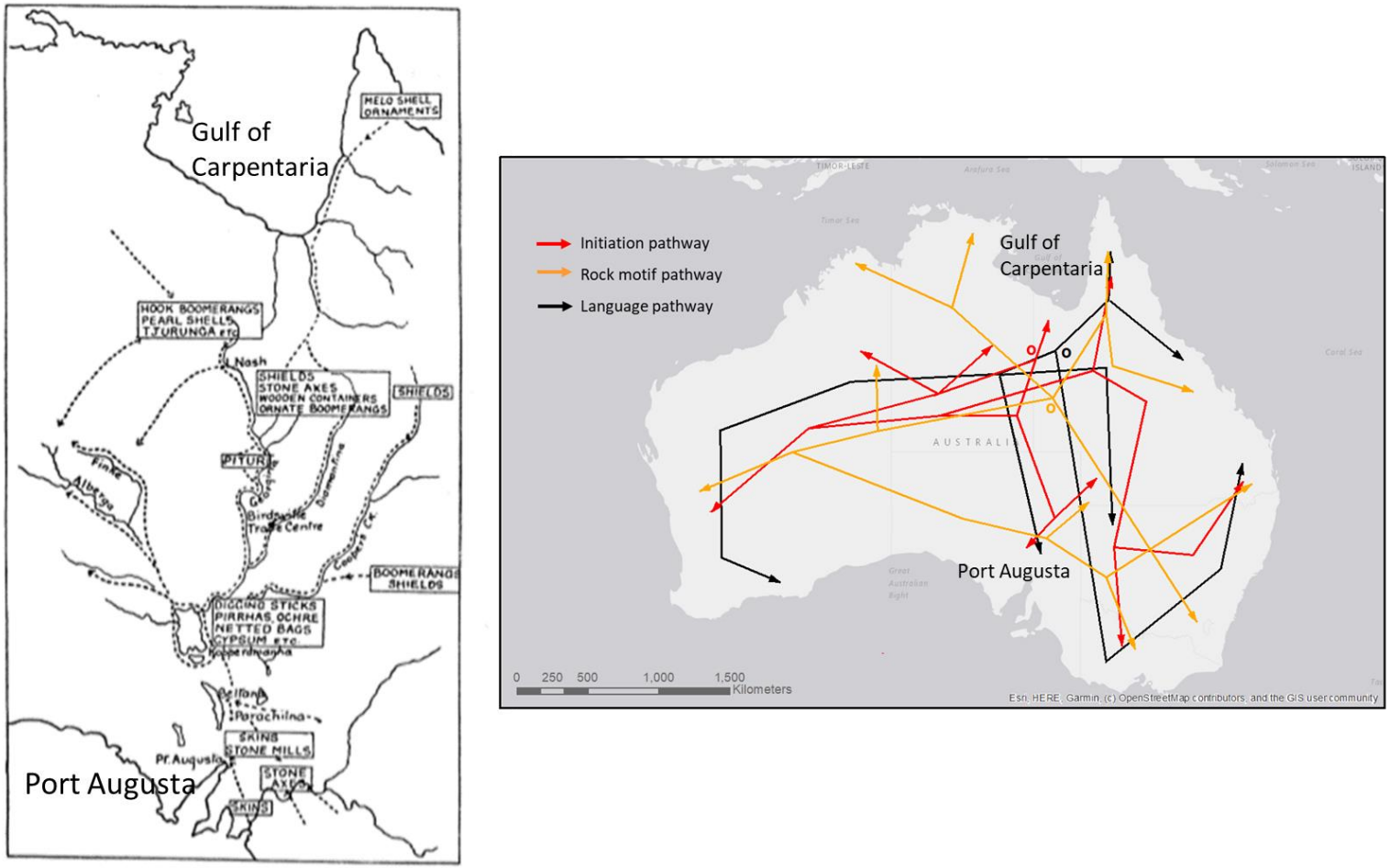


FIGURE 2.18 LEFT HAND MAP INDICATES THE NORTH-SOUTH *MURA-MURA* ROUTE (GULF OF CARPENTARIA TO PORT AUGUSTA) USED FOR EXCHANGE OF *PITURI* ('NATIVE TOBACCO'), DECORATIVE SHELLS, AXE HEADS AND OTHER ITEMS (MCCARTHY 1939). A NORTH-SOUTH EXCHANGE ROUTE FURTHER EAST (FROM PRESENT-DAY MELBOURNE) WAS ALSO MAPPED BY MCBRYDE (1984: 136). COMPARISON TO THE MODELLED LANGUAGE AND RITUAL PATHWAYS (RIGHT HAND MAP, FROM FIGURE 2.13) SUGGESTS CLOSE CORRESPONDENCE.

One anomaly in the rock motif phylogeny warrants further investigation. YKW (*YuinKuricWiradhuric*) in the south-east is grouped with northern regions in both networks (figure 2.17), yet, as is evident from the pathway analysis, this would involve cultural transmission across 2,000 km of Central Australia. Whilst directionally this aligns with a north-south exchange axis, it seems unlikely that such transmission would have taken place without influencing other regions along its path. YKW is grouped with the north because some of the figurative traditions appear similar and the reasons for this have been the focus of much rock art literature (Layton 1992: 126 & 242). Motifs could be a continuation of older traditions pre-dating Pama Nyungan expansion. Identified areas of human *refugia* during the last glacial maximum (Williams *et al.* 2013) include the Sydney basin (within YKW) but not neighbouring areas KN and BDW. However, *refugia* have been identified in other areas, such as Central/Western Australia (NYM/YR) without figurative traditions, so it is unclear why only YKW *refugia* might have been influential in this way. A more common theory is that YKW motifs developed independently to fortuitously resemble those in northern regions, perhaps due to their specific role in ritual practices. Shelters containing rock images in the region show little sign of domestic occupation which suggests a ritual function (Worms 1955). In a paper from 1897, R.H. Mathews records attendance at an initiation ritual with the *Darkinung,* inland from present-day Sydney:

'*A short distance from the [ceremonial] circle was a colossal representation of* Dharramoolun*, lying prone on his back, formed of the loose earth heaped up in high relief….a little way further was another raised image, also lying on the back, but of smaller dimensions…'*

There are similarities between the rock paintings and engravings in this region and the ephemeral ritual earth figures and tree carvings recorded by Mathews (illustrated in figure 2.19). For example, the size of the figures (engraving (ii) is unusually large at 3m in length), their wide body and genital shape, and the fact that the figures tend to be represented with spread arms (perhaps a signal that they are lying on their back). Possibly, the visual elements of ritual practice developed differently here to other areas, leading to independent development of a figurative rock art tradition co-incidentally similar to that observed in the north. This theme is returned to in the analysis of individual ritual traits in chapter 3.

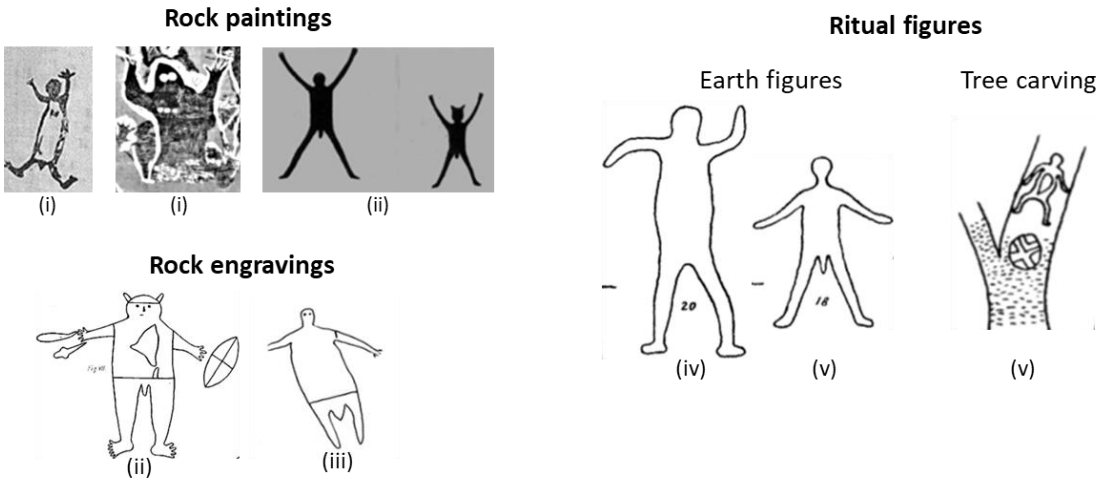


FIGURE 2.19 PAINTINGS AND ENGRAVINGS WITHIN THE *YUINKURICWIRADHURIC REGION* ARE SIMILAR IN STYLE TO EPHEMERAL RITUAL FIGURES FOUND WITHIN THIS AREA; (i) MCDONALD RIVER DISTRICT (SIM 1969); (ii) HAWKESBURY RIVER (MATHEWS 1894), FIGURE HEIGHTS 0.7M & 0.5M (PAINTED), 3.0M (ENGRAVED); (iii) SYDNEY BASIN (MCCARTHY & HANSEN 1960); (iv) MACQUARIE RIVER (MATHEWS 1896B), FIGURE HEIGHT 6.4M; (v) BOOMI (MATHEWS 1896B), FIGURE HEIGHTS 4.6M (EARTH) & 0.8M (CARVING).

Conclusion

Results from this chapter suggest phylogenetic methods and Boyd *et al.'s* cultural unit typology can be combined to produce useful models of ritual change. The models have highlighted that processes leading to ritual diversity are quite different depending on the ritual form. Mortuary traits seem to be type 4, they appear quite labile and are perhaps shaped more by diffusion than inheritance. Rock motifs appear to be type 3, phylogenetically tractable, perhaps because they are relatively neutral like language cognates, but having an independent history unrelated to the other cultural forms studied here. Initiation rituals seem to be type 2, their close (but not identical) phylogenetic association with language suggests they may be core to the Pama-Nyungan cultural tradition. Whilst mythical narratives linked to initiation seem to have been transmitted quite frequently between neighbours, this analysis suggests that, within the broad language areas applied here, at least some traits associated with the rites themselves have been resistant to such change.

The similarity in phylogenetic trees suggests initiation rites could be as old as language. Whilst this may seem surprising it does make intuitive sense; initiation is closely tied to group membership which in turn is closely tied to the language the group speaks. Such ritual longevity is not unknown. One familiar example is the Jewish rite of infant circumcision which is at least 2,500 years old (Wenham 1979). The association between

initiation and language provides some support to the hypothesis, discussed in the Introduction, that new ritual systems were one of the changes leading to Pama-Nyungan expansion (Evans & McConvell 1998). In the next chapter this idea is examined more closely. Firstly, analysing which individual traits are associated with language and, secondly, whether there is any evidence that such traits had a specific role in Pama-Nyungan expansion.

Chapter 3: Ritual trait variation and language

In the previous chapter, useful evolutionary models were developed by analysing each type of ritual holistically. In this chapter, a more fine-grained approach is adopted, examining variation at the level of individual trait and ethnolinguistic group (as opposed to language area). The aim is to answer a key question in the study of Australian ritual, whether the adoption of new, more complex ritual systems played a key role in the expansion of Pama-Nyungan societies, whose languages came to be spoken over more than 90% of the Australian continent.

As reviewed in the Introduction, language expansions such as Indo-European, Austronesian and Bantu, were likely influenced by known factors such as agriculture and technological development (Bellwood & Renfrew 2002, Gray *et al.* 2009, Currie *et al.* 2013). Much less is known about why hunter-gatherer expansions, such as Pama-Nyungan, might have taken place although they are likely to have occurred many times in the past (Anthony 1990, McConvell 2001). Their examination may help us understand more about the forces which have shaped human cultural diversity and enabled populations to inhabit most of the world's ecological niches (Bellwood 2013). As Pama-Nyungan is the only large-scale hunter-gatherer expansion for which a linguistic phylogeny is available, it provides a unique opportunity to apply quantitative methods to examine the reasons behind it. Calibrating the phylogeny using archaeological evidence for entry into the Western Desert around 3,000 years ago (Veth 2000), suggests initial expansion may have begun some 6,000 years ago (Bouckaert *et al.* 2018). Archaeological evidence from other regions suggests increases in Australian population during this period, possibly linked to the transition to a post-glacial climate and less arid conditions (Lourandos 1997, Hiscock 2007, Williams *et al.* 2015). Other changes are suggestive of new processes that could be related to language expansion during this time, including increased prevalence of multi-purpose small stone tools (Lourandos 1997, Hiscock 2007), new food production techniques (Beaton 1977, Lourandos 1983, Smith 1986) and evidence of large gatherings (Flood 1980, Lourandos 1997).

Building on this work, Evans & McConvell (1998) suggested that the development of complex ritual may have played a significant role in Pama-Nyungan expansion and their hypothesis frames the central question of this chapter. They suggested adoption of a more 'open culture of outward-reaching social alliances' was the driving force behind

expansion, which was achieved through a combination of new kinship systems and the introduction of large-scale ceremonial activity. Such events supported the formation of new alliances through joint-staging by members of different groups (the English terms 'owner' and 'manager' are often used by Indigenous Australians to explain these roles) and through their focus on epic cultural performances. The narrative elements of these, and their corresponding rights of enactment, tend to be shared across a number of territories and languages. Ceremonies are frequently orientated around lengthy novice initiations that, via the ritual and technical instruction taking place, provided a mechanism of transmission for this new culture. For the hosts, ceremonial events provided a source of potential spouses and the opportunity of dwelling in the wives' country. For newly invited groups, advantages included access to new material items via exchange networks, new food processing techniques, and participation in a richer, more elaborate ceremonial culture than their homeland. Control of marriage and ceremonial structures would increase the potential for shift to the language of the host group via direct transmission (as Pama-Nyungan males married out into the new groups), and via adoption (as a prestige language associated with an expansive new culture). Later waves of expansion into arid desert regions would have relied even more heavily on the ideologies of alliance and interdependence, because ability to retreat into neighbours' areas would be crucial in such hostile environments. The development of extended alliances through ritual and kinship, and its potential link to Pama-Nyungan expansion, has also been covered in Evans & Jones (1997), McConvell (2001) and O'Grady & Hale (2004).

In his analysis of rock motifs, Layton (1992: 245) also sees the development of kinship and ritual systems, in particular related to clan totemism, as critical changes taking place in the Pama-Nyungan period. Clans would have provided a more flexible means of organising relationships during a period of less predictable resources. New clan identities, cross-cutting existing relationships, needed to be reinforced through the introduction of ceremonial gatherings and new forms of rock imagery were developed to signify new social obligations and memberships. His analyses, and that of Morwood's (1986), suggest expansion in geometric motif forms, particularly in central and eastern Australia, could be related to this change. In these regions, geometric designs appear to have a sacred, ceremonial function whereas figurative motifs tend to be secular, related to hunting and foraging routes (Layton 1992: 237, 241). There are, however, exceptions to this generalisation, reflecting changing traditions within the Pama-Nyungan timescale as well as localised variation (*ibid*, 237). For example, as discussed in chapter 2, the large

figurative motifs in the Sydney area of south east Australia area appear to have particular ritual significance.

Mortuary rituals have not been specifically linked to Pama-Nyungan expansion but their features, such as complex rites, enactments and large-scale gatherings, suggest they may be relevant. Narratives are frequently associated with guiding the deceased spirit to their clan estate, which could be interpreted as maintaining the continued attachment of clans to territory (Peterson 1972). Rites may involve multiple stage (or compound) body disposal and associated ceremonies linked to ancestral lands. As discussed in chapter 2, compound disposal has been theorised as an imported tradition from south east Asia (Arthur & Morphy 2005) but could plausibly be related to the development of clan totemism, and the changes in kinship and ritual obligations hypothesised to be linked to Pama-Nyungan expansion.

This theoretical background suggests there may be a strong association between ceremonial systems and Pama-Nyungan language change. Ritual, in conjunction with kinship, may have played a critical role in extending social alliances, leading to Pama-Nyungan success. If this hypothesis is valid, we would expect ritual traits associated with initiation (particularly those linked to complex, elaborate ceremony), geometric rock motifs and possibly compound mortuary disposal to be most closely associated with language. Such a finding would support the idea of ritual being integral to Pama-Nyungan culture. However, such traits could simply be neutral, passed along with language change without conferring any particular benefit. To provide positive evidence for the theory of ritual advantage, I examine whether these traits can be actively connected to Pama-Nyungan success through association with a greater degree of language diversification. This is measured by comparing rates of phylogeny diversification when ritual traits are present to when they are not.

The chapter is in three parts, firstly, examining the trait's phylogenetic signal. This is a measure of the extent to which clustering of trait presence mirrors that of the language phylogeny. If the signal is significant, it suggests the trait has been conserved as part of linguistic history and might therefore be linked to language expansion. Secondly, the potentially confounding effect of geographic proximity is examined. Since language and geography are often closely related, a trait might appear to vary with language when in fact proximity is a better explanation. Such traits are more likely to have been horizontally transmitted and excluding them allows us to better identify traits with true phylogenetic signal. To examine trait variation with geography, an autologistic model developed by Towner *et al.* (2012) is used. This compares neighbour graphs of language similarity and

geographic proximity to trait distribution to assess whether trait variation is best explained by language, geography or some other factor.

Thirdly, traits are examined for an active connection to Pama-Nyungan expansion by measuring their association with linguistic diversity. As discussed in the Introduction, it is important to clarify here what is meant by language expansion. The Pama-Nyungan family has expanded both geographically, to cover 90% of the Australian continent, and in its diversity, to encompass over 300 separate languages. Typically, though not necessarily, such processes occur together. As speaker numbers expand across a territory (due to replacement of existing languages or migration into new habits) ecological self-sufficiency and the isolating action of natural landscape barriers tends to slow the spread of linguistic variants. This leads to an accumulation of language change that ultimately results in languages becoming distinct from their neighbours (Collard & Foley 2002, Axelsen & Manrubia 2014). In the case of Pama-Nyungan, geographic expansion does appear to be associated with linguistic diversification. The regular patchwork of language distribution throughout the continent is suggestive of an on-going fissioning process (see figure 0.1). The relatively small size of Pama-Nyungan groups also points to a regular pattern of diversification. Reliable data in this area is sparse due to the difficulty of recording numbers for mobile hunter-gatherers and the impact of colonial expansion and violence on population sizes. However, bearing these caveats in mind, available information suggests most groups consisted of only a few hundred speakers and large linguistic groups were relatively rare. In the Binford database (2001), the mean population size of 39 Pama-Nyungan language groups was 800, ranging from a low of 80 speakers up to a maximum of 3,500.

In this study, I use a novel method, BiSSE (Binary Speciation and Extinction - Maddison *et al.* 2007), to examine whether greater linguistic diversity (as defined by larger clades in the phylogeny) is associated with the presence of particular ritual traits. As language diversification appears to be linked to the expansion of Pama-Nyungan speakers, positive results from this analysis would suggest such traits may have supported, or been linked in some way, to the geographic expansion of people speaking Pama-Nyungan languages.

Measuring phylogenetic signal

Phylogenetic signal provides an indication of the extent to which trait distribution mirrors a given phylogeny. This was measured used the D value method, designed for discrete or binary traits (Fritz & Purvis 2010). When the signal is high, trait differences between close relatives on the phylogeny (those in sister lineages) will be small because they share

similar values; in the case of binary traits either all 1's or all 0's. Subtraction of one value from another will result in only a small difference which approaches zero if the trait distribution exactly mirrors the phylogeny. When the phylogenetic signal is low, sister lineages of the tree will contain traits with different values; for binary traits a mix of 1's and 0's and therefore the differences between them will tend to be higher. The D value model calculates the average of these sister clade differences for each trait across the phylogeny. Values close to or below 0 indicate the trait has high phylogenetic signal, whereas those close to or above 1 indicate the signal is low. Values are compared to a null model of trait distribution where D=1 (traits distributed randomly), to assess their statistical significance.

To prepare the trait data for analysis, small adjustments were made to the Chapter 1 dataset. Societies not included in the Pama-Nyungan phylogeny (due to insufficient language data) were removed: 9 from initiation and 8 from mortuary. One trait (#34 *mothForms*) was removed from rock motifs because it is only present in one society, therefore not phylogenetically informative. Two traits previously removed from the Meehan mortuary dataset for the phylogenetic modelling (because of non-independence vs more specific traits) were added back to the data for this analysis (*burials-all* and *compound disposals-all*). Summary data for the analysis is set out in table 3.1. The three datasets are included in Appendix 3 (worksheets InitData, MortData and RockData).

	#societies	**#traits**
Initiation ritual	100	27
Mortuary ritual	126	26
Rock motifs	47	37

TABLE 3.1 NUMBER OF SOCIETIES AND TRAITS ANALYSED IN D VALUE MODEL.

D value results

D values were calculated using the *phylo.d* function in R (included in the *caper* phylogenetics package) using the Pama-Nyungan consensus tree (Bouckaert *et al.* 2018, supplementary information). Results are included in Appendix 3_Dvalues and shown graphically in figure 3.1 and summarised in table 3.2. Observed D values were compared to the null model of random trait distribution (D=1), calculated using 1,000 simulations of randomly shuffled trait values. Compared to this null model, a statistically significant phylogenetic signal ($p<0.05$) was demonstrated for 100% (27/27) of initiation traits, 58% (15/26) of mortuary traits and 24% (9/37) of rock motifs.

For initiation, results provide additional confidence in the chapter 2 findings of close similarities between initiation and language phylogenies. Since D value analysis is at the individual language level, it also suggests using language areas (and majority rule for trait presence) in the chapter 2 modelling did not greatly compromise variation in the dataset. Since all traits have linguistic signal they can all be considered potentially relevant to Pama-Nyungan expansion. For mortuary ritual, D value results suggest more phylogenetic structure than found in the previous chapter, with some traits possibly relevant. There is no obvious clustering of trait type; those with statistically significant D values include methods of body disposal, corpse treatment and grave preparation and marking. For rock motifs, only 9 traits (24%) had statistically significant D values. This is consistent with chapter 2 findings demonstrating a lack of similarity between rock motifs and language. There was no bias toward particular types; 5 geometric motifs and 4 figurative motifs had phylogenetic signal.

	#traits	**#significant D (p<0.05)**
Initiation ritual	27	27
Mortuary ritual	26	15
Rock motifs	37	9

TABLE 3.2 TRAITS WITH STATISTICALLY SIGNIFICANT D VALUES.

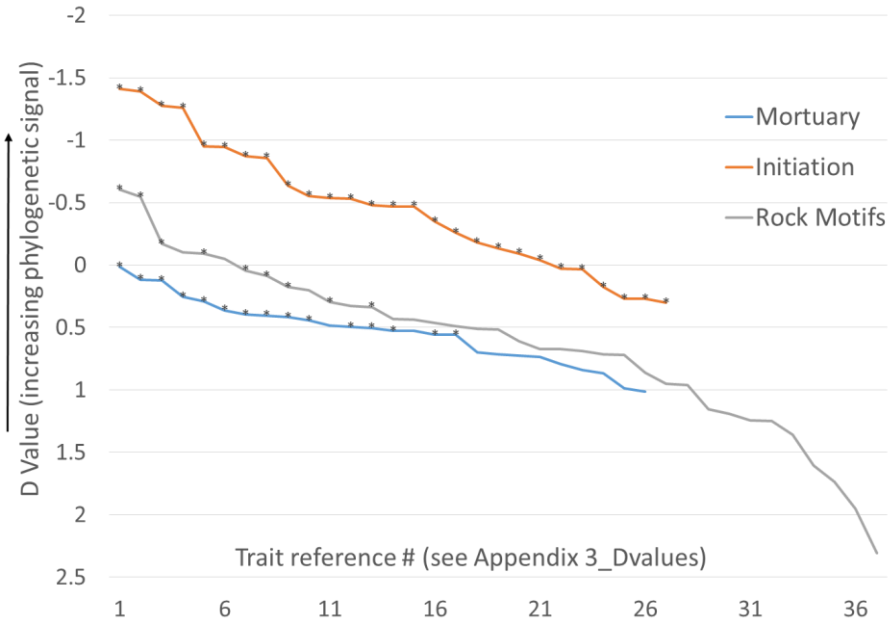


FIGURE 3.1 DISTRIBUTION OF D VALUES BY TRAIT AND BY RITUAL TYPE. LARGER NEGATIVE VALUES INDICATE INCREASING PHYLOGENETIC SIGNAL RELATIVE TO THE PAMA-NYUNGAN LANGUAGE PHYLOGENY. STARRED VALUES (*) ARE STATISTICALLY SIGNIFICANT (P<0.05) RELATIVE TO THE NULL DISTRIBUTION (D=1). TRAIT REFERENCE NUMBERS CORRESPOND TO THE DESCRIPTIONS LISTED IN APPENDIX 3_DVALUES; MORTUARY (TRAIT #'S 1-26), INITIATION (#'S 1-27) AND ROCK MOTIFS (#'S 1-37).

Autologistic modelling

This method tests whether evidence of phylogenetic signal from assessing D values is maintained when accounting for geographic proximity. Closely related Pama-Nyungan societies are often spatial neighbours and it is possible that trait clustering may be similar to the phylogeny because of horizontal transmission between societies. To examine geographic relationships, an autologistic model developed by Towner *et al.* (2012) was used to fit binary traits to phylogenetic and spatial neighbour graphs. Building on the work of Besag (1974 & 1975), the model assumes that trait presence or absence in each society depends probabilistically on its state in that society's spatial and linguistic neighbours. The strength of this dependence is measured by parameters λ (phylogenetic), θ (spatial) and β (a levelling parameter broadly analogous to the intercept in logistic regression). The autologistic model is fitted to each trait by an algorithm which predicts the trait value for each society in turn, determining the most suitable parameters λ, θ and β by combining results from many rounds of prediction. Parameter likelihoods are estimated through MCMC simulations using the Gibbs sampler (Geman & Geman 1984) to generate trait states.

For the analysis, a phylogenetic neighbour graph was constructed based on membership of the same language family, and a spatial neighbour graph based on distances between location co-ordinates for each society. As data on initiation and mortuary ritual is available for a relatively large number of societies, language families (as opposed to the larger language areas in chapter 2) were used to improve model resolution. These were defined by separating existing language areas *e.g. KulinNgarinyeric* to *Kulin* & *Ngarinyeric,* consistent with their phylogenetic grouping (figure 2.1), and ensuring, as far as possible, they contained a reasonable[3] number of societies. Allocation to language families is included in Appendix 1a_Allocation and a map of their locations in figure 3.2. Graphs were calibrated such that societies were connected to similar numbers of spatial and linguistic neighbours. Equalising these distributions ensures both neighbour types are able to have similar influence on a trait, ensuring their differential effects are reflected in the influencing parameters, θ and λ, rather than being a function of higher relative neighbour numbers (Towner *et al.* 2012). Metrics for each ritual are included in table 3.3.

[3] For initiation, for example, 15/20 (75%) families had at least 3 societies, 2 had 2 societies and 3 had 1.

	Initiation	Mortuary	Rock motif
Number of societies	100	143	49
Language families	20	22	12
Spatial radius (km)	300	350	450
Spatial neighbours:			
Total	280	555	103
Average per society	*5.6*	*7.8*	*4.2*
Unique	210	327	30
Linguistic neighbours:			
Total	288	557	111
Average per society	*5.8*	*7.8*	*4.5*
Unique	218	329	39

TABLE 3.3 NEIGHBOUR GRAPH METRICS.

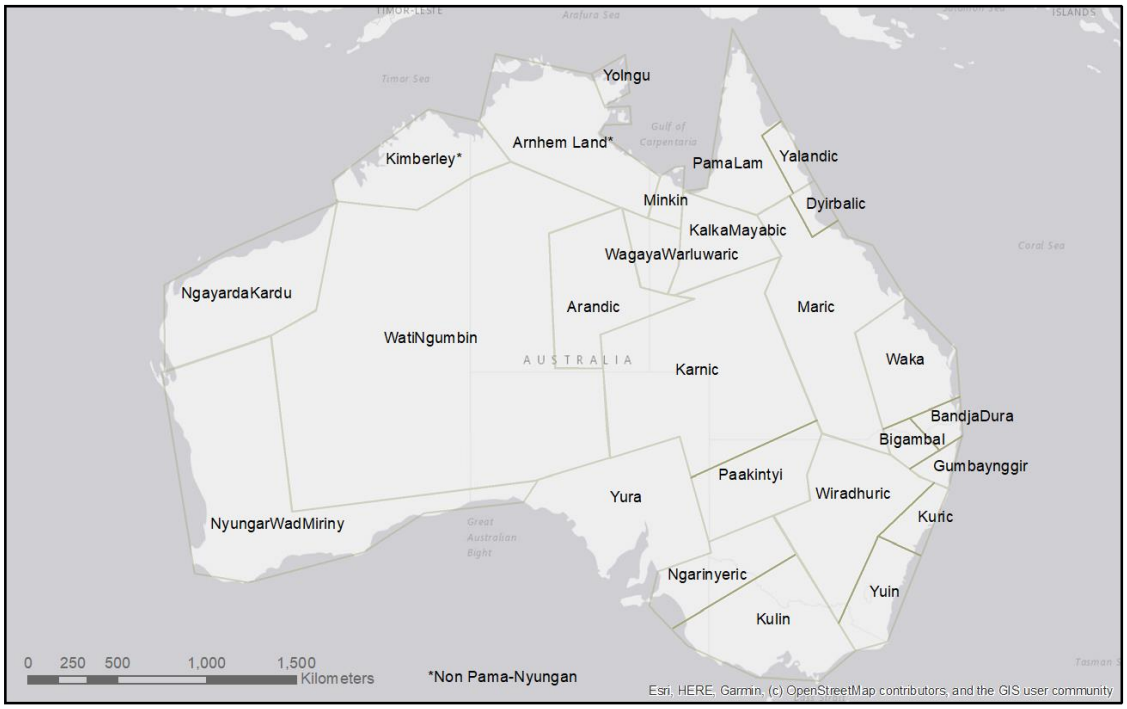


FIGURE 3.2 DISTRIBUTION OF LANGUAGE FAMILIES FOR AUTOLOGISTIC ANALYSIS.

To calibrate the graphs, societies were linked with radius distances that enabled matching of spatial and linguistic neighbours. For example, a 300km radius for societies with initiation data resulted in 280 spatial and 288 linguistic neighbours[4]. As expected, there

[4] Calibration used language and spatial pair matrices (neighbour pairs=1, non-neighbour pairs=0). For example, for initiation, 100 societies equates to 4,950 unique possible pairs of which 288 of were language family neighbours (and 4,662 were not). To find a similar number of spatial neighbours, different radii were examined and a value of 300km resulted in a close match

was some overlap between the two graphs (spatial neighbours often belong to the same linguistic family). However, all rituals had significant numbers of unique neighbours, enabling the separate effects of proximity and language to be identifiable in the model. For initiation, 75% (210/280) of spatial and 76% (218/288) of linguistic neighbours were unique. Mortuary ritual had 59% unique pairs of both spatial and linguistic neighbours, and rock motifs 29% unique spatial and 35% unique linguistic neighbours.

Neighbour graphs were prepared from the dataset using *Rgraphviz* (Gentry *et al.* 2019) and code supplied by Towner. They are shown in figure 3.3 for two example traits: rock motif *concentricCircles* and male initiation practice *circumcision*.

compared to language (280 neighbours). The number of unique neighbours was calculated by tabulating and comparing neighbour pairs between spatial and language.

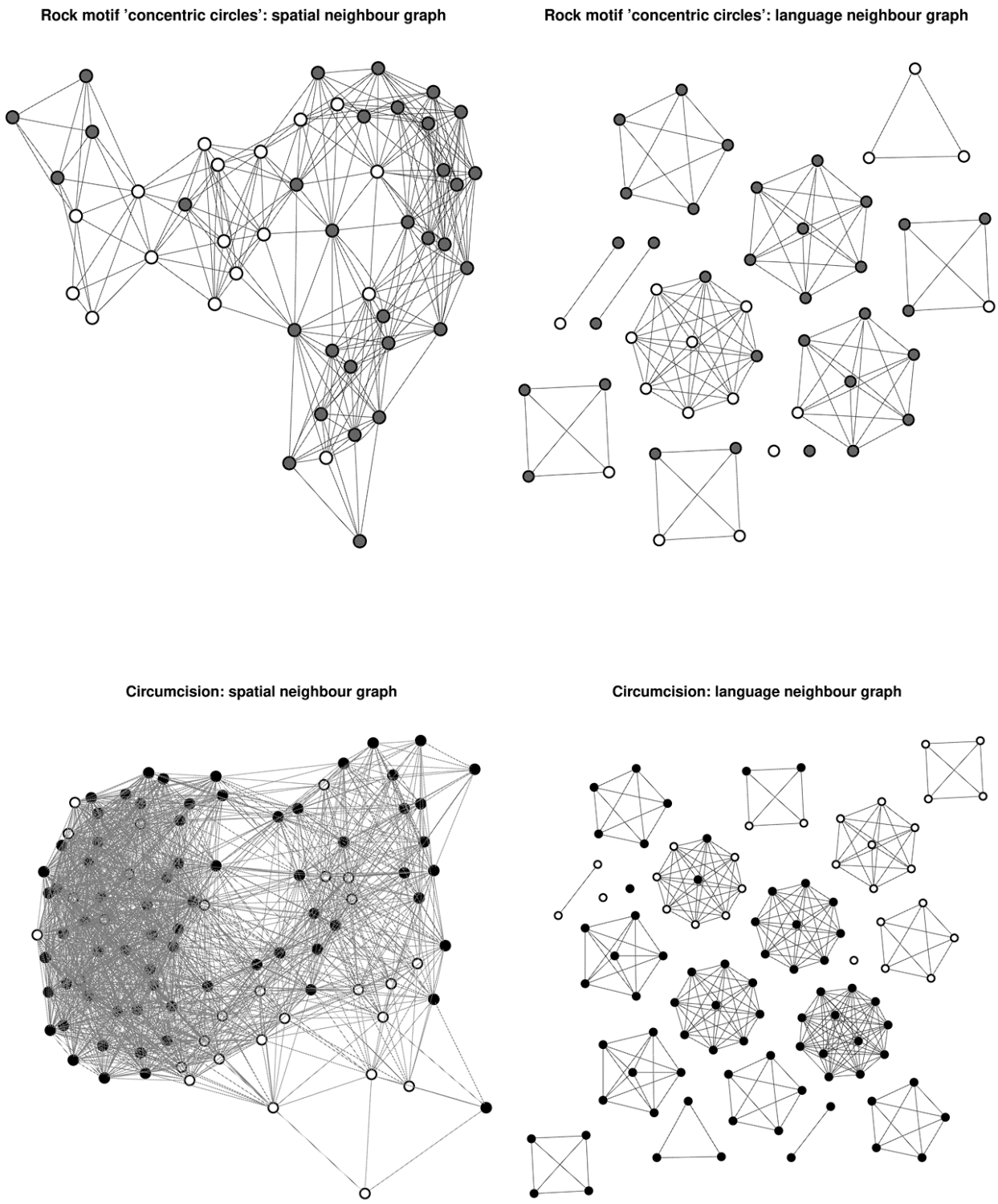


FIGURE 3.3 SPATIAL AND LINGUISTIC NEIGHBOUR GRAPHS FOR THE ROCK MOTIF *CONCENTRICCIRCLES* (ABOVE) AND THE INITIATION TRAIT *CIRCUMCISION* (BELOW). CLEAR CIRCLES REPRESENT SOCIETIES WHERE THE MOTIF IS PRESENT AND SOLID GREY CIRCLES WHERE NOT. GRAPHS WERE PREPARED USING *RGRAPHVIZ* (GENTRY *ET AL.* 2019), SELECTING THE "NEATO" LAYOUT OPTION. IN THE SPATIAL ROCK MOTIF GRAPH (ABOVE), GREY LINES CONNECT SOCIETIES SEPARATED BY LESS THAN 450 KM. OPTIMAL PARAMETER VALUES FROM AUTOLOGISTIC MODELLING WERE θ (SPATIAL) = +0.29 AND λ (LANGUAGE) = -0.03. THE GREATER INFLUENCE OF SPATIAL NEIGHBOURS CAN BE SEEN; SOCIETIES WITH THE MOTIF FORMING LINKED 'CHAINS' SUGGESTING SHARING BETWEEN NEIGHBOURS (LEFT HAND CHART). CONNECTIVITY VIA LANGUAGE IS LESS NOTABLE (RIGHT HAND CHART). IN THE SPATIAL *CIRCUMCISION* GRAPH (BELOW), GREY LINES CONNECT SOCIETIES SEPARATED BY LESS THAN 300 KM. CONTINUED ON FOLLOWING PAGE.

FIGURE 3.3 (CONT.) OPTIMAL PARAMETER VALUES FROM AUTOLOGISTIC MODELLING WERE θ (SPATIAL) = 0.00 AND λ (LANGUAGE) = +0.29. THE GREATER INFLUENCE OF LANGUAGE NEIGHBOURS CAN BE SEEN; THOSE SOCIETIES WITH THE TRAIT TENDING TO CLUSTER IN FAMILIES (RIGHT HAND CHART). SPATIAL CONNECTIVITY BETWEEN SOCIETIES WITH THE TRAIT IS LESS NOTABLE (LEFT HAND CHART). NOTE THE LARGE NUMBER OF SPATIAL CONNECTIONS COMPARED TO ROCK MOTIFS REFLECTS A DOUBLING IN THE NUMBER OF SOCIETIES AND A 33% INCREASE IN AVERAGE NEIGHBOURS PER SOCIETY (SEE TABLE 3.3).

The greater influence of spatial proximity can be seen in *concentricCircles*, the motif forming linked 'chains' with neighbours whereas connectivity via language is less notable. In *circumcision*, influence is in the opposite direction; societies with the trait tend to be clustered in language families but spatial connectivity is less marked. The large number of spatial connections in initiation (compared to rock motifs) reflects a doubling of societies and a 33% increase in their average neighbours (see table 3.3).

Using neighbour graphs, language (λ) and spatial (θ) parameters were estimated for all ritual traits that had statistically significant D values in the previous analysis (51 in total, table 3.2). Analysis was in R using Towner *et al.*'s code. Priors were tuned for parameter values (λ, θ and β, the levelling parameter) for each trait in turn[5]. Final values were estimated using 6,000 Gibbs realizations sampled from 12,000 MCMC generations at an interval of two, with the first 600 generations discarded as burn-in.

Autologistic results

Results for the 51 traits by parameter value are included in Appendix 3_Autologistic, and the values for λ and θ are illustrated graphically in figure 3.4. Models generally fitted the data well with parameters predicting trait values for societies with an average 82% accuracy (range 67 - 94%). For comparison, Towner *et al.'*s original paper, which analysed 44 North American Indian cultural traits, had an average predictive accuracy of 83% (range 66 - 96%).

Individual traits were assessed to determine which had confirmed phylogenetic distribution. If trait presence depended more strongly on the effect of λ (linguistic neighbour) than of θ (spatial neighbour) it was considered evidence of confirmed signal. 41 traits (80%) met this criterion *i.e.* λ values > θ, and 10 did not (starred values on figure 3.4). In comparison, an analysis of Indo-European folktales using the Towner *et al.* autologistic model with the same criteria, found 76% of tales were more strongly influenced by their linguistic rather than spatial neighbours (Da Silva & Tehrani 2016). Of

[5] For each trait, likelihood density graphs were generated for each of the parameter pairs (λ/θ, λ/β and θ/β) to identify their optimum ranges for analysis.

the 41 identified traits, 26 relate to initiation. In only one of these did λ not exceed θ; male tooth extraction. Here, the spatial effect (θ = 0.14) was equivalent to linguistic (λ = 0.14) suggesting a prominent role for diffusion.

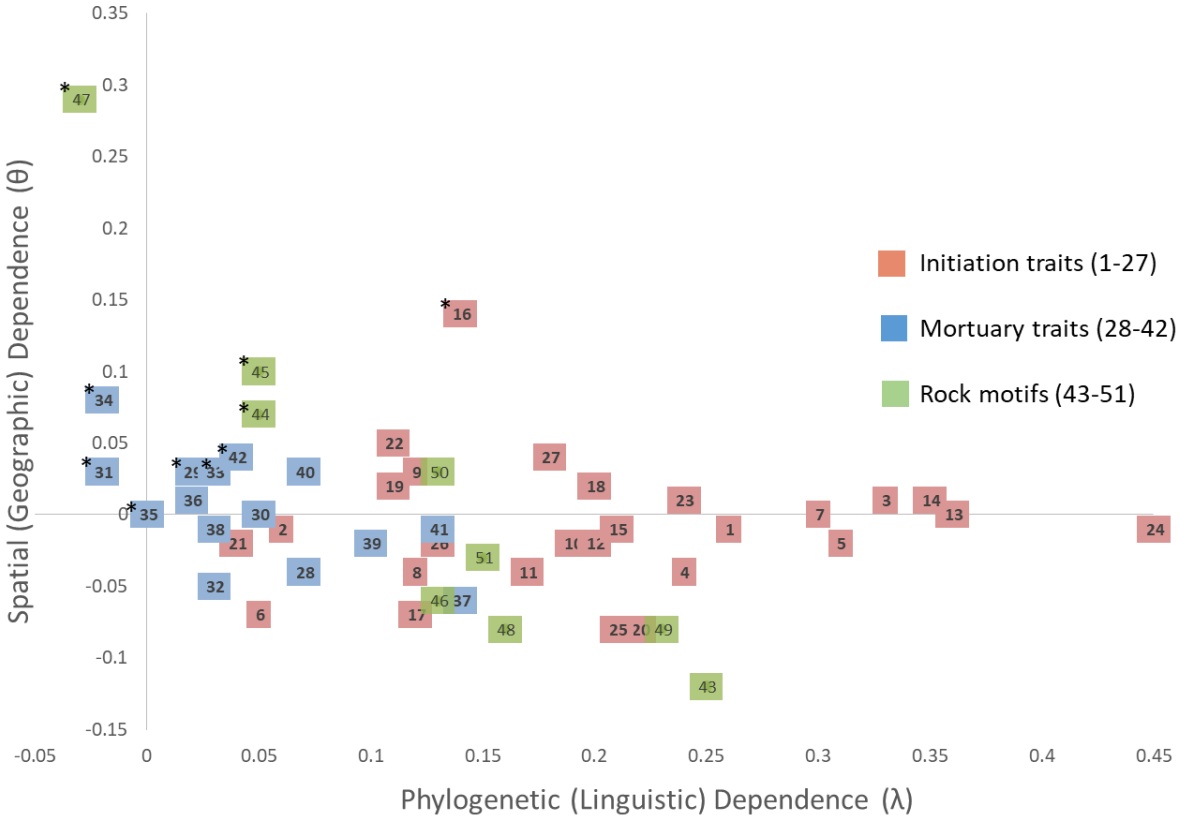


FIGURE 3.4 AUTOLOGISTIC MODELLING OF TRAITS, COLOUR CODED BY RITUAL TYPE. AXES REPRESENT THE LEVEL OF DEPENDENCE ON TRAIT DISTRIBUTION FROM PHYLOGENETIC (LINGUISTIC) NEIGHBOURS (HORIZONTAL AXIS), AND FROM SPATIAL NEIGHBOURS (VERTICAL AXIS). STARRED VALUES (*) HAD A SPATIAL CONTRIBUTION GREATER THAN OR EQUAL TO PHYLOGENETIC CONTRIBUTION AND WERE THEREFORE EXCLUDED FROM THE NEXT PHASE OF ANALYSIS (SEE TEXT). DESCRIPTIONS FOR EACH RITUAL TRAIT NUMBER ARE INCLUDED IN APPENDIX 3_AUTOLOGISTIC.

Nine mortuary traits had confirmed phylogenetic signal (λ > θ). Two were related to compound disposal (*CpdDisposalBurial* and *CpdDisposal-all forms*) suggesting they may be inherited practices which could be linked to Pama-Nyungan language change. This finding runs counter to the hypothesis discussed in chapter 2, that these practices may have arrived from south east Asia, spreading via diffusion from north to southern Australia. Six rock motifs had confirmed signal. Of these, four were figurative and only two geometric which does not support the link between development of geometric designs and Pama-Nyungan expansion. Geography seems to play an important role in motif distribution, with a number of motifs positive for spatial influence *e.g. concentricCircles, macropodFootprints* and *concentricArcs.* Such designs commonly represent 'birds-eye' views of marks left on the sand by animals, humans or ancestral

beings (see chapter 1 & Layton 1992: 148). In central Australia, they are frequently combined to depict journeys by Dreamtime beings that may coincide with optimal walking tracks between water holes or foraging routes *(ibid,* 55, 72). For example, the concentric circles used by the *Warlbiri* may signify either camp sites or the tracks of totemic species (Munn 1973). In the spatial neighbour graph example (figure 3.3) some societies with *concentricCircles* were visibly linked in a way which resembles motif usage (see figure 3.5). That such walking or dreaming tracks are often shared between societies may explain why, in this analysis, the effect of spatial neighbours is greater than linguistic neighbours for these motifs.

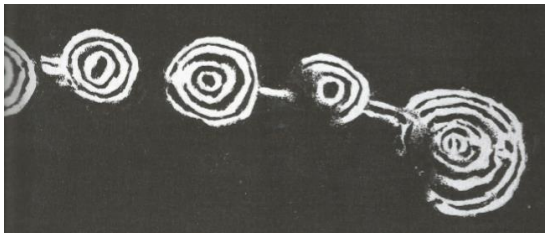


FIGURE 3.5 CONCENTRIC CIRCLES LINKED BY PARALLEL LINES, DEPICTING THE JOURNEY OF THE *K.* PYTHONS TO MUTITJULU, ULURU (LAYTON 1992: 53). ALSO DEPICTED ON COVER PAGE.

Autologistic results were also analysed in aggregate to establish whether different ritual types were subject to different influences. Mean values of positive and negative phylogenetic (λ) and spatial (θ) parameters, and the balancing parameter (β), were calculated across all traits for each of the three ritual types (table 3.4 & Appendix 3_Autologistic). Positive values indicate traits are more likely to be present in a society if they are also present in neighbouring societies. Negative values indicate traits are more likely to be present if they are *absent* in neighbours. To provide a measure of overall influence on ritual types from phylogeny and from geography, the integer values of positive and negative influences were summed together ('combined phylo' and 'combined geog' columns in table 3.4). For example, the overall influence from geography on initiation traits was 0.07 (positive 0.04 & negative 0.03).

Initiation has the strongest overall influence from phylogenetic (linguistic) neighbours (0.20) and a relatively low influence from geography (0.07), suggesting a close association to language, even when proximity is considered as a potentially confounding factor. Mortuary ritual had the lowest values for spatial and phylogenetic proximity (and the highest for the balancing β parameter), suggesting other factors have impacted trait distribution. This conclusion fits with the weak phylogenetic structure observed in

chapter 2, reinforcing the idea that mortuary ritual traits are quite labile. Different practices may have been widely adopted across societies, with variation observed in the ethnography perhaps more influenced by the social status of the deceased than by inherited tradition. Rock motifs were the most influenced by spatial neighbours (combined values of 0.19 compared to 0.07 (initiation) & 0.06 (mortuary), table 3.4) suggesting relatively high levels of diffusion, as discussed above. Rock motifs had the highest negative values (λ -0.03, θ -0.07) among ritual types, suggesting neighbour presence is more likely to result in trait absence. Potentially, such traits could be acting as unique identifiers of a society and it is possible that some rock motifs could be playing this role, perhaps acting as boundary markers to delineate territories (Layton 1992: 127). The largest negative motif (θ -0.12) is *mazeForms* which one could visualise as being used in this way *e.g.* to describe estate boundaries.

	+phylo (λ)	-phylo (λ)	Combined phylo	+geog (θ)	-geog (θ)	Combined geog	(-β)
Initiation	0.20	0.00	0.20	0.04	0.03	0.07	0.24
Mortuary	0.06	0.02	0.08	0.03	0.03	0.06	0.53
Rock motifs	0.14	0.03	0.17	0.12	0.07	0.19	0.19

TABLE 3.4 AUTOLOGISTIC RESULTS BY RITUAL TYPE.

The autologistic results suggest we can be relatively confident in the association between initiation practices and language, and that some mortuary traits and rock motifs may also be relevant. However, the results do not yet tell us whether such rituals had a role in Pama-Nyungan expansion. Traits might be neutral, transmitted along with population change without conferring any particular advantage. To better understand whether this might have been the case, the 41 identified traits were analysed using a novel method not previously employed in cultural analysis.

Diversification modelling

A key recurring question in evolutionary biology is how novel traits influence the diversification of species. Recent developments in modelling have enabled researchers to simultaneously infer the evolutionary rates of traits resulting in diversification, and the rates of speciation and extinction (the number of lineages gained and lost over time) of the phylogeny itself. BiSSE (Binary State Speciation and Extinction, Maddison *et al.* 2007) is one of the most popular tools in this field and has been used to examine the

diversification of a number of different species such as flowering plants (O'Meara *et al.* 2016), mammals (Price *et al.* 2012) and birds (Hugall & Stuart-Fox 2012). BiSSE computes the likelihood of the phylogenetic tree and observed binary trait distribution (0, 1) using state-dependent rates of speciation (λ_0, λ_1), extinction (μ_0, μ_1) and trait or character change (q_{01}, q_{10}). Maximizing this likelihood yields estimates for these six parameters, enabling not just speciation and extinction to be addressed, but also the rates of character state change that may be taking place. Hypotheses are tested using likelihood ratio tests, comparing unconstrained versus appropriately constrained models. Effectively, the model tests whether the phylogeny is more likely to have been produced if the rate of speciation is allowed to be higher (or lower) in regions of the tree where the trait is present. If this is the case, the trait is likely to have had an impact on tree (therefore species) diversification.

In applying this method to the cultural realm, I am using it to examine whether particular ritual traits are associated with language diversification. Since diversification (or fissioning) appears to be linked to the expansion of Pama-Nyungan speakers, positive results from this analysis would support the idea of these traits being linked to the geographic expansion of people speaking Pama-Nyungan languages. As discussed earlier, authors including Evans & McConvell (1998) have suggested that ritual advantage, introduced through the adoption of large-scale ceremonial activity, may have played a significant role in the expansion of Pama-Nyungan speakers across the continent. Such events could have supported the formation of new alliances through joint-staging by members of different groups and the use of lengthy novice initiations to provide a mechanism for onward transmission of the new culture. Control of ceremonial structures would increase the potential for shift to the language of the host group as Pama-Nyungan males married out into the new groups and the more prestigious language was adopted.

If the theory of ritual advantage is supported we would expect that diversification rates should be higher when ritual traits are present than when they are not. However, individual traits might be associated with language diversity for different reasons. They may be acting in isolation or, probably more likely, acting in concert with other traits as part of a ritual tradition (or broader cultural one). Unfortunately BiSSE does not currently allow traits to be modelled together (Pyron & Burbrink 2013) but, in this case, related ritual traits would be expected to have individually positive effects. It is also possible that traits might be linked to diversification for reasons unrelated to geographic expansion of the language family. They could, for example, have the same distribution as another factor impacting diversification, such as ecological conditions or features of the

landscape. Lastly, Pama-Nyungan expansion might also be associated with different ritual or cultural innovations in different regions, perhaps as a series of pulses as is thought to have been the case in the Austronesian expansion (Gray *et al.* 2009).

BiSSE likelihood calculations and hypothesis tests were carried out using the R package *Diversitree* version 0.9-13. The *make.bisse* function (FitzJohn *et al.* 2009) simultaneously simulates, for each of the trait or character states 0 and 1, rates[6] of speciation (λ_0, λ_1), extinction (μ_0, μ_1), and trait transition (q_{01}, q_{10}). Inferences about these rates are made based on their maximum likelihood[7] using the function *find.mle* (FitzJohn *et al.* 2009). This estimates the probability of observing the data (the language phylogeny and trait distribution) given proposed values for the six rate parameters. To estimate whether trait presence (state 1) leads to a statistically significant difference in speciation rate, a likelihood ratio test (LRT) is used, comparing, for each trait, the unconstrained six-parameter model to a five-parameter model with speciation rates constrained to be equal. If the unconstrained model ($\lambda_0 \neq \lambda_1$) has a higher likelihood of producing the phylogeny than the constrained model ($\lambda_0 = \lambda_1$), trait presence is inferred to have had a significant effect on its topology *i.e.* the tree's diversification profile. To assess the role played by character change, LRTs were also conducted for transition rates, comparing the unconstrained and constrained rates ($q_{01} = q_{10}$) models. The process for these calculations follows that laid out in the *Diversitree* manual (version 0.9-13, updated Jan 2020).

BiSSE uses a single, rooted, ultrametric tree (all taxa are equidistant from the root) for the maximum likelihood estimation and assumes this is fully resolved[8]. To preserve the complete Pama-Nyungan phylogeny, taxa were coded as gaps (NA) where trait data was missing. Because estimations rely heavily on phylogenetic structure, simulations suggest parameter certainty is not significantly compromised with decreasing character information, even when as few as 20% of taxa are included (FitzJohn *et al.* 2009). In this study, data on initiation and mortuary ritual exceeds that threshold but rock motifs are marginally below it (16%), which may impair the model's ability to resolve parameter differences. Another simulation study (Davis *et al.* 2013) suggested small overall sample sizes (*e.g.* less than 300 taxa in the phylogeny) can lead to reduced parameter accuracy.

[6] Rates are assumed to be constant over the phylogeny, meaning that average rates are being compared *e.g.* λ_0 & λ_1. Allowing variation would enable a more fine-grained analysis because traits may have greater or lesser effects at different points in the language expansion.
[7] There is currently no automated Bayesian option, which would allow use of a multiple tree sample to account for phylogenetic uncertainty.
[8] As with most phylogenies, extant taxa are likely to be missing from Pama-Nyungan. Simulation studies suggest this can lead to lower estimates of absolute speciation and extinction rates (Nunn 2011: 188). However, as this study is examining relative rates, the effect of such under sampling is expected to be much reduced.

Although the Pama-Nyungan phylogeny is marginally above this threshold (306 taxa) its relatively small size needs to be borne in mind when interpreting results. Furthermore, in the same study, low character state frequencies (*e.g.* below 10%) also resulted in reduced precision. In this analysis, 3 of the 41 ritual traits tested were below this threshold. These limitations are discussed further in the results section. Input data for the BiSSE analysis is shown in table 3.5.

	#societies	**proportion of phylogeny***	**#identified traits**
Initiation ritual	100	33%	26
Mortuary ritual	126	41%	9
Rock motifs	49	16%	6

*Pama-Nyungan majority-rule consensus tree includes 306 taxa (Bouckaert *et al.* 2018)

TABLE 3.5 SOCIETIES AND TRAITS ANALYSED USING THE BISSE MODEL.

Diversification results

Speciation rate ratios (λ_1/λ_0) were reported, rather than net diversification rates (speciation minus extinction rate), because the focus here is on the effect of trait presence on language expansion and because limitations in estimating extinction rates often result in low estimates (Pyron & Burbrink 2013, Simpson *et al.* 2018). This was the case in the analysis, with extinction rates for all traits estimated as zero or close to it. Transition rate results focused on the ratio towards character loss (q_{10}/q_{01}) in line with previous findings suggesting cultural traits are easier to lose than acquire (see chapter 2). Results for all 41 traits are included in Appendix 3_BiSSE. 20 traits had a statistically significant effect on diversification and these are shown in table 3.6 and figure 3.6.

	#identified traits tested	**Significant effect on λ_1/λ_0 ($p<0.05$)**	**Proportion**
Initiation ritual	26	15	58%
Mortuary ritual	9	3	33%
Rock motifs	6	2	33%

TABLE 3.6 TRAITS WITH A STATISTICALLY SIGNIFICANT EFFECT ON DIVERSIFICATION RATES, BY RITUAL TYPE.

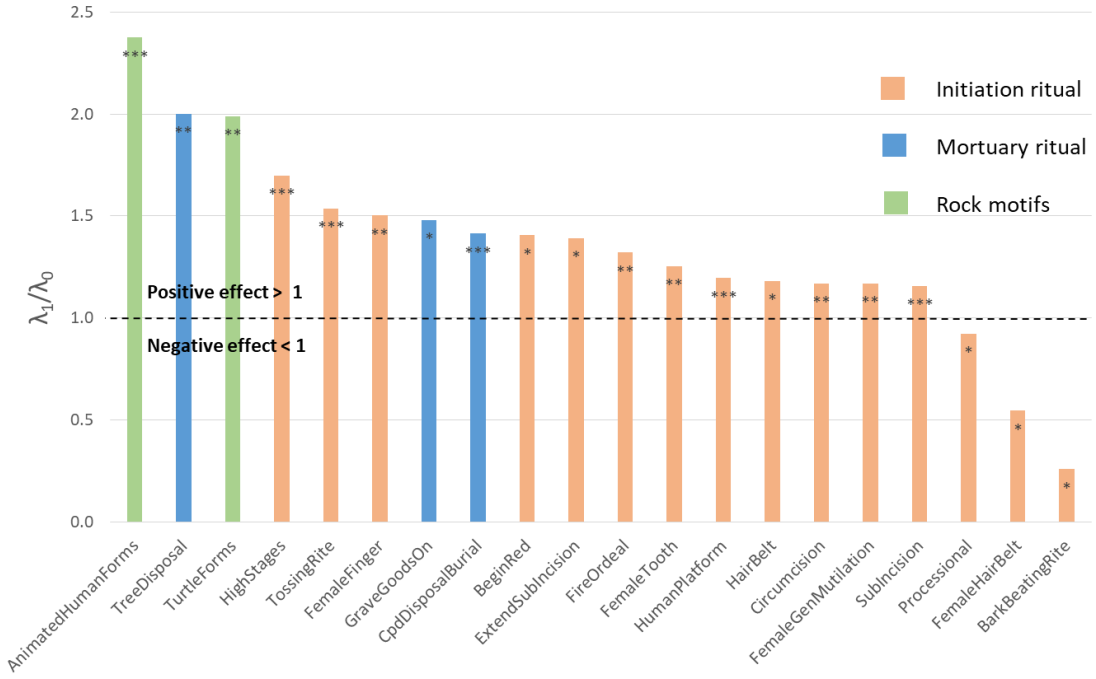


FIGURE 3.6 INDIVIDUAL TRAITS WITH A STATISTICALLY SIGNIFICANT EFFECT ON DIVERSIFICATION RATES (λ_1/λ_0) FROM MAXIMUM LIKELIHOOD *DIVERSITREE* ANALYSIS (***P < 0.001, **P < 0.01, *P < 0.05). 17 TRAITS HAD A POSITIVE EFFECT ON LANGUAGE DIVERSIFICATION AND 3 HAD A NEGATIVE EFFECT.

The presence of initiation traits had a generally positive effect on diversification. Of the 26 analysed, 15 (58%) were statistically significant and for 80% (12/15) of these the rate was higher when the trait was present. Results were therefore supportive of the hypothesis of ritual advantage. Three mortuary traits had a statistically significant positive impact: the presence of tree disposal, compound disposal with burial first, and the placing of personal items on the grave. Two rock motifs were significant: the presence of animated human motifs and turtle forms.

Given the relative novelty of using BiSSE to analyse cultural data, and the limitations outlined earlier (particularly the relatively small sample and phylogeny size), it is important to treat these results circumspectly. To examine whether their effect on diversification was plausible, the five traits with the most statistically significant results (***p<0.001 in figure 3.6) were plotted onto the language tree and modelled using maximum likelihood ancestral reconstruction (Mk1 model in *Mesquite v3.40*). A sixth trait, tossing rite, also had a p value below 0.001 but was excluded because its character presence (9% of taxa) was below the parameter accuracy threshold noted earlier (Davis *et al.* 2013). For visual clarity, each of the five traits were plotted onto a language tree pruned to the number of taxa for which data were available. The plots are included in figures 3.7 to 3.11.

The first three traits relate to initiation and the consistency of their distribution, both within and between traits, suggests a role in diversification is plausible. The presence of High Stages (more than 4 initiation stages) is mainly confined to one clade and has a reconstructed presence at ancestral node A, although only with 22% probability (see figure 3.7). Human Platform (figure 3.8) has a similar distribution but with a 100% probability of being present at the same node A. It is also reconstructed to nodes deeper in the phylogeny: B (100%) and C (54%). Sub-incision (figure 3.9) also has a reconstructed presence at these same nodes A (100%), B (100%) and C (79%). In addition, it has a 59% probability of being present at the root of the tree (node D). Taken together, the consistent distribution of the three initiation traits suggests an association with clade diversification is possible, and therefore that the BiSSE results are plausible. The one mortuary ritual trait with a highly statistically significant result, compound disposal with burial first (figure 3.10), had a relatively dispersed distribution but was reconstructed to two ancestral nodes: E (69%) and F (35%). The rock motif, animated human forms (figure 3.11), was reconstructed to deeper nodes G (63%) and H (97%) in different parts of the tree. The analysis for these two traits suggest their role in diversification is plausible, however the more dispersed distributions and generally lower ancestral node probabilities, suggests a lower level of confidence should be assigned to their involvement than is the case with initiation.

Transition rates (q_{10}/q_{01}) are also reported in Appendix 3_BiSSE. In comparison to the constrained model (rates set to equal), LRTs returned significant results for 24/41 ritual traits. Of these, 22 had a higher rate of loss (1-0) than gain (0-1), directionally consistent with findings from other cultural analyses. The mean average rate (q_{10}/q_{01}) was 25.2 (after excluding one large value) suggesting differential rates of character change are important for explaining the phylogenetic distribution of the trait. In chapter 2, phylogenetic model fit improved using differential character rates for rock motifs, but not for initiation and mortuary ritual. However, these results suggest such rates may continue to be important when considering individual trait variation and this topic is returned to in chapter 4.

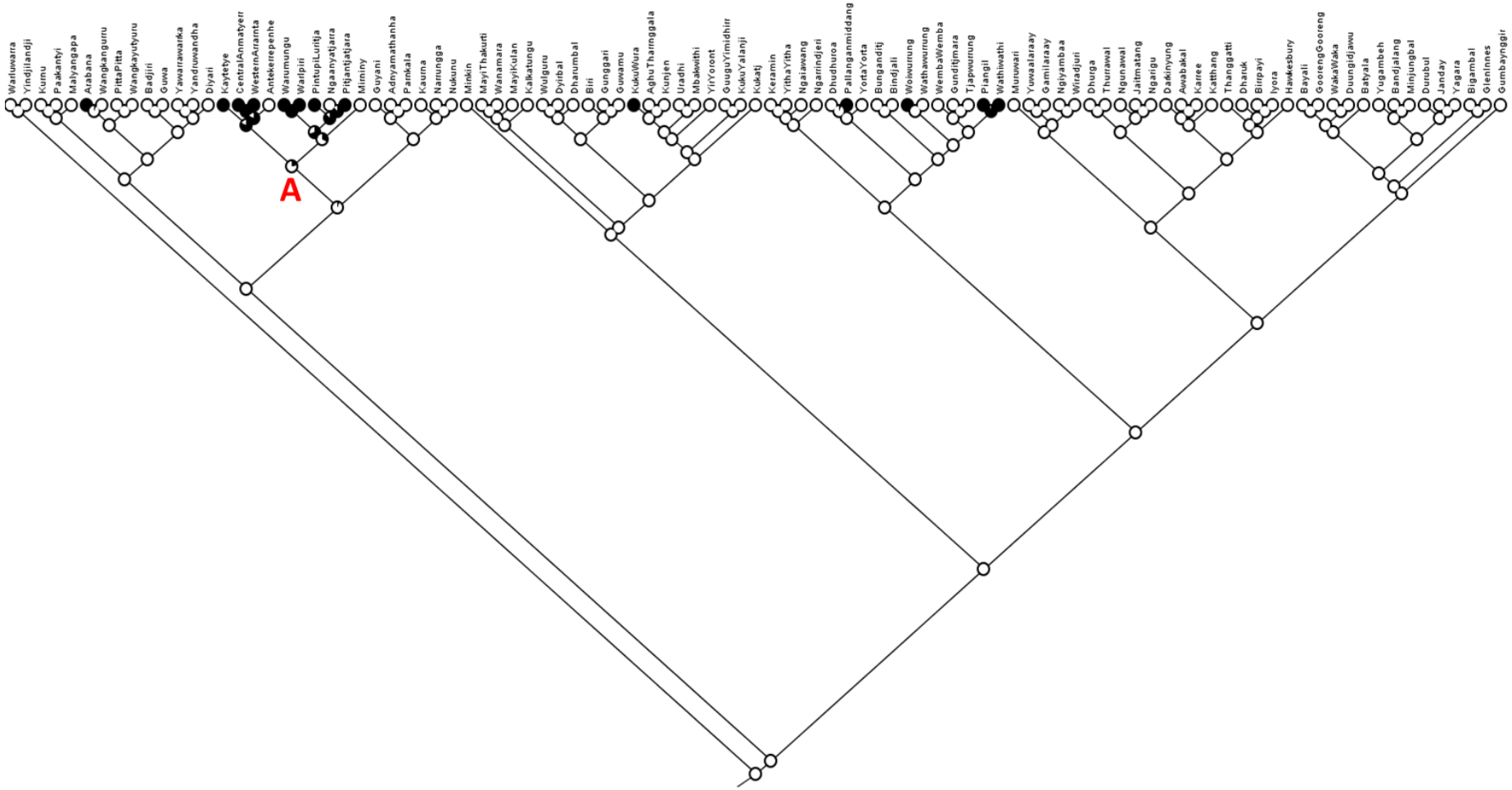


FIGURE 3.7 PRESENCE OF HIGH NUMBER (>4) OF INITIATION STAGES (IN BLACK) MAPPED TO PRUNED LANGUAGE TREE (100 TAXA). RELATIVE SHADING OF INTERNAL NODES IS PROPORTIONAL TO THE PROBABILITY THAT THE CHARACTER IS PRESENT IN THE ANCESTRAL STATE, BASED ON MAXIMUM LIKELIHOOD VALUES GENERATED USING THE MK1 MODEL IN MESQUITE V3.40. NODE A IS DISCUSSED IN THE TEXT.

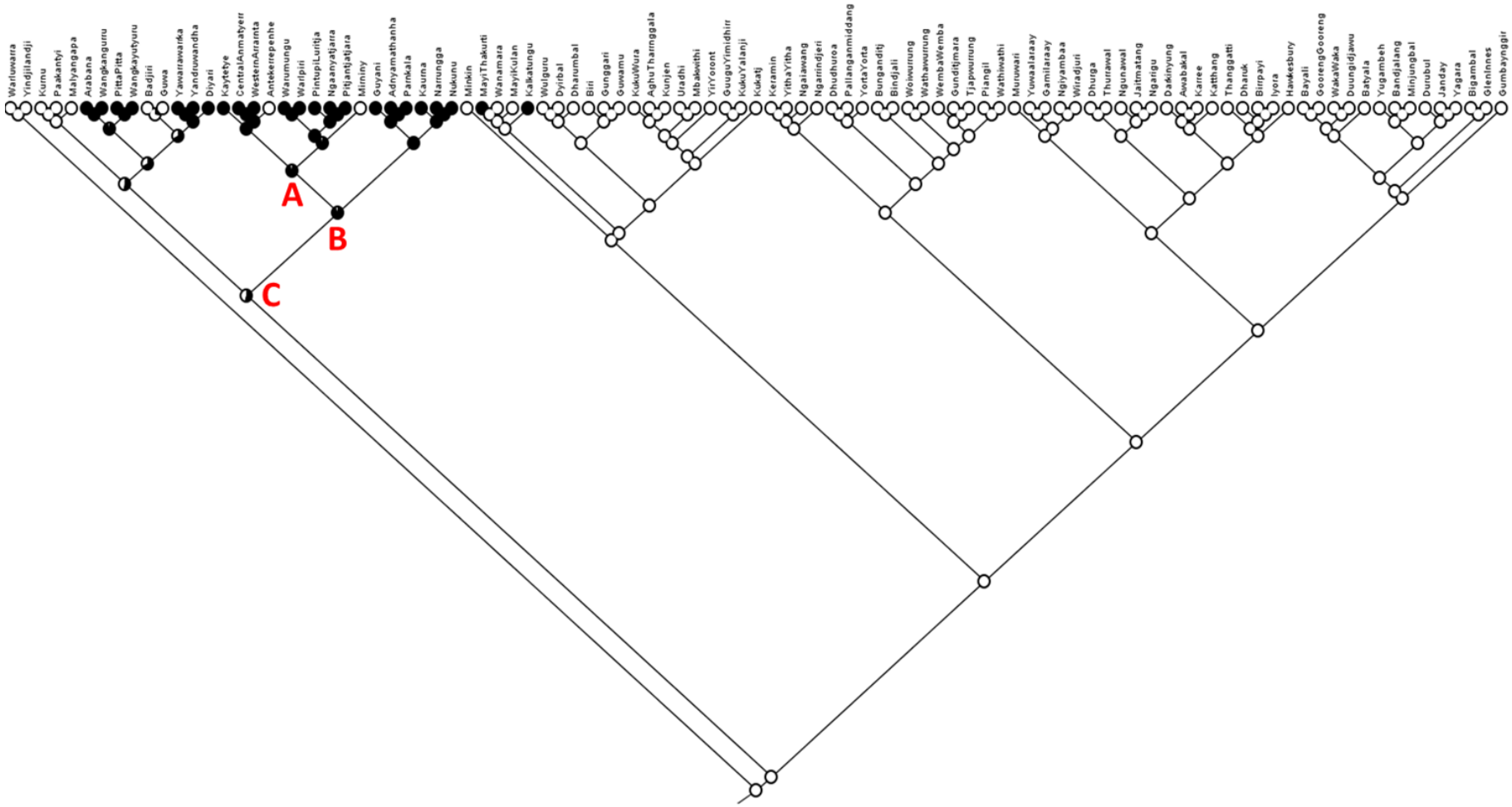


FIGURE 3.8 PRESENCE OF HUMAN PLATFORM IN INITIATION CEREMONIES (IN BLACK) MAPPED TO PRUNED LANGUAGE TREE (100 TAXA). RELATIVE SHADING OF INTERNAL NODES IS PROPORTIONAL TO THE PROBABILITY THAT THE CHARACTER IS PRESENT IN THE ANCESTRAL STATE, BASED ON MAXIMUM LIKELIHOOD VALUES GENERATED USING THE MK1 MODEL IN MESQUITE V3.40. NODES A, B & C ARE DISCUSSED IN THE TEXT.

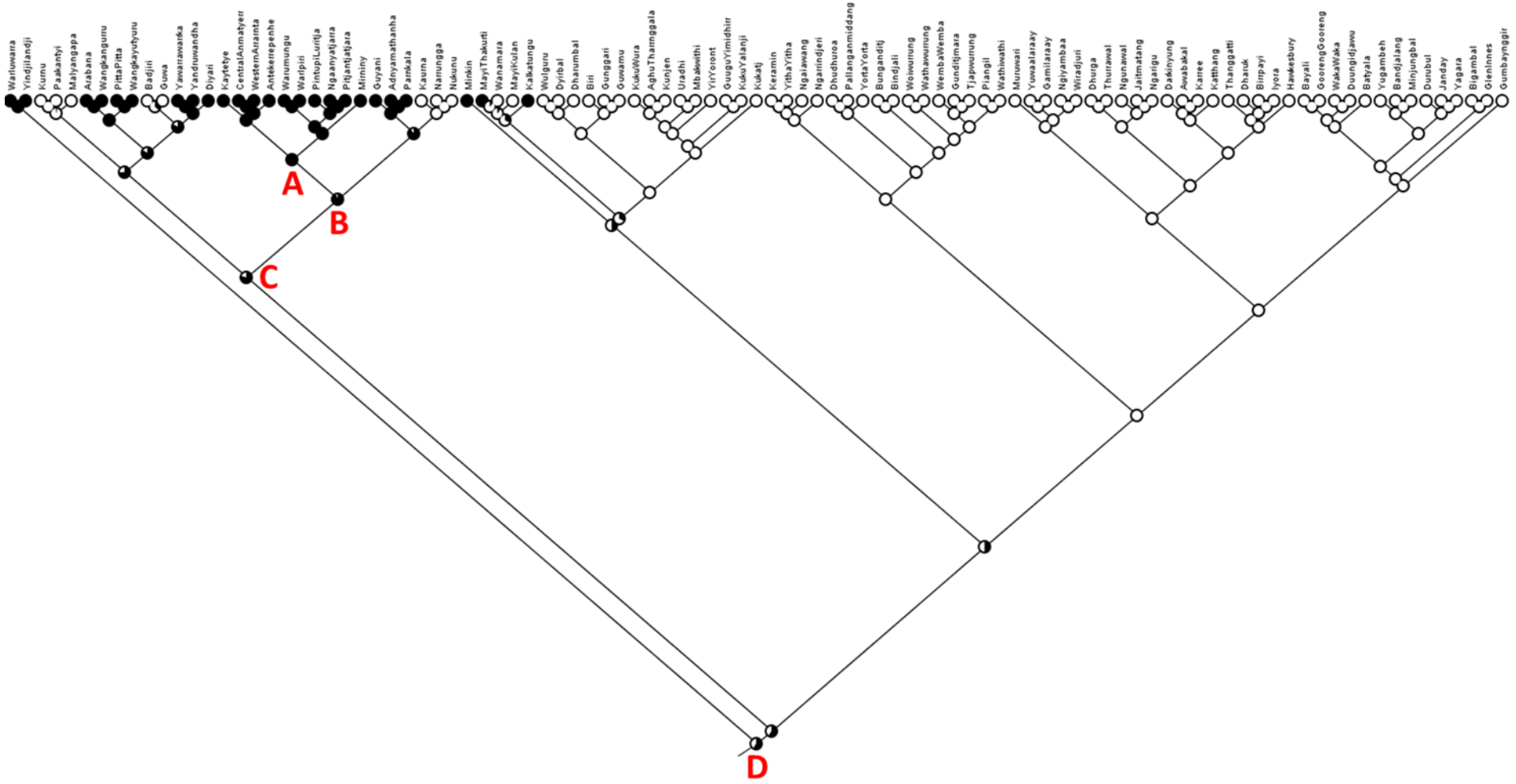


FIGURE 3.9 PRESENCE OF SUB-INCISION (IN BLACK) MAPPED TO PRUNED LANGUAGE TREE (100 TAXA). RELATIVE SHADING OF INTERNAL NODES IS PROPORTIONAL TO THE PROBABILITY THAT THE CHARACTER IS PRESENT IN THE ANCESTRAL STATE, BASED ON MAXIMUM LIKELIHOOD VALUES GENERATED USING THE MK1 MODEL IN MESQUITE V3.40. NODES A TO D ARE DISCUSSED IN THE TEXT.

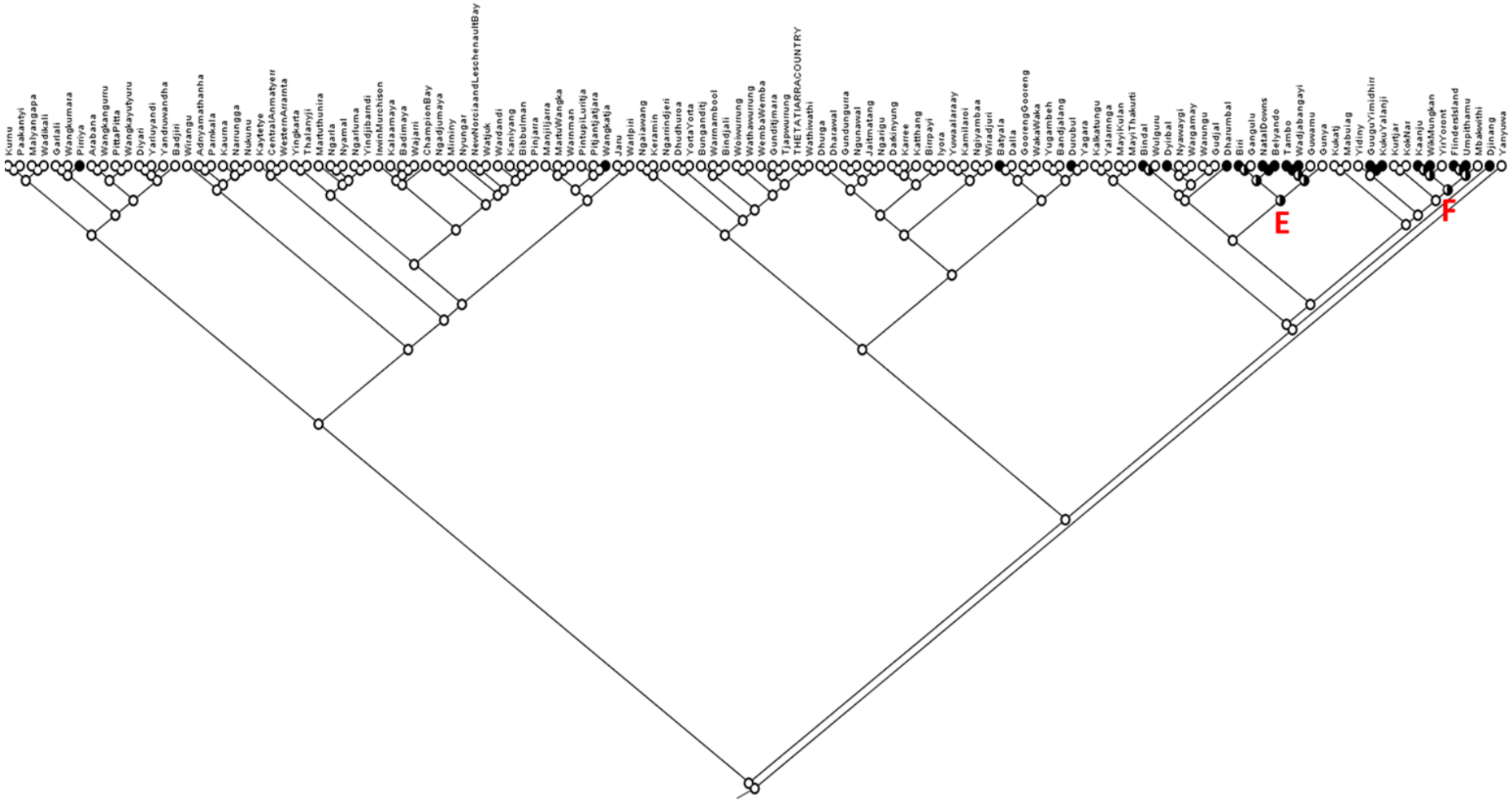


FIGURE 3.10 PRESENCE OF COMPOUND MORTUARY RITUAL-BURIAL FIRST (IN BLACK) MAPPED TO PRUNED LANGUAGE TREE (126 TAXA). RELATIVE SHADING OF INTERNAL NODES IS PROPORTIONAL TO THE PROBABILITY THAT THE CHARACTER IS PRESENT IN THE ANCESTRAL STATE, BASED ON MAXIMUM LIKELIHOOD VALUES GENERATED USING THE MK1 MODEL IN MESQUITE V3.40. NODES E & F ARE DISCUSSED IN THE TEXT.

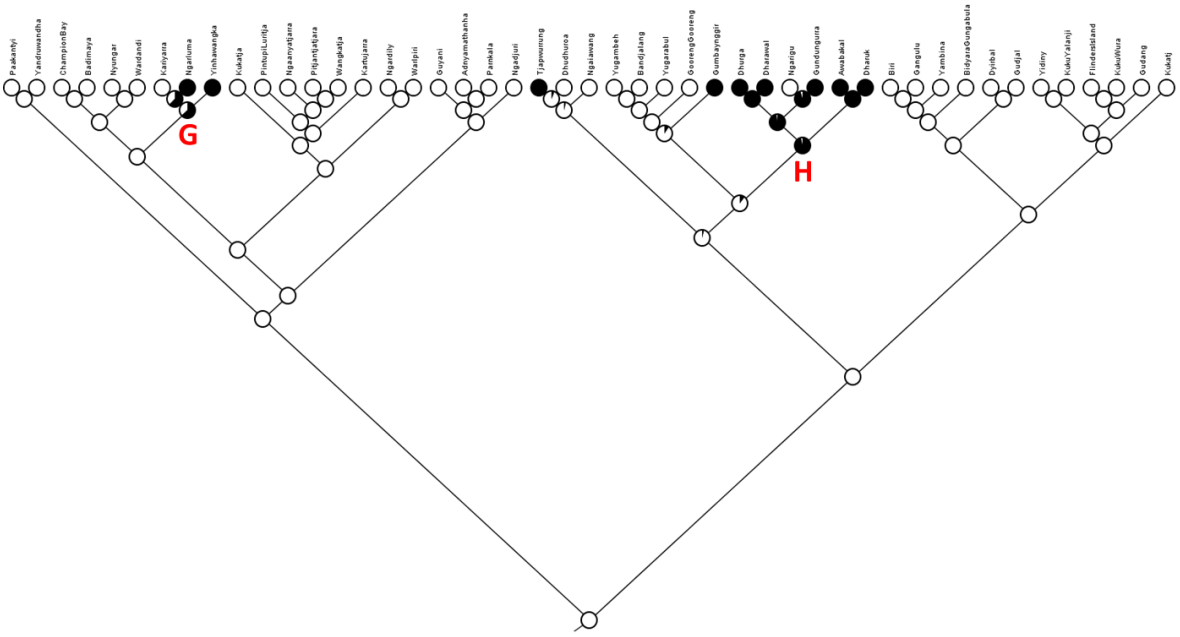


FIGURE 3.11 PRESENCE OF ANIMATED HUMAN FORMS ROCK MOTIF (IN BLACK) MAPPED TO PRUNED LANGUAGE TREE (47 TAXA). RELATIVE SHADING OF INTERNAL NODES IS PROPORTIONAL TO THE PROBABILITY THAT THE CHARACTER IS PRESENT IN THE ANCESTRAL STATE, BASED ON MAXIMUM LIKELIHOOD VALUES GENERATED USING THE MK1 MODEL IN MESQUITE V3.40. NODES G & H ARE DISCUSSED IN THE TEXT.

Transition rates (q_{10}/q_{01}) are also reported in Appendix 3_BiSSE. In comparison to the constrained model (rates set to equal), LRTs returned significant results for 24/41 ritual traits. Of these, 22 had a higher rate of loss (1-0) than gain (0-1), directionally consistent with findings from other cultural analyses. The mean average rate (q_{10}/q_{01}) was 25.2 (after excluding one large value) suggesting differential rates of character change are important for explaining the phylogenetic distribution of the trait. In chapter 2, phylogenetic model fit improved using differential character rates for rock motifs, but not for initiation and mortuary ritual. However, these results suggest such rates may continue to be important when considering individual trait variation and this topic is returned to in chapter 4.

Discussion

This chapter has focused on the role of ritual advantage in Pama-Nyungan expansion and which traits might have been involved. The approach followed is summarised on figure 3.12. 90 initial traits were narrowed to 51 using D values to identify those with linguistic signal. These were reduced to 41 after removing the effect of geographic proximity, estimated using autologistic modelling. Finally, the BiSSE diversification model was used

to identify those with a positive impact on diversification, indicating a possible 20 traits linked to Pama-Nyungan expansion.

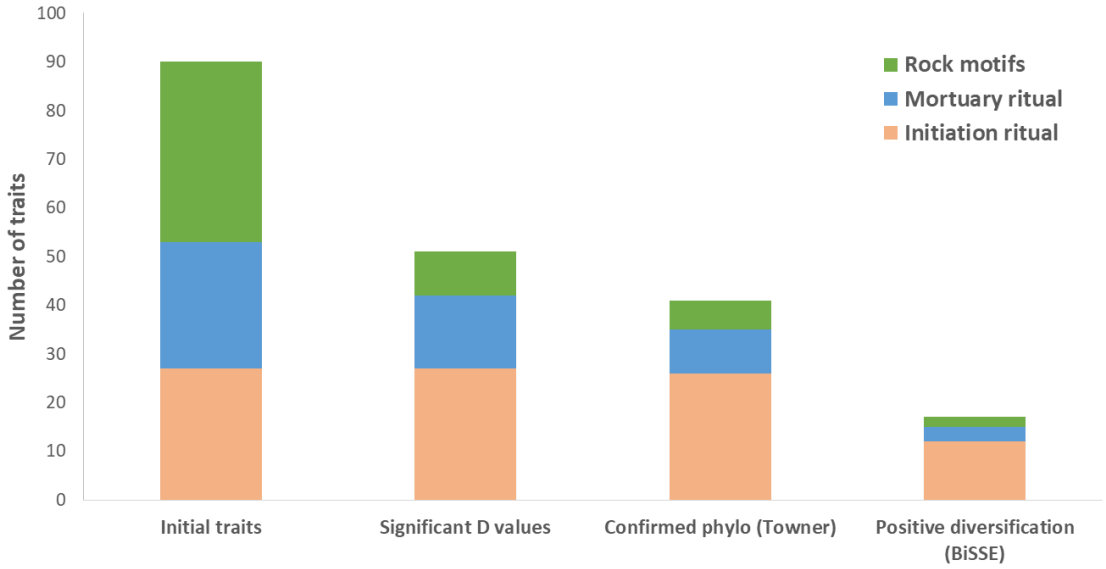


FIGURE 3.12 SUMMARY OF APPROACH FOR IDENTIFYING RITUAL TRAITS POTENTIALLY ASSOCIATED WITH PAMA-NYUNGAN EXPANSION.

How might these traits be linked to the theory of ritual advantage? Authors have suggested the use of ceremony may be associated with Pama-Nyungan expansion. If this hypothesis is valid, we would expect traits associated with complex and elaborate initiation ceremonies, and possibly geometric rock motifs and compound mortuary disposal, to be closely associated with Pama-Nyungan language and diversification. Initiation practices are clearly linked in this way. The majority of these traits 'survived' the three filters of analysis; 12 of the 17 traits with a statistically significant positive effect on Pama-Nyungan diversification are related to initiation. Next, I examine the traits themselves, their distribution and related ethnography, to consider how they might be linked to the idea of ritual advantage.

Initiation. The traits associated with diversification are a mix of ceremonial (5 traits) and individually costly (7 traits). The distribution of two of the male ceremonial traits, *beginRed* and *hairBelt*, is shown in figure 3.13. Where *beginRed* is present, the novice is painted with red ochre at the beginning of ceremonies. This may represent blood, either prefiguring later rites or acting as an alternative to them. Such practices may symbolise the ritual death of the novice as they enter a liminal state (Berndt & Berndt 1996: 171). In some cases, myths associate red ochre deposits with the menstrual blood of ancestral beings (Spencer & Gillen 1899: 438).

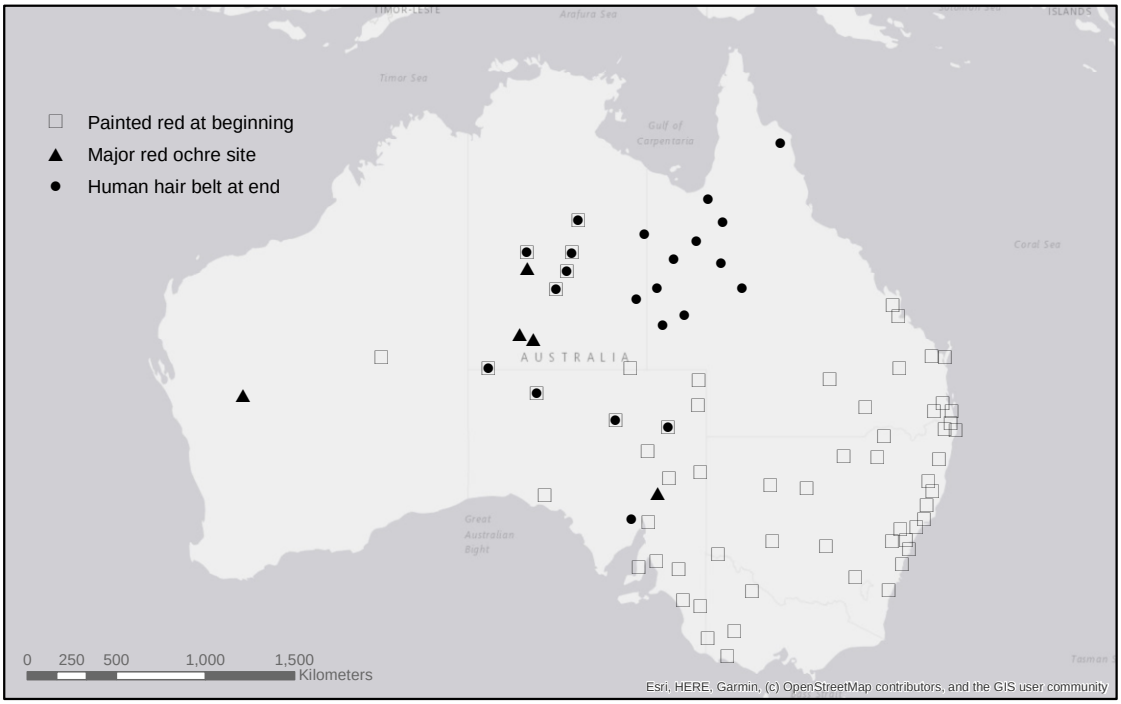


FIGURE 3.13 DISTRIBUTION OF TWO SYMBOLIC MALE INITIATION TRAITS, USE OF HUMAN HAIR BELT AND RED OCHRE PAINTING AT THE BEGINNING OF THE CEREMONY, WHICH HAD A SIGNIFICANT EFFECT ON PAMA-NYUNGAN DIVERSIFICATION. THE DISTRIBUTION OF MAJOR RED OCHRE SITES IS ALSO SHOWN.

The second trait records whether the novice receives a belt made of human hair (usually at the end of ceremonies). As well as a visible sign of manhood, other symbolism may be important. Human hair is often used to signify relationship and obligations, for example between son-in-law and father-in-law (*ibid,* 440). I have illustrated these two traits together because they might relate to alternative mechanisms of alliance formation. The hair belt commonly features in the north, red ochre in the south, with some overlap between the two in the centre. Red ochre deposits are common throughout the continent but material from certain sites (see figure 3.13, Smith & Fankhauser 2018) was highly valued because of its silvery sheen and actively traded over hundreds of kilometres (Peterson & Lampert 1985). Proximity to higher quality ochre may have been a factor in the introduction of red painting to novice initiation. However, its use to represent blood could also be connected to the introduction of more costly rituals in central and southern groups to facilitate alliances, with hair belt use in the north perhaps more associated with alliance formation through kinship obligations.

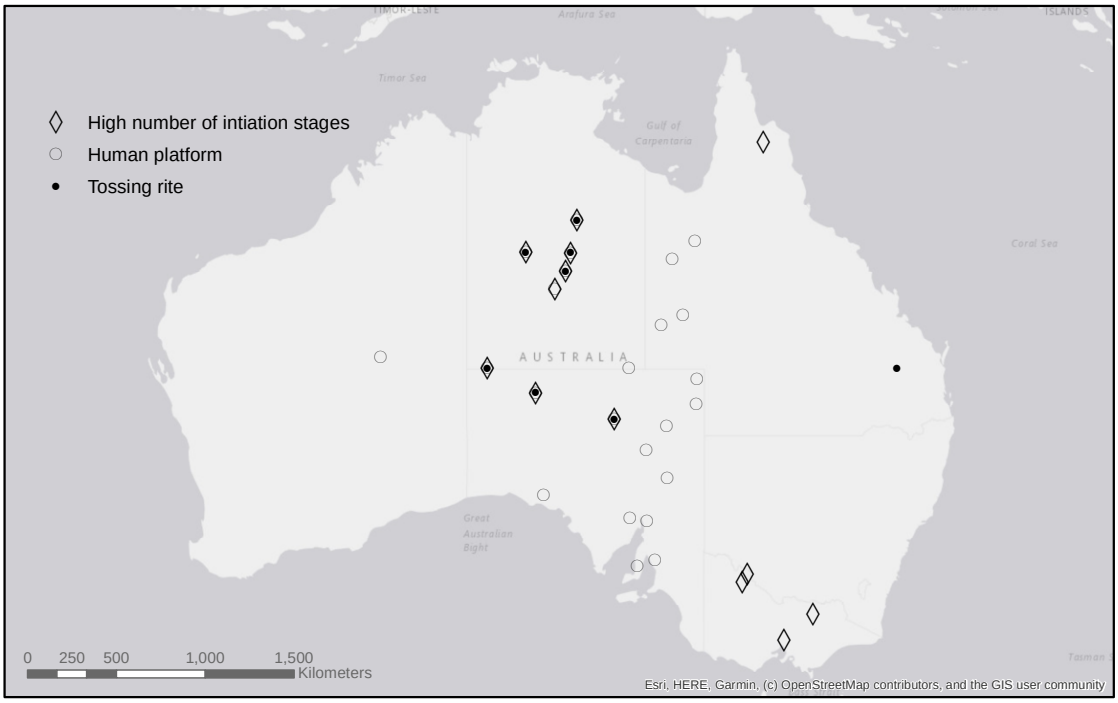


FIGURE 3.14 DISTRIBUTION OF THREE SYMBOLIC MALE INITIATION TRAITS, HIGH NUMBER OF INITIATION STAGES (5 OR MORE), USE OF A HUMAN PLATFORM AND TOSSING RITE, WHICH HAD A SIGNIFICANT EFFECT ON PAMA-NYUNGAN DIVERSIFICATION.

The distribution of three further ceremonial traits, *humanPlatform*, *tossingRite* and *highStages* is shown in figure 3.14. The first two are common to central Australian ceremonies as can be seen. The human platform includes adult males from different kinship groups to the novice. Circumcision and/or sub-incision is performed, often by a prospective father-in-law, whilst the novice lies on his back on top of the platform (Spencer & Gillen 1899: 263). In the tossing rite the novice is thrown into the air and caught several times be a group of adult males. Some myths associate the tossing up with the flight into the air of a woman chased by an ancestral being (Berndt & Berndt 1996: 170). The trait *highStages* is also included in figure 3.14; initiation usually takes place over multiple age-stages and societies with five or more were considered high relative to the Australian ethnographic record. Such groups had two distinct distributions, the centre and the south east. *HighStages* is closely associated with both *humanPlatform* and *tossingRite* in central initiation practices which may explain why the three together had positive results in the analysis. Alternatively, they may have individually positive effects through promoting shared bonds between adult males that help facilitate alliance formation. This is discussed further below.

Of the 12 initiation traits affirmatively linked to diversification, the majority (7/12) are individually costly rather than ceremonial, involving either mutilation or a painful test.

These encompass both male (4) and female (3) ceremonies and their distribution is shown in figures 3.15 & 3.16. For males, *fireOrdeal* includes jumping through fire and smoke, standing on hot coals, avoiding or being hit by 'fire-sticks' or sitting very close to fire for long periods. There appear to be two distributions, one in the centre and one encompassing southern and eastern regions, which may be associated with different meanings. In the centre, the rite may be connected with purification of the individual, after sub-incision for example, as they leave the liminal state and enter the adult world (Berndt & Berndt 1996: 173). In the south-east, symbolism is emphasised, the pain of fire equated to the touch of an ancestral being (Mathews 1896a). In both cases, fire ordeals are also painful tests for the novice. The traits *circumcision* and *sub-incision* have a central distribution also noted by previous authors (see Berndt & Berndt 1996: 169). In this analysis, the traits coincide, except in three southern groups without sub-incision (see figure 3.15). In *circumcision*, the foreskin is cut with a sharpened stone or piece of shell. In *sub-incision*, performed at a later age, a deep cut is made along the underside of the penis and the urethra (tube connected to the bladder) opened lengthwise, from the tip of the penis down towards its base. In some groups, the length of this cut is extended as part of later age-set ceremonies (Spencer & Gillen 1899: 255), as indicated by the trait *extendSubIncision*. Ceremonies are commonly linked to supernatural authority with a bullroarer (producing an unearthly, eerie sound) often representing the presence of a mythical figure. Symbolic references vary, but one 'widely acknowledged across the Northern Territory' (Berndt & Berndt 1996: 176) is that the penis represents the fertility earth mother figure the rainbow snake, and the sub-incision cut is her uterus. Thus, the rite may represent the combination of male and female organs required for fertilisation to take place. Some observers suggest the cut represents the female vagina and the blood-letting a woman's menstrual flow (*ibid*, 175). Sub-incision is rare outside Australia (see chapter 4) and is undoubtedly very costly for the individual; medical experts rated it one of the highest in terms of pain and risk of complications (see chapter 1). Its central distribution coincides with arid desert conditions and the connection between these environments and costly initiation practices is returned to later and in chapter 4.

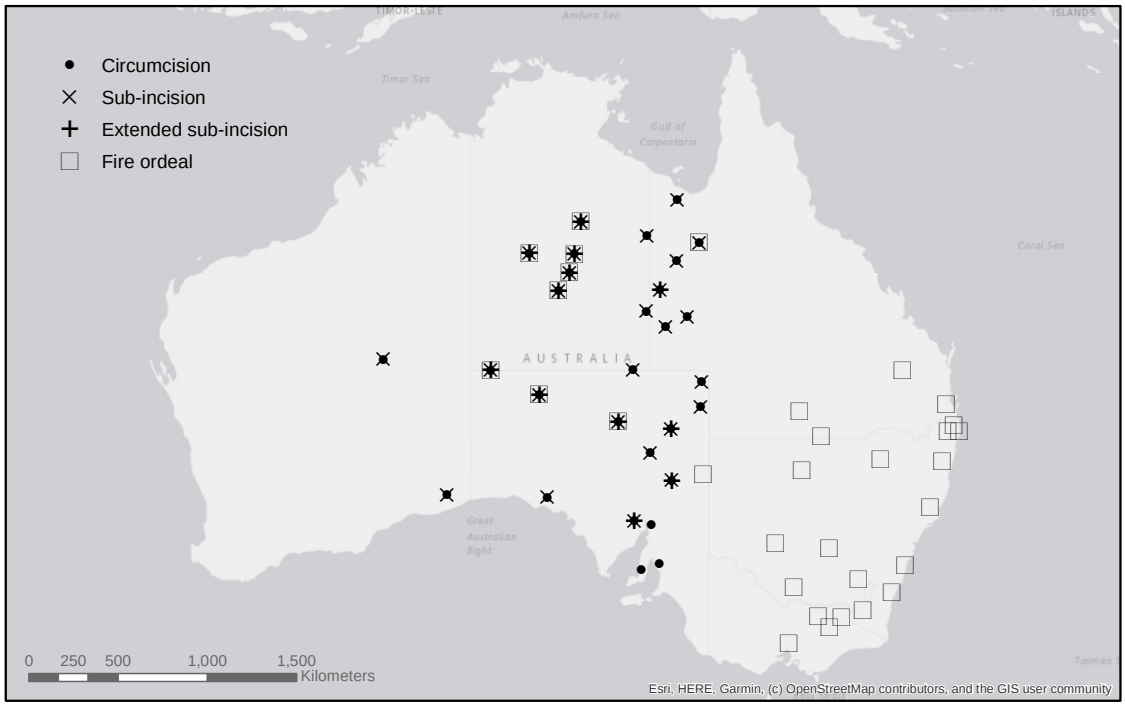


FIGURE 3.15 DISTRIBUTION OF FOUR COSTLY MALE INITIATION TRAITS, CIRCUMCISION, SUB-INCISION, EXTENDED SUB-INCISION AND FIRE ORDEALS, WHICH HAD A SIGNIFICANT EFFECT ON PAMA-NYUNGAN DIVERSIFICATION.

Distribution of the three costly female traits is shown in figure 3.16. Girl's initiation ceremonies tend to be shorter and less elaborate than those boys and more closely associated with puberty. In some groups, *toothExtraction,* the knocking out of one or more front teeth with a stone or wooden mallet, takes place at this time. A more painful and traumatic intervention occurs in some groups, involving cutting either of the vulva or from the vagina to the perineum (Berndt & Berndt 1996: 181), and this is recorded as *femGenMutiliation.* As with males, these costly practices are mainly confined to central areas and both traits have an overlapping distribution.

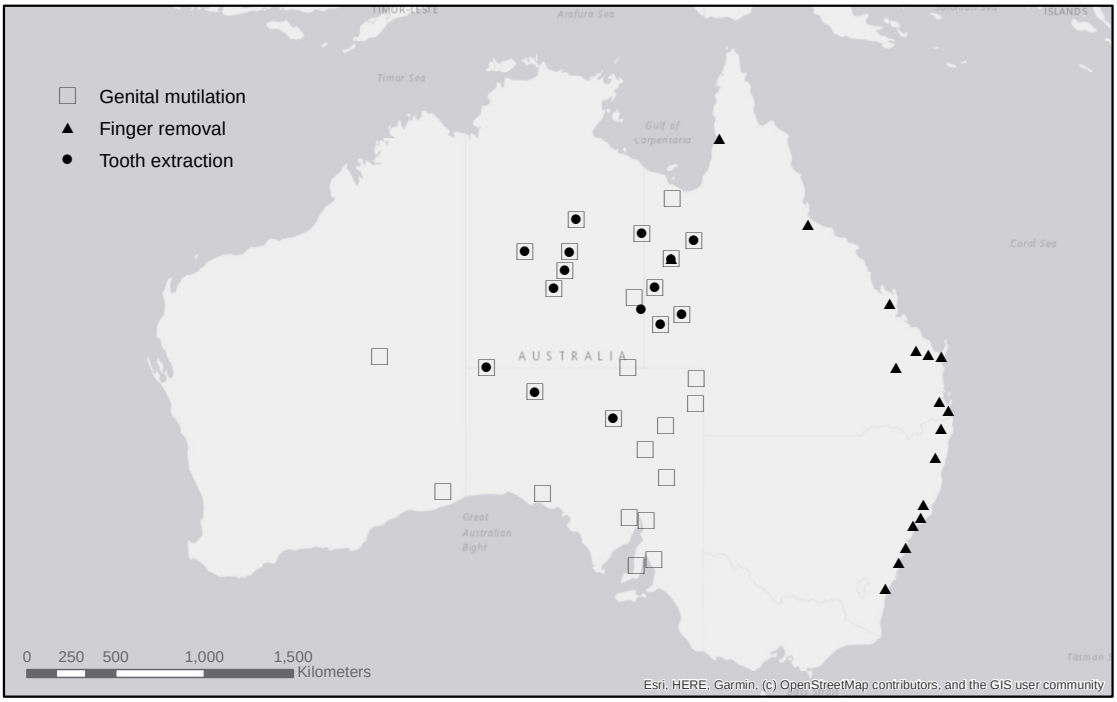


FIGURE 3.16 DISTRIBUTION OF THREE COSTLY TRAITS ASSOCIATED WITH GIRLS' INITIATION, GENITAL MUTILATION, FINGER REMOVAL AND TOOTH EXTRACTION, WHICH HAD A SIGNIFICANT EFFECT ON PAMA-NYUNGAN DIVERSIFICATION.

A third trait, *fingerRemoval,* is quite differently distributed occurring predominantly on the eastern coast. Usually the tip of the fourth or fifth finger is removed, often by bounding the joint tightly until the tip atrophies and falls off. Mathews (1907) noted that it was done to provide good luck for women when they start to go fishing (which may coincide with puberty).

Some further points are relevant to initiation. The hypothesis of Pama-Nyungan expansion postulated by Evans, McConvell and others links it to ritual, but in particular the adoption of elaborate, large-scale rituals. Evidence from this study is mixed on this point. Of the two traits most associated with elaborateness and scale, *highStages* is positive but *processional* (different ceremonial grounds linked by a processional path of carved objects), actually had a slightly negative effect on diversification (λ_1/λ_0 0.92, $p<0.05$). Examination of other traits linked to ceremony indicates the majority did not meet the testing criteria. Of the original 27, more ceremonial (9) than costly traits (6) were excluded. Examples include novice painted white at end of ceremonies, elders painted black during ceremonies, bark-beating and tree-climbing enactments. Costly rites not meeting the criteria also tended to be less severe tests: male and female scarification, male tooth extraction and high (prolonged) segregation from the wider group. Conversely, traits which met the criteria were more likely to be costly (7), often severely

so, than ceremonial (5), suggesting the use of severe rites may be particularly important. This position is further supported when those ceremonial traits that did have positive results are examined. Both *humanPlatform* & *tossingRite* are integral to central Australian ceremonies involving sub-incision, which might explain their results. The presence of *highStages* and *beginRed* is also common in these rites, however they do occur elsewhere so the picture is not straightforward. Overall, results for initiation suggest more confidence in the role played by costly rituals than those linked to ceremony. Perhaps it was the adoption of these rites, rather than the ceremonies themselves, which played the most important role in alliance formation and therefore Pama-Nyungan expansion.

Another finding is that costly traits with positive results are fairly evenly split between male (4) and female (3). Whilst women's ceremonies may have been underreported by ethnographers (see chapter 1), those recorded tended to be shorter, less elaborate and involve less wide social participation than males (Berndt & Berndt 1996: 180); something that also points to less influence from ceremony. The significance of costly traits for girls as well as boys also suggests their use might relate to actions of joint, rather than male-oriented, collaboration *e.g.* food sharing rather than access to wives or warfare. These ideas are tested more specifically in chapter 4.

Mortuary ritual. Five further traits had statistically significant effects on diversification and, since they had relatively high λ_1/λ_0 values (figure 3.6), the associations warrant further investigation. Three mortuary traits were significant: compound disposal with burial first, the placing of personal items on the grave and corpse disposal in trees. The presence of compound disposal was predicted as potentially related to Pama-Nyungan expansion; rites are typically complex, large-scale and relate to ideas of clan ownership hypothesised to have changed over this period. Interestingly, there was no support for other forms of compound disposal (such as drying or elevation first) or for the composite trait of all types, suggesting the importance of this particular ceremony rather than the category as a whole. The use of grave goods or tree disposal was not predicted to have an impact on diversification, however plotting the distribution of all three traits (figure 3.17) suggests they may be playing complementary roles. Whilst there is some overlap, they appear to follow distinctive geographic distributions, perhaps indicating that tree disposal (in the east) and grave goods (in the centre and west) replaced compound disposal rituals arriving from the north (either via diffusion or Pama-Nyungan expansion). Why might this have happened? One theory, discussed in the thesis Introduction, is that the use of compound disposal relates to kinship. Conflict between sexes arising from exogamous marriage practices may be mediated through the act of separating the (female) flesh of

the corpse from the (male) bones in a secondary ceremony. This may symbolise reversion to the original social state (Bloch & Parry 1982: 20), especially if the bones are deposited in the deceased's patrilineal descent group territory. An association between change in mortuary rites and change in kinship practice (examined in chapter 4) would lend support to this theory.

Alternatively, these intensive multi-stage rituals might have been replaced because of more limited resources or wider foraging ranges in the arid interior. If this is the case, the alternatives adopted might provide evidence of what was most important about the ritual that required preserving. Later secondary burial rites serve to maintain the corpse in a liminal state, sustaining the link to the dead for a longer period thereby assisting the adjustment of the living (Walter 1999). Similarly, items placed on graves are normally significant to the deceased, creating a focal point for those mourning their loss (Hallam & Hockey 2018). Tree disposals could also play this role, the visibility of the deceased providing a focal point for their remembrance. Theories linking kinship and remembrance to mortuary ritual are examined further in chapter 4.

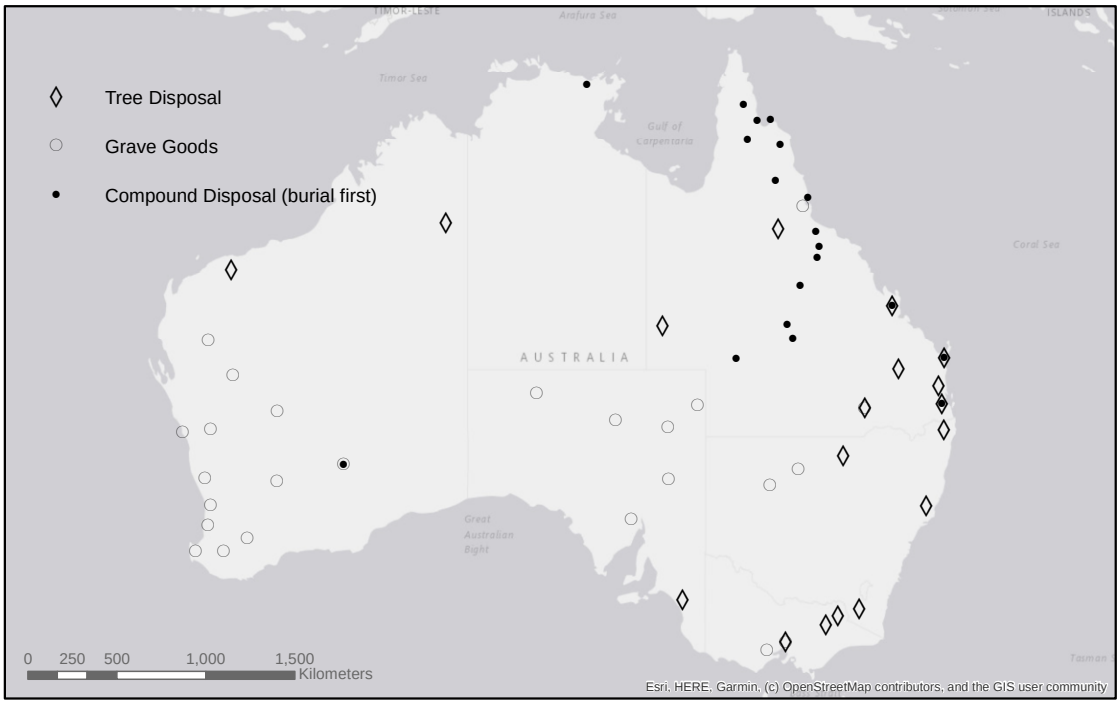


FIGURE 3.17 DISTRIBUTION OF THREE MORTUARY TRAITS, COMPOUND DISPOSAL WITH BURIAL FIRST, PLACING GRAVE GOODS ON THE GRAVE, AND TREE DISPOSAL OF THE BODY, WHICH HAD A SIGNIFICANT EFFECT ON PAMA-NYUNGAN DIVERSIFICATION.

Rock motifs. Two rock motifs had a statistically significant effect on diversification: animated humans and turtle forms. Both are figurative in nature, so do not support the predicted link between geometric motifs and Pama-Nyungan expansion. Animated human figures were present in 29% (14/49) societies. Their distribution is shown on figure 3.18, together with example illustrations from 9 sites. Non-Pama-Nyungan (NPN) and Proto Pama-Nyungan languages are hypothesised to share a common ancestor (McConvell & Bowern 2011), therefore it is possible that some of NPN's visual culture was inherited by early Pama-Nyungans. Comparison between the two regions may be informative, therefore paintings from NPN areas Kimberley and Arnhem Land are also included. Here, depictions of human figures tend to be more elaborate, with a greater stylistic range. They are also more frequent, there are relatively few representations of human activity in Pama-Nyungan regions, except in the south east.

As discussed in chapter 1, Australian rock images are often not that old and in some cases can be considered contemporary. Consequently, we know something of the meaning of images from reported conversations with Indigenous people. In Kimberley, depictions of ritual *Wandjina* (figure 3.18, image #20b) are directly incorporated into ceremonies through re-touching of the image (Layton 1992: 47). In Arnhem Land, long thin figures represent *Mimi* (image #17), trickster spirits connected to the dead (*ibid*, 79). Similar figures (*Wurrula-Wurrula*) are also present in Kimberley (*ibid*, 83).

Why might the presence of animated human motifs be associated with Pama-Nyungan expansion? Stylistically, they have little similarity to Kimberley and Arnhem Land except the long, thin figures of Queensland known as *Quinkan* (image #23), are similar to the *Mimi* of Arnhem Land (image #17) and also thought to be trickster spirits (Layton 1992: 134). Human depictions are relatively infrequent and do not appear to be a major feature of material visual expression. From the Queensland *Quinkan,* the next known depiction of active humans is nearly 2,000km away (Cobar cave paintings, image #24) and there are very few depictions across the whole of central and western Australia.

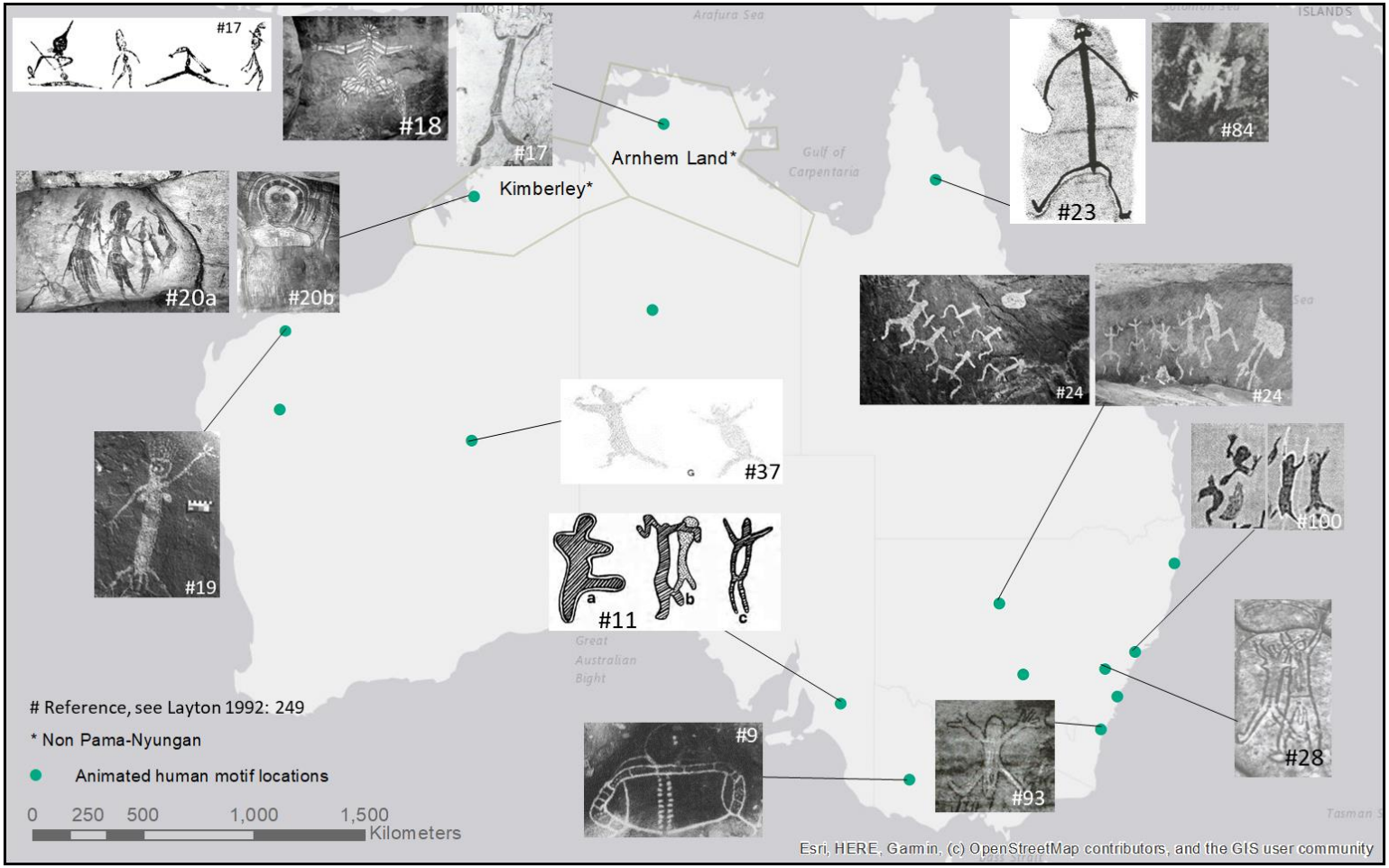


FIGURE 3.18 DISTRIBUTION OF THE ROCK MOTIF *ANIMATED HUMANS*, WHICH HAD A SIGNIFICANT EFFECT ON PAMA-NYUNGAN DIVERSIFICATION. EXAMPLE MOTIFS ALSO SHOWN.

However, the south east is an exception, with many more sites featuring representations of human activity. Images in this region (*YuinKuricWiradhuric*) were discussed in Chapter 2 with the frequently large, paintings and engravings (images #9, #28, #93 & #100) thought to depict ancestral creator figures such as *Baiame* important in ceremonial life (Mathews 1897). Might this ritual development be associated with Pama-Nyungan expansion? For societies in this area, such as *Awabakal*, *Dharawal* and *Dharuk*, creation springs from a single supreme being as opposed to multiple totemic ancestors in the centre and north. Termed 'sky heroes' by Elkin because they live in the sky, 'a place possessing much quartz crystal and fresh water', they see and know everything, bestowing material culture, social laws and initiation rites (Elkin 1979: 253). Questions here are answered '*Baiame* say so' whereas elsewhere such sources of authority largely rest with multiple dreamtime ancestors who travelled over the land (Eliade 1973: 35). As single authoritative figures, perhaps *Baiame* and other sky heroes are types of Moralising High God (MHG). Development of these deities has been theorised to increase cooperative behaviour through shared beliefs with other societies, supernatural monitoring and the threat of punishment (Norenzayan 2013, Atkinson *et al.* 2015). Greater levels of co-operation both within and between societies with MHGs might have increased Pama-Nyungan success leading to linguistic expansion in the region.

Alternatively, the connection between animated human motifs and Pama-Nyungan expansion may be due to their association with other factors. Since the majority of motif sites are in the temperate south-east, a relatively resource-productive region, ecology could be one such factor. The second rock motif positively impacting diversification, turtle forms, might be similarly linked. As with animated humans, motifs are more frequent and stylistically more elaborate in Arnhem Land and Kimberley (see figure 3.19). Typically, they have a secular function, signifying availability of the species (Layton 1992: 74) or recording someone's presence (*ibid*, 77). There may be an association with 'sympathetic magic' , for example, tracing the motif to increase luck at hunting or possibly increase rites linked to ensuring plentiful numbers (*ibid,* 48). I am not aware of any specific association between turtle motifs and social or ritual factors that might impact Pama-Nyungan diversification. However, their presence could signal a particularly productive environment, both species availability and a link to relatively plentiful habitats.

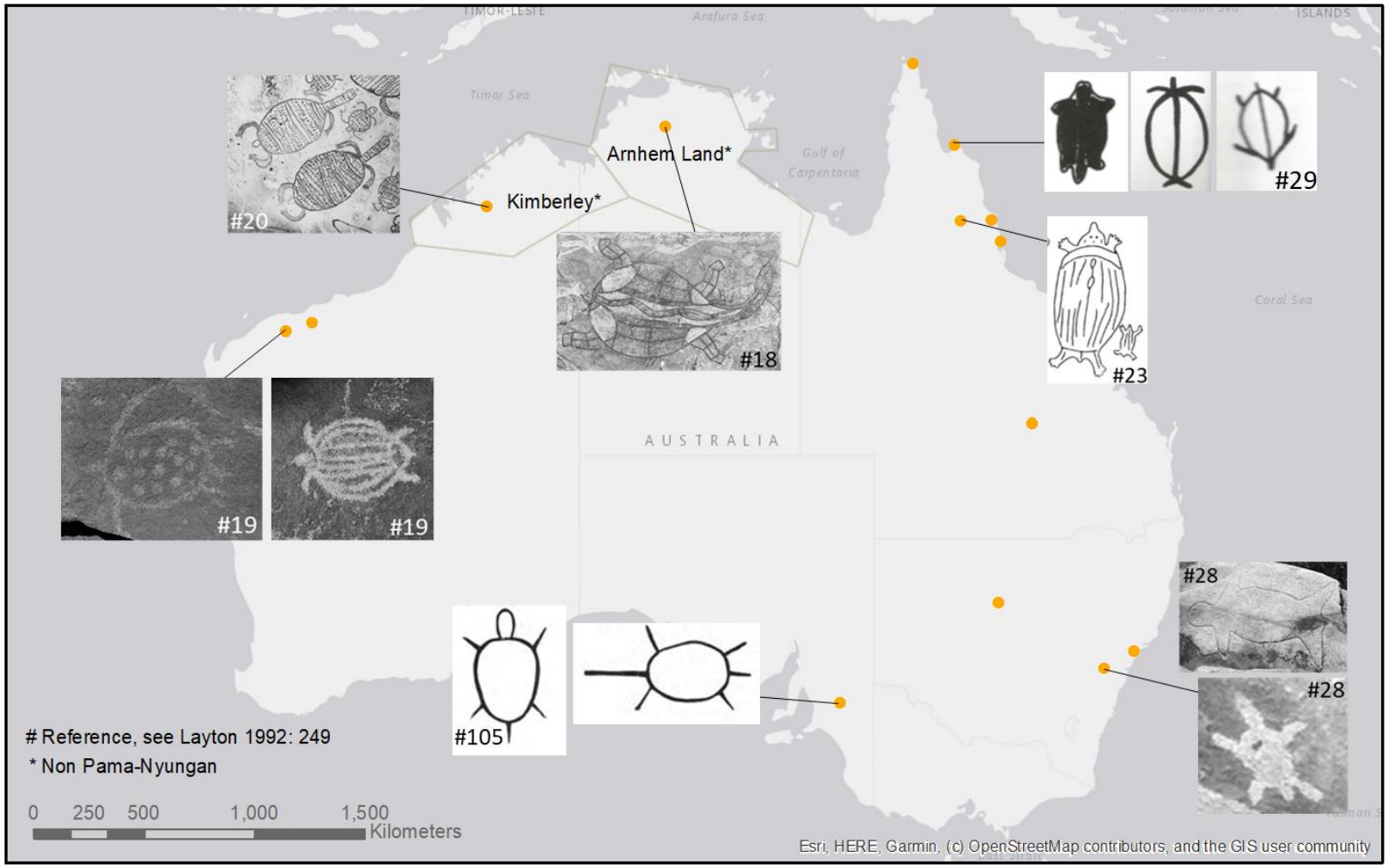


FIGURE 3.19 DISTRIBUTION OF THE ROCK MOTIF *TURTLE FORMS*, WHICH HAD A SIGNIFICANT EFFECT ON PAMA-NYUNGAN DIVERSIFICATION. EXAMPLE MOTIFS ALSO SHOWN.

The turtle motif has been found in relatively few locations (12/49) and, although two are in the interior (presumably linked to freshwater species such as the eastern long-necked turtle) the majority are relatively near the coast, which may be associated with more plentiful resources. Another trait with a coastal distribution, female finger removal, also had no clear links to wider ritual traditions, suggesting other factors such as resource productivity might be important.

Ecological impact. The link between ecological conditions and language diversification has been the subject of considerable research. Language diversity tends to increase towards the equator (Collard & Foley 2002, Currie & Mace 2012) and languages in tropical regions often have relatively small ranges (Collard & Foley 2002, Mace & Pagel 1995). Two mechanisms have been suggested to explain this: isolation and ecology. Isolation mechanisms are associated with landscape features acting as population barriers that slow the spread of linguistic variants, leading to accumulation of language changes which distinguish languages from neighbours (Axelsen & Manrubia 2014). Ecological mechanisms assume small groups are likely to be self-sufficient where food supply is plentiful and reliable, whereas areas with sparse or unpredictable resources may require social connectivity across larger ranges to secure food and water, reducing linguistic distinctions (Nettle 1998, Collard & Foley 2002). In a statistical analysis of global language diversity, Hua *et al.* (2019) found that the effect of climate was stronger than potentially isolating landscape features such as altitude range and river density. However, climate and isolation combined still explained less than 45% of the total variance. In Australia, Birdsell (1953) demonstrated that tribal territory sizes, usually designated by linguistic affiliation (Tindale 1940), were proportional to mean annual rainfall, with the largest in arid regions of central Australia, and the smallest in biologically richer coastal strips. More recently, Gavin *et al.* (2017), using a model assuming maximum group size and rainfall limits to population density, predicted 56% of the variation in Pama-Nyungan languages per unit area. Interestingly, the model underestimated the level of linguistic diversity in the arid central eastern region. They suggest this may be due to additional water supplied from rivers and lakes *e.g.* Darling River and Lake Eyre (although the latter is seasonal).

To assess the impact of current climate conditions on Pama-Nyungan language diversification, I used the widely-applied Köppen-Geiger (KG) classification that encompasses rainfall, temperature and seasonality in one measure (Kottek *et al.* 2006). In Australia, the dominant type of land area is desert or arid (78%), followed by temperate (14%) and tropical (8%). To determine whether climate affects language diversity, each of the 306 linguistic groups was categorised as desert or arid (state 0, 52% of groups) or

non-arid (state 1, temperate or tropical, 48% of groups). See Appendix 3_Climate. There was a relatively small (λ_1/λ_0 = 1.08, p=0.02) effect on diversification rate suggesting climate may be relevant. Using a more stringent classification and allocating each society to the KG class desert (state 0, 24% of groups) or non-desert (state 1, 76% of groups), led to an interesting result; the impact was actually negative *i.e.* a ratio below 1 (λ_1/λ_0 = 0.85, p=0.0007). Societies occupying desert habitats seem to be *more* associated with language diversification than non-desert societies. Results are included in Appendix 3_BiSSE. Although territories associated with each language are larger in desert regions (Tindale 1940, Bowern 2016), they appear to be areas of high linguistic diversity (something also underestimated in Gavin *et al.'s* model above). Bouckaert *et al.* (2018) made a similar observation in their modelling of the pathway of language expansion. Different rates of movement were associated with coastal vs inland spread and they suggest water is a limiting factor; when this is scarce people travel more quickly, leading to smaller more fragmented groups. Furthermore, a prediction of Whitehouse's imagistic theory of ritual, to be discussed in the next chapter, is that cohesion formed by negative arousal rituals will, because it is based on memories of shared trauma with particular participants, tend to foster localised, exclusive communities (Whitehouse 2004: 73). Such painful rituals, that are common in desert conditions, may act as isolating mechanisms, allowing accumulation of linguistic change and the separation of languages from neighbours. This topic is returned to in chapter 4.

Based on the above results, the association of language diversity with animated human motifs and turtle forms does not appear related to ecological conditions at a generalised level. However, localised productive habitats may still have influenced population size. For example, the large gatherings known to occur in south eastern areas due to seasonal surpluses of fish, cycad nuts and moths (Lourandos 1997) could be relevant. The links could be chance findings; the number of rock motif data points is slightly below the 20% of phylogeny threshold indicated by FitzJohn *et al.* (2009), potentially affecting results. Alternatively, there may be other associations. Additional factors hypothesised to be related to Pama-Nyungan expansion could be tested using this approach including archaeological evidence of changes in microlith presence or more intensive food production techniques such as seed-grinding. Since the development of ritual may be closely connected with kinship, the presence of more elaborate or extended kinship structures could also be analysed. This is a complex area, largely beyond the scope of the present ritual-focused study. However the link between kinship and one ritual practice, compound body disposal, is one of the theories considered in the next chapter.

Conclusion

Tests for linguistic signal and diversification show a strong association between initiation practices and Pama-Nyungan expansion, as hypothesised by Evans & McConvell (1998) and others. Mortuary rites linked to compound disposal (and possibly remembrance), and rock motifs associated with animated humans (possibly linked to supreme beings), may also be associated with diversification, perhaps linked to different pulses of language expansion. I am unable to draw any conclusions relating to geometric rock motifs, maybe because similar designs are often utilised in multiple ways: clan totems, boundary markers, social structures, hunting sites *etc.* making it difficult to isolate whether particular motifs are associated with Pama-Nyungan advantage. Alternatively, given that patterns of historical change for rock motifs were identifiable in aggregate (in chapter 2), and this was independent of language, the development of geometric motifs may not be directly associated with changes taking place during Pama-Nyungan expansion.

Hypotheses suggest that ritual, by providing a vehicle for collaborative activity, played an important role in the formation of new Pama-Nyungan alliances. Results from this chapter (and chapter 2) suggest some ritual practices, particular those associated with initiation, likely were important. However, I have yet to demonstrate whether this was because of their role in alliance formation and, if it was, by what mechanism this was achieved. This chapter's results suggest painful and costly rites, rather than those linked to ceremony, were most associated with Pama-Nyungan expansion, indicating that costly signalling or shared trauma may be two important mechanisms. These theories, and others, are considered in the next chapter. The BiSSE diversification analysis highlighted that allowing traits to have variable transition rates of gain and loss improved the modelling of their distribution. The analytical method used in chapter 4 examines this effect in more detail. If ritual gain is faster when the theorised independent trait *e.g.* warfare, desert environment, is present, compared to when it is not, the finding provides support to the theory under test.

Chapter 4: Hypotheses of ritual adaptation

Rituals can be costly endeavours. Commitment and resources are needed to create the symbolism, expressed, for example, through ceremony and body decoration, which connects participants to shared values and deeper ideas of meaning. Activities can be time intensive and those involved may travel long distances to take part. For some rituals, there may be direct costs to the individual such as painful mutilations. The implementation of these elements of ritual, its symbolism, participation and suffering, requires a high degree of effort and commitment from group members. What influences could have led this practice to evolve?

Studies of ritual's common features have produced a number of theories. These were previously discussed in the Introduction and are briefly re-capped here. Generally, they emphasise its ability to connect participants to sources of authority and meaning, essentially a psychological origin, or its role in connecting participants together and promoting social cohesion, essentially a sociological one. Durkheim (2001 [1912]) was one of the first authors to posit a sociological origin for ritual, suggesting it was a way of harnessing, and constructively dealing with, the positive emotion released through the act of people coming together. Turner (1969) focused on ritual's innovative ability, through the use of liminal or threshold states, to construct socially useful categories such as adulthood or marriage, which enabled the community to operate more effectively. The key element for Rappaport (1999) was ritual's focus on mutually shared performance. This brings a sense of permanence and continuity to the group, providing a foundation from which shared values and beliefs meanings can be established. While such collective endeavours may help all individuals, societies need to resolve the free-rider problems that result; ensuring those receiving a benefit pay their fair share of the costs. The painfulness of many ritual actions, such as markings and mutilations, may be a solution, because they serve as 'hard to fake' signals of commitment to the group (Irons 2001, Sosis *et al.* 2007). Another problem might be persuading participants that shared representations are valid, particularly those invoking intangible deities and counter-intuitive concepts. Henrich (2009) suggests costly rites are a way of doing this because they act as 'credibility enhancing displays'. Only those deeply committed to beliefs would engage in such acts and these demonstrations persuade others of their validity. Painful rituals can be traumatic experiences for the individuals involved, leading to intense

memories of the event. When these are shared with other participants strong emotional bonds are forged that may provide a powerful motivation for collective action (Whitehouse 2004). Pain may also be used in rituals because of its transformative quality. Acting in a similar way to psychotropic agents, intense pain releases opiates that induce both euphoric and dissociative feelings, making the novice more receptive to new mental states such as unity with others and submergence of individual concerns (Glucklich 2001).

Building on this background, specific theories have been proposed to explain ritual's adaptive benefit and what stimulus may have led it to first evolve. In this chapter, four of the most influential are examined in more detail: (1) external alliance formation, (2) within-group alliance formation, (3) unequal power relations and (4) gender and conflict. Using insights gained from previous chapters, seven specific tests are proposed that are most relevant to the Pama-Nyungan case. Firstly, the use of elaborate ceremony to support external alliance formation. As previously discussed, this was suggested by Evans & McConvell (1998) to be linked to Pama-Nyungan success. Secondly, the use of painful, costly rites to support within-group alliance formation is examined. These rites were most associated with Pama-Nyungan expansion in chapter 3 and collective action needs for both warfare and challenging ecological conditions are tested here (Irons 2001, Sosis *et al.* 2007, Whitehouse 2004). Thirdly, Australian societies are considered less egalitarian than other hunter-gatherers by some authors and ritual may be being used to maintain unequal power relations. The use of elaborate ceremony to support male elder control over wives (Bloch 1989) and the use of grave markings to legitimise rights over favourable resources (Saxe 1970, Goldstein 1981) are tested in relation to this hypothesis. Fourthly, ritual's role in supporting greater social significance for women (Brown 1963) and the use of secondary mortuary rituals to mediate gender conflict arising from different kinship structures (Bloch & Parry 1982) are examined. Results from chapter 3 suggested initiation of girls and secondary mortuary rites were associated with Pama-Nyungan expansion. The theoretical background to these four theories, their relevance to the Pama-Nyungan case, and the testing methodology for the seven hypotheses proposed to examine them, is set out in more detail below and summarised in table 4.1.

Ritual theory	Test	Ritual trait	Independent trait
External alliance formation	#1	Elaborate ceremony	Population density
Within-group alliance formation	#2	Costly rites	Warfare
Within-group alliance formation	#3	Costly rites	Desert habitat
Unequal power relations	#4	Elaborate ceremony	Marriage age difference
Unequal power relations	#5	Grave marking	Sedentism
Gender and conflict	#6	Girls' initiation	Subsistence
Gender and conflict	#7	Compound disposal	Patrimoiety

TABLE 4.1 SUMMARY OF RITUAL THEORIES AND THE SEVEN TESTS PROPOSED TO EXAMINE THEM.

Four theories, seven tests

(1) External alliance formation. The use of ceremony as a platform for outward Pama-Nyungan collaboration (suggested by Evans, McConvell and others) is closely aligned to Rossano's (2009) hypothesis of ritual's ability to mediate relations between neighbours. Huxley (1914), drawing on parallels with repetition and patterning in animal behaviour, noted that ritual seemed to stimulate 'efficient patterns of action in other individuals'. Rappaport (1999) suggested mutually shared ritual performance provides a foundation for establishing shared connections and values. Linked to these ideas, Rossano hypothesised that ritual developed as a way of stabilising relationships between residential groups through inhibiting natural defensive responses, giving mechanisms of pro-sociality time to operate. The collaborative benefits gained from reduced conflict may have been the stimulus which led ritual to evolve. As a test for this hypothesis, Rossano suggests that 'where more extensive inter-group relations are noted, more elaborate and demanding social rituals will also be present'. To examine this theory, 'extensive inter-group relations' are quantified using population density; assuming that where this is higher more residential groups are likely to be in contact with one another. 'Elaborate and demanding' is quantified using the volume of different attributes for each society in the setting and ceremony categories of male initiation (usually the most significant ritual in Australian life). A higher number of attributes indicates more effort required to create elaborate settings, deliver more performance elements, decorate participants *etc.* If the hypothesis is valid, rituals with a greater number of ceremonial attributes should be associated with Pama-Nyungan societies that have a higher population density.

(2) Within-group alliance formation. Rather than stabilising relations between groups, ritual may be being used to support closer alliances within them. The benefits of within-

group solidarity are likely to be different to those gained through external alliances, suggesting different stimuli that may have led ritual to evolve. Two theoretical benefits are tested. Firstly that improved group solidarity leads to an improved ability to prosecute warfare and, secondly, that such alliances mean the group's members are better adapted to meet challenging environmental conditions. Theories of within-group alliance formation centre on the use of rites that are costly and painful for the individual. Either these act as signals of individual commitment to the group (Irons 2001, Sosis *et al.* 2007), persuade others that shared beliefs are valid (Henrich 2009) or build solidarity with others. The latter may be formed through shared memories of traumatic or emotional experiences (Whitehouse 2004) or the ability of pain to produce an altered, unifying state (Glucklich 2001).

Looking first at warfare, analysis of male rituals across 60 societies (Sosis *et al.* 2007) found a significant association between costly rites, assessed as a relative score of suffering, and the presence of warfare, but no association with other collaborative activities such as co-operative food production or food sharing. Sosis *et al.* suggest reciprocity can be employed in these pursuits to prevent free-riders from accruing long-term benefits, but that in warfare men cannot solely rely on expectations of future cooperation, since they may not be alive to reciprocate. The study also found that costly rites were more associated with hunter-gatherer societies, suggesting that larger societies can coerce participation in warfare through punishment (*e.g.* imprisonment), so are less dependent on ritual signs of commitment. That rituals involving high levels of suffering are associated with warfare, and that these rites are particularly prevalent in hunter-gatherer societies, suggests it could be a candidate for the stimulus that led ritual to evolve.

As discussed in chapter 1, archaeological evidence indicates violence and warfare were widespread in Australia during the Holocene. Early ethnographic accounts reference conflict between Indigenous Australian groups and describe two types of combat. Firstly, regulated settling of disputes normally involving the exchange of spears and sometimes individual hand to hand fighting. Occasionally such exchanges escalated into fatal violence. Secondly, active raiding of other groups, often revenge attacks, which nearly always resulted in fatal encounters and regularly escalated into repeated cycles of violence. If the costly signalling hypothesis is valid, societies that practice active raiding (which carries a much greater risk of fatality) should also possess costly initiation rites.

The second test examines the benefit of ritual in adapting to challenging environmental conditions. Cohesive within-group bonds may facilitate improved co-operation between

group members that is likely to be particularly critical in marginal habitats where resources are both scarce and variable. Such conditions may have provided the stimulus for ritual to evolve, with more cohesive groups better adapted to compete for limited resources (Whitehouse 2004: 78). Hayden (1993: 166) notes that rites of passage in Australia seem to become more severe as conditions worsen, suggesting this is because increasingly strong alliances are required to survive in more challenging habitats. However, whilst Sosis *et al.* did not test environment specifically, they found, as referred to above, no connection between costly rites and co-operation over resources. The Pama-Nyungan case could be different however; many societies are located in arid, desert environments with sparsely distributed populations that may make reciprocity harder to employ and monitor. The association between such challenging habitats and the presence of costly rites is therefore examined in this study.

For both the above tests, costly rites were quantified using a more medically-orientated approach than adopted by Sosis *et al.* using physician, as opposed to graduate student, assessments. Individual costly rites, defined as body markings or ordeals during initiation, were independently ranked by two experienced UK medical specialists (both orthopaedic consultants) on a scale of 0-10 for both likely painfulness and longer-term health risk. Scores were summed and averaged across both specialists to give an overall costliness measure for each rite. Physician scoring is likely to provide a more accurate assessment of the relative painfulness of different procedures and of the overall health risks required to be borne by individuals to become societal members.

(3) Unequal power relations. An alternative hypothesis to alliance formation is that ritual serves to mask the underlying reality of relationships, thereby maintaining the advantage of particular groups (Bloch & Parry 1982, Bloch 1989, Geertz 2000). On this basis, hunter-gatherer societies, which tend to have minimal social stratification (Barnard & Woodburn 1988), would be expected to have less ritual complexity. This is largely the case for African hunter-gatherers, for example, but not Australian, where elaborate ritual plays a central role (Woodburn 1979 & 1982). Bloch (1989:17) suggests this is because societies are much less egalitarian; men betroth their daughter's in marriage and, through the promise of daughters to others, obtain control over other men, establishing a complex age-based hierarchy over access to wives (Berndt & Berndt 1996: 202, Binford 2001: 282). Rose (1960) coined the term 'gerontocracy' to describe this practice, noting that, in combination with polygyny, it leads to men in their forties and fifties monopolising the majority of women of marriageable age. Elaborate and demanding rituals may support these unequal relationships, maintaining the forced bachelorhood of young men through

long initiation periods and the authority of older men through belief in their religious power (Maddock 1974, Bern 1979, Keen 2004, Keen *et al.* 2006). The first test of unequal power relations examines this hypothesis. If it is valid, greater levels of inequality should require more elaborate rituals to maintain them. 'Levels of inequality' are quantified using the age difference between males and females at the time of marriage, assuming the larger this difference is, the more the society is orientated towards elder male control. 'Elaborate and demanding' is quantified using the same criteria as (1) above.

In the second test, a different theory is examined. Unequal power relations may be related to differences in resource control that are maintained through mortuary ritual. Although such differentials are a regular feature of agricultural societies, they are much less common in hunter-gatherers, probably because of their frequent mobility. Some favourable habitats may, however, encourage longer-term residence patterns leading to the emergence of differences over resource access. Grave markings and memorials have been suggested as a way to legitimise rights over favourable habitats. Whilst such commemorations create a focal point for remembrance of the dead (Hallam & Hockey 2018) they may also be advantageous to the living, confirming their lineal descent from the deceased to legitimise claims over territory (Saxe 1970, Goldstein 1981). In Australia, seasonal camps were often established in areas of plentiful resource (McBryde 1978, Flood 1980) resulting in some societies adopting a partially sedentary lifestyle with relatively few camp moves during the year (Binford 2001: 271). Many Pama-Nyungan societies used specific burial grounds marked with carved trees or other objects (Meehan 1971, Berndt & Berndt 1996: 461, Pardoe 1988). If the hypothesis is supported, the presence of grave markings in Pama-Nyungan Australia should be associated with partial sedentism in these societies.

(4) Gender and conflict. The final theory tested is that ritual's primary role is to enable communities to operative more effectively through constructing socially useful categories and through managing conflict (Turner 1969). One such useful category is adulthood; the values, know-how and attributes required of adults are modelled in initiation rites which the adolescent needs to pass through to be accepted as full member of the social group. Whilst analyses of initiation often focus on males, in a cross-cultural study of 182 societies Schlegal & Barry (1979) recorded more ceremonies for women (46%) than men (36%). They suggest differences between societies may be related to the social significance of gender. In a separate cross-cultural study of 75 societies, initiation rites for girls were more likely to be present where women's contribution to subsistence was above the median level (Brown 1963).

Sexual division of labour is near universal across the ethnographic record for reasons probably encompassing infant care needs, physical size differences and protection of reproduction (Hayden 1993). Complementary procurement of animals by men, and of plants by women, seems to have been an efficient and productive way of organising food-related tasks. Keen (2004), in a study of seven Australian societies across different geographies and ecologies, found strong similarities in their organisation of food production with no particular differences between desert, temperate and equatorial societies. However, men's and women's work was more separate in the desert (they rarely foraged together) which may be linked to the presence of a distinct ceremonial life for women in this region (Keen 2004). Furthermore, productivity from hunting is less reliable here with plant foods forming a greater proportion of diet. This may contribute to a higher social significance for women that is reflected in a more significant ritual life. Thus, Brown's (1963) hypothesis, linking the presence of girl's initiation to greater women's subsistence contribution, appears to be a relevant test for Australia and is examined in the study.

In the second test, the theory of mediating within-group conflict is examined. Ritual's ordered yet flexible structure can provide an effective platform for the resolution of differences within groups (Turner 1969). As discussed in the Introduction, mortuary ritual may be used to mediate gender conflict through symbolic representation of the corpse. The act of separating the (female) flesh of the body from the (male) bones in a later mortuary ceremony symbolising reversion to the original social state. Conflict is likely to be greater in exogamous societies where male kin and female non-kin live together (and *vice versa*). Bloch & Parry (1982: 20) suggest that, where rites of secondary body disposal are present, the societal distinction between kin and affines is likely to be more marked. In Australia, such a distinction is expected where patrimoieties are present because home estates are held through patrilineal descent, therefore female affines will nearly always live with male kin away from their childhood home (Dousset *et al.* 2015). Secondary (or compound) disposal rituals take place in Pama-Nyungan societies and similar symbolic references are present. For example, the generational (although not descent) moieties of the *Pitjantjatjara* are bone (*nganantarrka*) for one's own moiety, and flesh (*tyanamiltyan*) for the alternative moiety. This suggests the hypothesis linking secondary rites to patrimoieties may be relevant and it is tested in this study.

Data preparation: binary traits

As discussed in chapter 1, inconsistencies in reporting are likely to have resulted in missing data for some groups. Conversely, if societies have multiple ethnographic accounts it may lead to a greater variety of attributes being observed. To help address these problems, binary categories are used for the analysis. Whilst this approach has the disadvantage of flattening some of the variation, the major advantage is that differences in reporting will have much less impact. Whether a society is categorised as 0 ('low') or 1 ('high') is likely to be much less affected by inconsistencies in reporting. Binary categories also allow use of the Pagel discrete method, discussed below, that enables mechanisms of causality to be tested. Using the same data categorisation and method across the seven hypotheses also maintains a consistent testing approach. Methods to create binary categories include using the mid-point of the measurement scale, the median of the data or splitting the data into three categories and discarding the middle category (Rucker *et al.* 2015). For the majority of tests, the latter method is used because, by removing the more arbitrary classification of middle values, it preserves more of the statistical power of the continuous dataset (Gelman & Park 2009). Although it provides greater confidence in categorisation, removing middle values does reduce the size of the character set. For most tests (5 out of 7), it still left sufficient data for analysis (average 53 societies with matched data), but for two tests (male elder control and girls' initiation) it resulted in more limited datasets, therefore median cut-off was used.

Data are also required for the independent variables, those hypothesised to lead to ritual change, encompassing both ecological and sociological parameters. Various sources were used for this. As discussed above, warfare data was collected direct from ethnographies. Ecology was assessed by applying the Köppen-Geiger classification previously used in chapter 3. For population density, Radcliffe-Brown's map of estimated population at the time of colonisation was used to create high/low binary categories, with data verified for accuracy against other data sources. For the presence of patrimoieties, the *Austkin* project database (www.austkin.net) was used, which details social categories from published and archival sources for the majority of language groups. Values for the remaining independent variables: sedentism, marriage age difference and female subsistence contribution were taken from the Binford database (Binford 2001).
This includes over 200 variables relating to subsistence, mobility, and social organization across 339 ethnographically documented groups of hunter-gatherers. Australian material is relatively well represented; 56 groups are recorded, with 39 from the Pama-Nyungan area.

Analytical approach

In examining associations between traits it is important to understand whether they provide evidence of adaptation or could instead be the result of common ancestry. Pairs of traits may be associated because of shared history and we can only be confident the trait is an adaption if it has evolved (or been lost) more than once in association with another trait or environmental condition. The problem of non-independence (or 'Galton's problem') is addressed in this study by using phylogenetic comparative methods. Failure to correct for shared ancestry can lead to high error rates, both in registering false associations but also failing to detect positive ones (Nunn 2011: 144). To test associations between cultural traits, language phylogenies can control for non-independence on the basis that language and population histories tend to be closely related (Mace & Holden 2005, Currie 2013, Bellwood 2013). This approach has been widely applied in comparative cultural analyses such as kinship and pastoralism (Holden & Mace 2003), marital residence (Fortunato & Jordon 2010), political complexity (Currie *et al.* 2010a), moralising high gods (Watts *et al.* 2015a) and human sacrifice (Watts *et al.* 2016). We already know from previous chapters that many Pama-Nyungan traits have a similar distribution to language, so correction for non-independence is particularly important in this study. The method used is Pagel's (1994) discrete test for binary traits, using the Pama-Nyungan language phylogeny (Bouckaert *et al.* 2018).

Pagel discrete maps the presence (state 1) or absence (state 0) of the two traits being compared to societies on the language phylogeny, and estimates the rate at which trait presence should be gained (0/1) and lost (1/0) to generate the observed distribution of states across the tree. In other words, the model solves for transition rate values that maximise the likelihood of the observed data distribution. The calculation takes place independently for both traits to produce two likelihood values, and the product of these represents the overall likelihood of the independent model *i.e.* one in which the traits do not influence each other. The calculation is then repeated but this time allowing transition rates to vary depending on whether the other trait is present or not. This dependent model solves for eight transition rates (compared to four, two for each trait, in the independent model). For example, the 0/1 rate for the first trait will have two values, one if the second trait is present and one if it's not. If allowing these rates to vary results in a significantly higher likelihood of generating the observed data than with the independent model, it suggests the traits are influencing each other and may be evolving in a correlated fashion.

A further advantage of the discrete method is its operation within a Bayesian framework as part of the *Bayes Traits* software platform (Pagel & Meade 2006). Language phylogenies, including Pama-Nyungan, contain uncertainties in relationships that can be accommodated using samples of trees, rather than one consensus tree, in the comparative analysis. *Bayes Traits* uses the Markov Chain Monte Carlo (MCMC) algorithm to search and sample tree space, generating marginal likelihood estimates of model fit integrated over the tree sample. Correlation between traits does not necessarily mean causation, they might both be influenced by something else that leads them to vary together. An important additional advantage of Pagel discrete is that it provides a way of examining this using comparisons between models with constrained and unconstrained transition rates. For example, if the transition between 0,1 (trait1 state0, trait2 state1) and 1,1 (trait1 state1, trait2 state1) has a significantly higher rate than between 0,0 and 1,0 it suggests that the presence of trait2 causes trait1 to evolve and not *vice versa.*

Analyses were performed in *Bayes Traits V3* following the procedures outlined in the *Bayes Traits* manual (November 2016). Method choices were similar to those followed by Watts *et al.* (2016) in their phylogenetic comparative study of human sacrifice and political complexity in Austronesian societies. Analyses used a sample of 4,058 Pama-Nyungan phylogenies supplied by C. Bowern (from Bouckaert, Bowern *et al.* 2018)[9]. To ensure all available data was utilised, and to maintain consistency across the seven tests, full phylogenies were used in each case (306 taxa) with missing data coded as gaps (-). Increasing the amount of data available, even without comparator values, is likely to increase phylogenetic accuracy (Wiens 2008, Wiens & Morrill 2011) and the discrete model assumes missing values take either state 0 or 1 with equal probability (see *Bayes Traits* manual). The MCMC analysis requires transition rate priors to be set and, to reduce uncertainty and arbitrariness in this choice, a hyper prior was used. These priors are themselves drawn from prior distributions which is a less restrictive method for setting values (Bernardo & Smith 2000, Currie & Mead 2014). Hyper priors were seeded from an exponential distribution based on a range informed using Maximum Likelihood (ML) estimates of transition rates for independent and dependent models. ML calculations used the majority-rule consensus tree (Bouckaert *et al.* 2018) with the number of optimisation attempts set to 100 to ensure stability of estimates. To avoid over-parameterizing the MCMC model compared to the data available, the reverse-jump method was applied which minimises the number of parameters by only adding

[9] Branch lengths were re-scaled by a factor of 0.001 to prevent rate estimates from becoming very small in the computation (see *Bayes Traits* manual).

additional ones if they improve model fit (Pagel & Meade 2006). Each analysis was run for 1,010,000 iterations, with the first 10,000 removed as burn-in. At the end of each run, log marginal likelihoods (likelihoods integrated over all parameter values) were calculated using a stepping-stone sampler to ensure stable estimates (Xie *et al.* 2011). This was run across the posterior distribution using 1,000 stones with 10,000 iterations each. To ensure consistency, each analysis was run three times and the mean values reported.

Bayes Factors (BF) were used to test between independent and dependent models. These are calculated as twice the difference between the log marginal likelihoods of the posterior distributions of each model. Whilst interpretation is somewhat arbitrary, Raftery's (1996) criteria are commonly applied: BFs below 2 provide no support for the dependent model, 2–5 suggest positive support, 5-10 strong support, and BFs over 10 indicate very strong support (see also *Bayes Traits* manual). Constraint analyses were performed for those hypotheses with BF support to assess why the dependent model was favoured and whether causality could be determined. For example, if desert location leads to the evolution of painful rites, these societies should gain those rites at a higher rate than non-desert groups. To test whether this is the case, the model is constrained to sample only models of co-evolution in which societies with desert and non-desert locations have an equal chance of gaining painful rites. If location does affect the rate of gain, the constrained model should have a substantially worse fit (as measured by BF support) than the unconstrained model. In the following section, data preparation is summarised for each of the seven tests, re-capping on the work detailed in chapter 1. This is followed by results for all hypotheses.

Test #1 (external alliances): elaborate ceremony vs population density

Data: elaborate ceremony. To define trait values, the number of different attributes used in the setting and ceremony categories was summed for each linguistic group. The total number of possible attributes was 137 (setting 42, ceremony 95) with the median 20 per group (range 0-52). Splitting this into three categories for the 109 societies: 33 were categorised 0 (low ceremony < 16 attributes), 38 categorised 1 (high ceremony > 23 attributes) with the remaining 38 groups (16-23 attributes) discarded. See Appendix 1a_Ceremony. A total of 71 societies were therefore carried forward for analysis.

When creating discrete boundaries it is important to consider whether they adequately represent the data in question (MacCallum *et al.* 2002). In this dataset, high ceremony tends to be recorded when there are a large number of setting attributes and this depends, in particular, on the presence of a processional pathway to the sacred ground.

Such paths usually contain human, animal and ancestral figures sculpted from earth and bark that require substantial effort to construct. Alternatively, high ceremony can be driven by the number of performative attributes. These include different enactments such as sorcery, mock battles *etc.* and novice decoration with painting, feathers and hair design. Review of the ethnography suggests a high number of these attributes tends to be associated with a high number of different age-stage ceremonies required for initiation completion (> 4 per novice). The presence of processional or high-stage attributes can be used as markers to test the validity of the binary categories created. Of the 33 societies categorised 0 (low), 29 (88%) had neither processional nor high-stages attributes. Of the 38 categorised 1 (high), at least one of these attributes was present in 35 (92%) of these societies. The categories therefore appear to be representative of the variation in ritual investment observed in the ethnography. See Appendix 1a_Ceremony.

Data: population density. Hunter-gatherer population sizes are difficult to record due to mobility and seasonal variation in group size. Radcliffe-Brown (R-B) made the first systematic estimate of Australian population distribution at the beginning of the colonial era, using historical records combined with theoretical assumptions about hunter-gatherer organisation. Whilst approximate, it has remained a reasonable guide to historical population density across the continent (figure 4.1, Arthur & Morphy 2005). In this study, the focus is on high or low binary categories rather than numerical values, therefore R-B's map provides sufficient detail for categories to be estimated with reasonable confidence. It also enables categorisation of every society for which we have ceremony data.

Visual inspection suggests population densities fall into four categories. These were recorded for each of the 306 societies in the phylogeny based on their language location using *Austlang*. 81 societies were highest density (category 1), 56 (category 2), 69 (category 3) and 100 (category 4 – lowest density). As with ritual data, the more arbitrary middle values (categories 2 & 3) were removed to preserve greater statistical power, leaving 181 high/low density groups for analysis. These were matched to the societies with high/low ceremony, resulting in 32 groups with data for both traits. To verify population density categories, comparison was made to limited data available from ethnographies. High/low categories were compared to 9 societies matched to Binford's database, see table 4.2. Keen (2004) also estimated population densities using ethnographic sources for 7 societies (his table 13.1) and, whilst there were no exact matches to Binford's data, 3 neighbouring societies are included in the table for comparison.

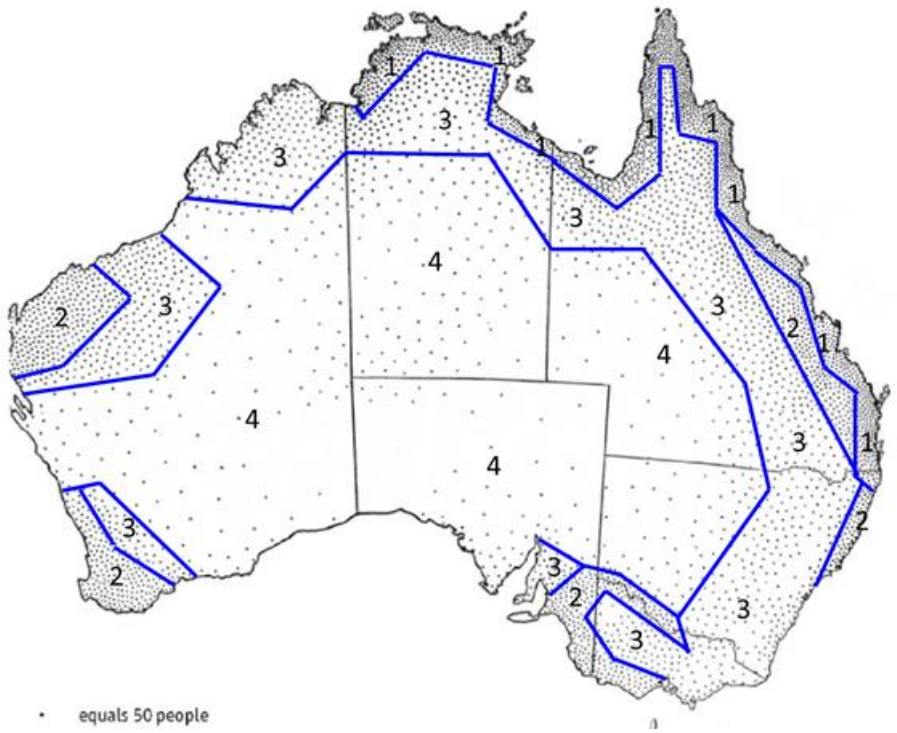


FIGURE 4.1 RADCLIFFE-BROWN'S 'ESTIMATED NUMBER OF ABORIGINAL PEOPLE IN 1788' REPRODUCED IN ARTHUR & MORPHY (2005). VISUAL INSPECTION SUGGESTS POPULATION DENSITIES FALL INTO FOUR CATEGORIES WHICH ARE OVERLAID ON THE MAP. SOCIETIES IN CATEGORIES 1 (HIGH) AND 4 (LOW) WERE INCLUDED IN THE ANALYSIS, IN COMPARISON TO THOSE WITH HIGH AND LOW LEVELS OF CEREMONY.

Society *(neighbour)*	**Category 0=low, 1=high**	**Binford (2001) (pp/100 sq. km)**	***Keen (2004) (pp/100 sq. km)***
Warlbiri	0	1.2	
Pintupi Luritja *(Pitjantjatjara)*	0	1.5	*0.5 - 1.3*
Diyari	0	1.9	
Western Arrernte	0	2.7	
Ngiyambaa *(Yuwaalaraay)*	0	5.1	*1.7 - 3.3*
Yir Yoront	1	8.0	
Bandjalang	1	13.4	
Durubul	1	21.7	
Aghu Tharrnggala *(Kuuku Ya'u)*	1	n/a	*7.1 - 40.0*
Kuku Yalanji	1	50.0	

TABLE 4.2 POPULATION DENSITY CATEGORIES BASED ON RADCLIFFE-BROWN'S MAP, COMPARED TO MATCHING VALUES FROM BINFORD'S HUNTER-GATHERER DATABASE (2001) AND TO NEIGHBOURS *(IN BRACKETS)* FROM KEEN'S 2004 ANALYSIS ADJUSTED TO PP/100 SQ. KM FOR EASIER COMPARISON.

In general, there is good correspondence between both data sets and the binary categories, providing support for the method used. Final binary data for the ceremony vs population density analysis are included in Appendix 4_Test#1Ceremony (final data for the forthcoming 6 hypothesis are similarly referenced *e.g.* Appendix4_Test#2Warfare). Of the 32 societies with data for both traits, 15 had high ceremony (3 with high population density and 12 with low) and 17 had low ceremony (9 with high population density and 8 with low):

Test #1	High Ceremony	Low Ceremony	*Total*
High Population Density	3	9	*12*
Low Population Density	12	8	*20*
Total	*15*	*17*	***32***

Test #2 (within-group alliances): costly rites vs warfare

Data: costly rites. Reviewers ranked separately, on a scale of 0-10, the likely painfulness of each procedure and its longer-term health risks. Scoring was generally consistent between the two medical specialists with only 5 of the 28 traits differing by more than 20%. Reviewer 1 considered fire ordeals, scarification and arm tying more painful, and chin biting to have a higher risk from infection, than did reviewer 2. Scores were summed and averaged across both specialists to give an overall costliness measure for each procedure. The total possible score was 244.5 with median 45.0 per society (range 0-134.5). Splitting the data distribution into three categories, 36 societies were categorised 0 (low costliness < score of 36) and 34 categorised as 1 (high costliness > score of 61) with the remaining 39 groups (score 36-61) discarded. See Appendix 1a_CostlyRites. A total of 70 societies were therefore carried forward for analysis, reduced to 65 after allocation to the language tree.

Data: warfare. Ethnographic reports were linked to a total of 63 linguistic groups with 37 meeting the criteria for active raiding (see Appendix 1a_Warfare) and allocated binary category 1. Reports linked to the remaining 26 groups contained descriptions of violence that featured regulated combat only (spear exchanges, orchestrated individual fights *etc.*) and were allocated to binary category 0. This was the case even if fatalities were recorded because it is the presence of active raiding which carries the greater risk for group members. Since violent events were actively examined in these 26 societies the assumption is that, if active raiding did exist, it is unlikely to have been overlooked by the ethnographer. Defining societies by whether active raiding was recorded or not should

therefore provide a good indication of the relative risks of warfare between them. The geographic distribution of the 37 groups with active raiding and 26 without was illustrated in chapter 1 (figure 1.2). Active raiding groups tend to be clustered together which makes intuitive sense because they are likely to be caught in cycles of violence with each other. Of the 63 societies with warfare data, 6 could not be matched to the language tree giving a revised total of 57. They were matched to the 65 groups with high/low costly rites and 33 societies had data for both traits. 20 had costly rites (12 with active raiding and 8 without) and 13 had low cost rites (8 with active raiding and 5 without):

Test #2	High Cost Rites	Low Cost Rites	*Total*
Active Raiding	12	8	*20*
No Active Raiding	8	5	*13*
Total	*20*	*13*	***33***

Test #3 (within-group alliances): costly rites vs desert habitat

This test examines the use of costly rites in adapting to challenging environmental conditions. Cohesive within-group bonds formed through such rituals may facilitate improved co-operation between group members that is likely to be particularly critical in marginal habitats where resources are both scarce and variable. If the hypothesis is valid, costly rites (defined in test 2 above) should be present in more challenging habitats. Societies in desert locations are assumed to be those with the most difficult environmental circumstances, facing both low and highly variable resource availability. The Köppen-Geiger classification (Kottek *et al.* 2006) was used to categorise societies as either desert (category 1) or non-desert (0). As this data is available for all groups, categories were applied to all 65 societies with high/low costly rites data. 32 had high cost rites (14 with desert location and 18 without) and 33 were low cost (1 with desert location and 32 without):

Test #3	High Cost Rites	Low Cost Rites	*Total*
Desert Location	14	1	*15*
Not Desert Location	18	32	*50*
Total	*32*	*33*	***65***

Test #4 (unequal power relations): elaborate ceremony vs marriage age difference

Data: ceremony. If this hypothesis is valid, we would expect greater levels of inequality to require more elaborate and demanding rituals to maintain them. To quantify elaborate ceremony, the same analysis as test 1 is used, but, as only limited data is available for marriage age difference (see below), the full dataset was used to maximise the number of matching societies. Data for the 109 societies was divided into two categories (rather than three as above); those at or below the median (20 attributes) were categorised 0 (low ceremony, 62 societies), and those above categorised 1 (high ceremony, 47 societies). 9 groups could not be matched to the language tree, leaving 100 societies for analysis.

Data: age difference on marriage. To quantify the level of inequality, average difference between males and females at the time of first marriage is used. This is not always the actual difference as, for example, the first marriage of a 25 year old male could be to an older widow of 40, as in some Pama-Nyungan societies. However, higher male *first* age suggests greater elderly male control over the marriage process, and lower female *first* age both reduced female agency and, often, the presence of an adult-controlled betrothal system for girls (Berndt & Berndt 1996: 225). Furthermore, increasing average age difference on first marriage tends to lead to higher polygyny rates (percent of males with more than one wife) because there are more girls of marriageable age than men; a conclusion supported by comparative analysis (Binford 2001: 299). For this test, data was sourced from Binford's database of 39 Pama-Nyungan societies; there was one missing data point, giving 38 overall. Binford recorded age differences as categories; 1: < 5 years, 2: 5-10, 3: 10-15 and 4: >15 years. Since the number of societies with data was relatively low, the middle category was retained for this analysis resulting in two binary categories, 0 (Binford 1 & 2; 18 societies) and 1 (Binford 3 & 4; 20 societies). These were matched to the 100 societies with high/low ceremony data and 21 societies had data for both traits. Of these, 11 had high ceremony (5 with high marriage age difference and 6 low) and 10 had low ceremony (3 high age difference and 7 low):

Test #4	High Ceremony	Low Ceremony	*Total*
High Marriage Age Diff.	5	3	*8*
Low Marriage Age Diff.	6	7	*13*
Total	*11*	*10*	***21***

Test #5 (unequal power relations): grave markings vs sedentism

Data: grave markings. These were defined using a composite category of traits associated with leaving a permanent or semi-permanent mark of the individual's resting place. Nine traits were associated with burial markings *e.g.* carved trees, huts, posts, clearings, plus the trait compound disposal was also included it supports longer-term maintenance of the dead's connection with the land (see Appendix 1b_GraveMarkings). The data distribution suggested categorising groups with no markings as 0, absent (25 societies) and those with 2 or more as 1, present (53 societies). The middle category with only one type of marking was discarded (42 societies). A total of 78 societies were therefore carried forward for analysis, although 12 of these (mainly in Western Australia) could not be allocated to the language tree, giving a revised total of 66.

Data: sedentism. Material was initially sourced from the Binford database of 39 Pama-Nyungan societies where mobility level was recorded as fully nomadic, semi-nomadic or semi-sedentary. Since the test examines whether longer-term residence patterns affect the use of grave marking, fully nomadic societies were assumed to have no sedentism (coded 0), with semi-nomadic or semi-sedentary assumed to have some degree of sedentism (coded 1). This small dataset was expanded, firstly, adding 59 societies with a desert location assuming they are likely to be fully nomadic (coded 0) because of the high variability in resources. Secondly, adding 12 societies based on ethnographic accounts of seasonal food surpluses likely to lead to increased levels of sedentism (and possibly competition over rights to these). These included moths (Flood 1980), oysters (McBryde 1978), fish (Mathews 1903) and bunya nuts (Howitt 1904: 595). This led to a total of 110 societies with data on sedentism. This was matched to the 66 societies with no/high grave markings and 32 societies had data for both traits. Of these, 23 had high grave markings (7 with sedentism and 16 without) and 9 had no markings (1 with sedentism and 8 without):

Test #5	High Grave Markings	Low Grave Markings	*Total*
Sedentism	7	1	*8*
No Sedentism	16	8	*24*
Total	*23*	*9*	***32***

Test #6 (gender and conflict): girls' initiation vs subsistence contribution

Data: girls' initiation. The hypothesis suggests initiation of girls will be present where women's contribution to subsistence is above the median level. To define the trait value,

the number of attributes used in these rites was summed for each group. The total number of possible attributes was 29 (ordeal 15, ceremony 14) with the median 2 per group (range 0-11). As only limited data is available for subsistence (see below) it was necessary to use the full ceremony dataset in order to maximise the number of matching societies. It is assumed that no or very few traits indicates lack of societal focus on female initiation. Data for 109 societies was divided into two categories; those at or below the median were categorised 0 (minimal ceremony, 60 societies), and those above categorised 1 (high ceremony, 49 societies). 9 groups could not be matched to the language tree leaving 100 societies for analysis.

Data: subsistence contribution. This was sourced from Binford where male vs female percentage contribution to subsistence is recorded from ethnographies. Values were based on the relative quantities of food coming from plants, animals and aquatic resources and how collection roles are allocated (Binford 2001: 304), and not on relative calorie contribution (which is rarely available). The median female contribution was 52.5% (range 37.5% to 65.0%). 22 societies were at or below the median (coded 0) and 17 were above it (coded 1). Data was matched to the 100 societies with low/high female ceremony and 23 societies had data for both traits. Of these, 16 had high female ceremony (9 with above median (high) subsistence, 7 below median (low) subsistence) and 7 minimal (low) ceremony (2 above-median subsistence and 5 below):

Test #6	High Female Ceremony	Low Female Ceremony	*Total*
High Subsistence	9	2	*11*
Low Subsistence	7	5	*12*
Total	*16*	*7*	***23***

Test #7 (gender and conflict): compound disposal vs kinship

Data: compound disposal. This was taken directly from Meehan's table 10 (see chapter 1 & Appendix 1b_Allocation). Mortuary rites involving compound disposal were present in 53 out of 126 societies, after matching to the language tree.

Data-kinship. The hypothesis suggests that secondary corpse disposal rites are associated with high societal distinction between kin and affines. In Australia, social categories usually involve either patrimoieties or matrimoieties (dual divisions) or sections (divisions into four or eight). In patrimoieties, father and son share the same moiety and in matrimoieties, mother and child. In both, marriage is to the opposite moiety. In a four-section system, mother, father and child have separate sections, and marriage is to the

fourth section. Patrimoieties, unlike the other categories, are made up of sets of clans, each connected to a clan estate (Dousset *et al.* 2015). Distinctions between kin and affines are expected to be more marked in this category because female affines will nearly always live away from their home estate (held through patrilineal descent). In matrimoieties or sections, affines will not necessarily live away (as the categories are not connected to estates) therefore kin distinctions are likely to be less highly defined. Categorising Australian kinship is complex; categories sometimes overlap within a society and ethnographic interpretation can vary. Data was sourced from the *Austkin* database (Dousset *et al.* 2015) with patrimoieties counted as present (coded 1) if they have been recorded at least once for a society. Of the 126 societies with data on compound disposal, 104 were matched to *Austkin.* 45 societies had compound disposal (16 with patrimoieties and 29 without) and 59 did not (5 with patrimoieties and 54 without):

Test #7	Compound Disposal	No Compound Disposal	*Total*
Patrimoieties	16	5	*21*
No Patrimoieties	29	54	*83*
Total	*45*	*59*	***104***

Results: all tests

Results are summarised on table 4.3. For each test and model there was a high consistency between the three MCMC runs, suggesting the number of iterations was sufficient to reach stable likelihood estimates. In four of the tests, the dependent model did not have a better likelihood than the independent model as measured by Bayes Factor: costly rites and warfare, elaborate ceremony and male elder control, grave marking and sedentism and compound disposal and patrimoieties. Three tests did support trait coevolution; there was strong support for costly rites and desert location (BF 8.9), and positive support for girls' initiation and contribution to subsistence (BF 3.0) and for elaborate ceremony and population density (BF 2.1).

To examine causality, I assessed, for each of the three tests with positive results, whether presence of the independent trait *e.g.* desert location, increases the rate the ritual trait *e.g.* costly rites, is acquired. States are labelled according to trait presence *e.g.* elaborate ceremony and high population is (1, 1) and rates according to *Bayes Traits* convention *e.g.* from state (1, 1) to state (0, 1) is rate q42 (see figure 4.2). To test whether presence of the independent trait increases the rate of ritual gain, the model is restricted so that both rates of gain, those with (=q24) and those without (=q13) the independent trait, are

equal. If restriction leads to a worse likelihood (as measured by Bayes Factor) it suggests one rate is significantly higher than the other, providing support to the idea that presence of the independent trait is causing the ritual trait to be acquired. These results are summarised on table 4.4. The restricted gain model (q24=q13) was significantly worse than the unrestricted model for girl's initiation (BF 4.6) suggesting contribution from women's subsistence may be causally related to development of this ceremony. However, there was no evidence of causation for high population density and elaborate ceremony (BF -1.1) or costly rites and desert location (BF -1.9).

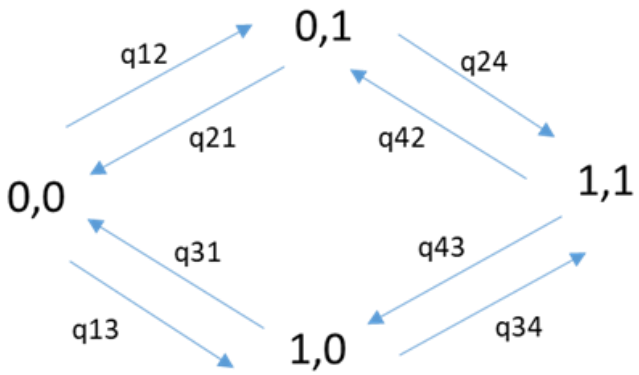


FIGURE 4.2 TRANSITION RATE LABELS BETWEEN STATES *E.G.* STATE (0, 1) IS RITUAL TRAIT ABSENT, INDEPENDENT TRAIT PRESENT.

			Number of societies			Rate prior		Independent MCMC model				Dependent MCMC model				
Test	**Trait 1 (ritual)**	**Trait 2 (indep-endent)**	**Matched**	**Un-matched (trait 1)**	**Un-matched (trait 2)**	**Max lh range**	**Hyper prior range**	**run1**	**run2**	**run3**	**mean (B)**	**run1**	**run2**	**run3**	**mean (A)**	**Log Bayes Factor 2*(A-B)**
#1	Elaborate ceremony	Population density	32	33	149	0 - 0.25	0 - 0.5	-65.8	-65.9	-65.8	-65.9	-64.8	-64.8	-64.8	-64.8	**2.1**
#2	Costly rites	Warfare	33	32	24	0 - 90	0 - 100	-75.7	-75.4	-75.6	-75.6	-77.8	-76.8	-77.1	-77.3	**-3.3**
#3	Costly rites	Desert habitat	65	0	241	0 - 0.92	0 - 1.5	-137.9	-138.1	-138.0	-138.0	-133.2	-133.0	-133.1	-133.1	**9.7**
--	Sub-incision	Desert habitat	100	0	206	0 - 0.55	0 - 1.0	-127.9	-127.0	-127.4	-127.4	-116.4	-116.3	-116.3	-116.3	**22.2**
#4	Elaborate ceremony	Marriage age diff.	21	79	17	0 - 26	0 - 50	-90.7	-91.0	-91.2	-91.0	-92.1	-92.4	-92.4	-92.3	**-2.7**
#5	Grave marking	Sedentism	32	34	78	0 - 0.92	0 - 1.5	-90.6	-90.8	-90.7	-90.7	-90.6	-90.6	-90.6	-90.6	**0.1**
#6	Girls' initiation	Subsistence contribution	23	77	16	0 - 18	0 - 50	-74.8	-75.0	-75.0	-74.9	-73.3	-73.7	-73.2	-73.4	**3.0**
#7	Compound disposal	Patrimoiety	104	22	0	0 - 78	0 - 100	-128.2	-128.0	-128.1	-128.1	-128.1	-128.1	-127.9	-128.0	**0.1**

TABLE 4.3 BAYES FACTORS FOR INDEPENDENT AND DEPENDENT MODELS OF TRAIT EVOLUTION FOR SEVEN RITUAL THEORIES RELEVANT TO PAMA-NYUNGAN AUSTRALIA. HYPER PRIOR RANGES FOR ESTIMATING MCMC RATE PARAMETERS WERE BASED ON MAXIMUM LIKELIHOOD (MAX LH) VALUES USING A CONSENSUS PHYLOGENY. MCMC MODELS USED A SAMPLE OF 4,058 TREES.

Test	Trait 1	Trait 2	run1	run2	run3	mean (B)	Unrestricted model (A) (table 4.3)	Log Bayes Factor (2*(A-B))
			Restricted gain model (q24=q13)					
#1	Elaborate ceremony	Population density	-64.26	-64.16	-64.36	-64.26	-64.81	**-1.1**
#3	Costly rites	Desert habitat	-132.26	-132.10	-132.07	-132.14	-133.10	**-1.9**
#6	Girls' initiation	Subsistence contribution	-75.96	-75.51	-75.68	-75.72	-73.42	**4.6**
--	Sub-incision	Desert habitat	-119.38	-119.16	-119.40	-119.31	-116.32	**6.0**
			Restricted loss model (q42=q31)					
#6	Girls' initiation	Subsistence contribution	-76.10	-76.14	-75.32	-75.85	-73.42	**4.9**

TABLE 4.4 RESTRICTED AND UNRESTRICTED DEPENDENT MODELS OF TRAIT EVOLUTION FOR THE RITUAL THEORIES WITH POSITIVE SUPPORT IN THE MCMC ANALYSIS (TABLE 4.3). RESTRICTING RATES OF RITUAL TRAIT GAIN WITH AND WITHOUT THE INDEPENDENT TRAIT TO BE EQUAL (q24=q13) RESULTED IN A WORSE LIKELIHOOD FOR GIRL'S INITIATION AND SUB-INCISION SUGGESTING A SIGNIFICANT DIFFERENCE IN THESE RATES. FURTHER ANALYSIS OF GIRLS' INITIATION SUGGESTED A DIFFERENCE IN LOSS RATE WHEN HIGH SUBSISTENCE CONTRIBUTION.

		Rates of trait 1 gain						**Rates of trait 1 loss**				
Trait 1	**Trait 2**	*without trait 2*		*with trait 2*		*difference*		*without trait 2*		*with trait 2*		*difference*
(Ritual)	**(Independent)**	**q13** (0,0 to 1,0)	ESS	**q24** (0,1 to 1,1)	ESS	**(q24 - q13)**		**q31** (1,0 to 0,0)	ESS	**q42** (1,1 to 0,1)	ESS	**(q31 - q42)**
Sub-incision	Desert habitat	0.00	n/a*	0.24	811	**+0.24**		0.25	753	0.07	715	**+0.18**
Girls' initiation	Subsistence contribution	0.18	684	0.01	279	**-0.17**		0.16	564	0.01	272	**+0.15**

ESS: Estimated Sample Size (*rate was zero across the entire sampled posterior distribution)

TABLE 4.5 MEAN RATES FROM DEPENDENT MODEL OF SUB-INCISION AND GIRLS' INITIATION ANALYSED USING *TRACER 1.5*. CONTINUED ON FOLLOWING PAGE.

TABLE 4.5 (CONT.) ESS VALUES (NUMBER OF EFFECTIVELY INDEPENDENT DRAWS FROM POSTERIOR DISTRIBUTION) EXCEED 200, A CONVENTIONAL CUT-OFF FOR DATA SUFFICIENCY (RAMBAUT *ET AL.* 2018). POSITIVE RATE DIFFERENCES SUGGEST SUPPORT FOR CAUSATION *I.E.* THAT RITUAL TRAIT GAIN IS HIGHER (AND RITUAL TRAIT LOSS LOWER) WITH THE INDEPENDENT TRAIT THAN WITHOUT IT. SUB-INCISION WAS POSITIVE IN BOTH DIRECTIONS, SUGGESTING DESERT HABITAT LED TO ITS DEVELOPMENT AND PREVENTS ITS LOSS. GIRLS' INITIATION WAS POSITIVE FOR LOSS, SUGGESTING HIGH SUBSISTENCE STABILISES THE TRAIT, BUT NEGATIVE FOR GAIN SUGGESTING OTHER REASONS MAY HAVE LED TO ITS DEVELOPMENT (SEE TEXT).

Discussion

Costly rites. The association between costly rituals and desert location had the strongest support in the analysis. The model allowing the presence of one trait to influence the other had a much higher likelihood than the model assuming these traits were independent. The finding provides support to the hypothesis that more costly, painful rituals are likely to be associated with harsher conditions because these require stronger alliances (Whitehouse 2004, Hayden 1993). How should the failure to establish causality be interpreted? The result may be related to the use of a binary distribution. Whilst nearly all desert societies had costly rites (14 out of 15), 18 non-desert societies (out of 50) also had costly rites. Binary categories were used to provide greater confidence over missing data but they inevitably flatten variation. Examining scores for all societies classified as high cost (see Appendix 1a_CostlyRites) indicates those with the highest values have predominantly desert locations (see figure 4.3).

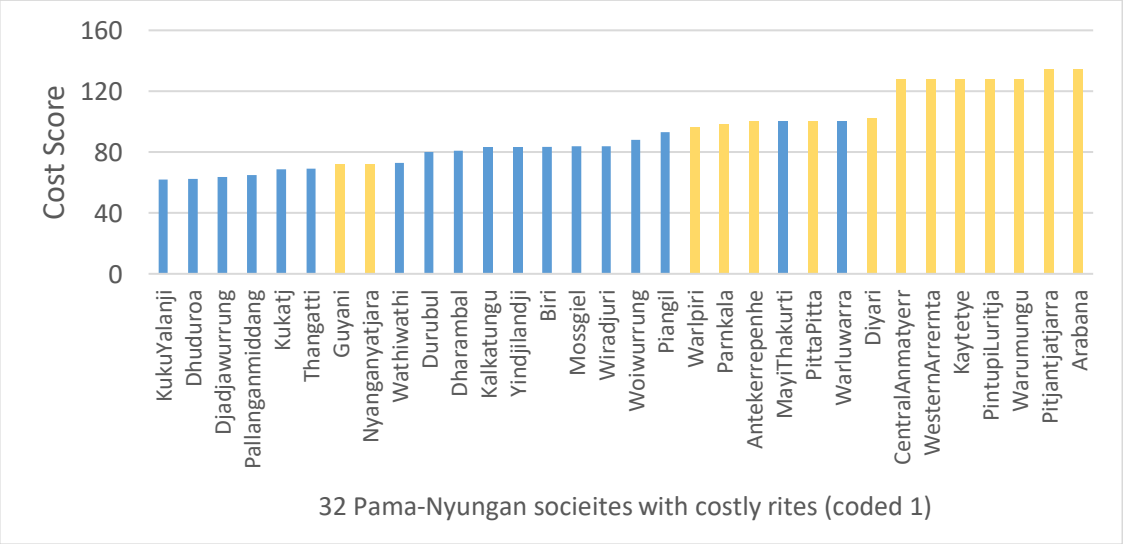


FIGURE 4.3 MALE INITIATION COST SCORES; DESERT SOCIETIES IN YELLOW, NON-DESERT IN BLUE.

Whilst other Bayesian comparative methods, using multi-state or continuous data, could accommodate this variation, they do not provide a method for interpreting causality. An alternative approach is to examine the binary distribution of particularly costly rites. The five highest scoring rites are listed in table 4.6.

	#societies	Cost score
Extended sub-incision	14	17.0
Sub-incision	29	16.5
Neck scarification	3	13.0
Chest or stomach scarification	46	12.5
Fire ordeal	28	12.5

TABLE 4.6 FIVE HIGHEST COST INITIATION PROCEDURES BASED ON PHYSICIAN ASSESSMENTS OF LIKELY PAINFULNESS AND LONGER-TERM HEALTH RISKS (SEE APPENDIX 1A_COSTLYRITES FOR MORE DETAILS).

Sub-incision ranks highest (either it's standard or extended forms) suggesting it as a relevant example for examining causality. Extended sub-incision has a relatively narrow distribution (14 societies) whereas the standard form is present in a wider range (29 societies). It is also distributed across a number of different language clades as shown in figure 4.4 below (26 societies could be allocated to the phylogeny) and a similar analysis was presented in chapter 3 (figure 3.9). This distribution suggests it as a suitable candidate for testing association with an independent variable (in this case desert habitat) because it is likely to have been gained or lost multiple times (loss maybe more likely in this case, see below).

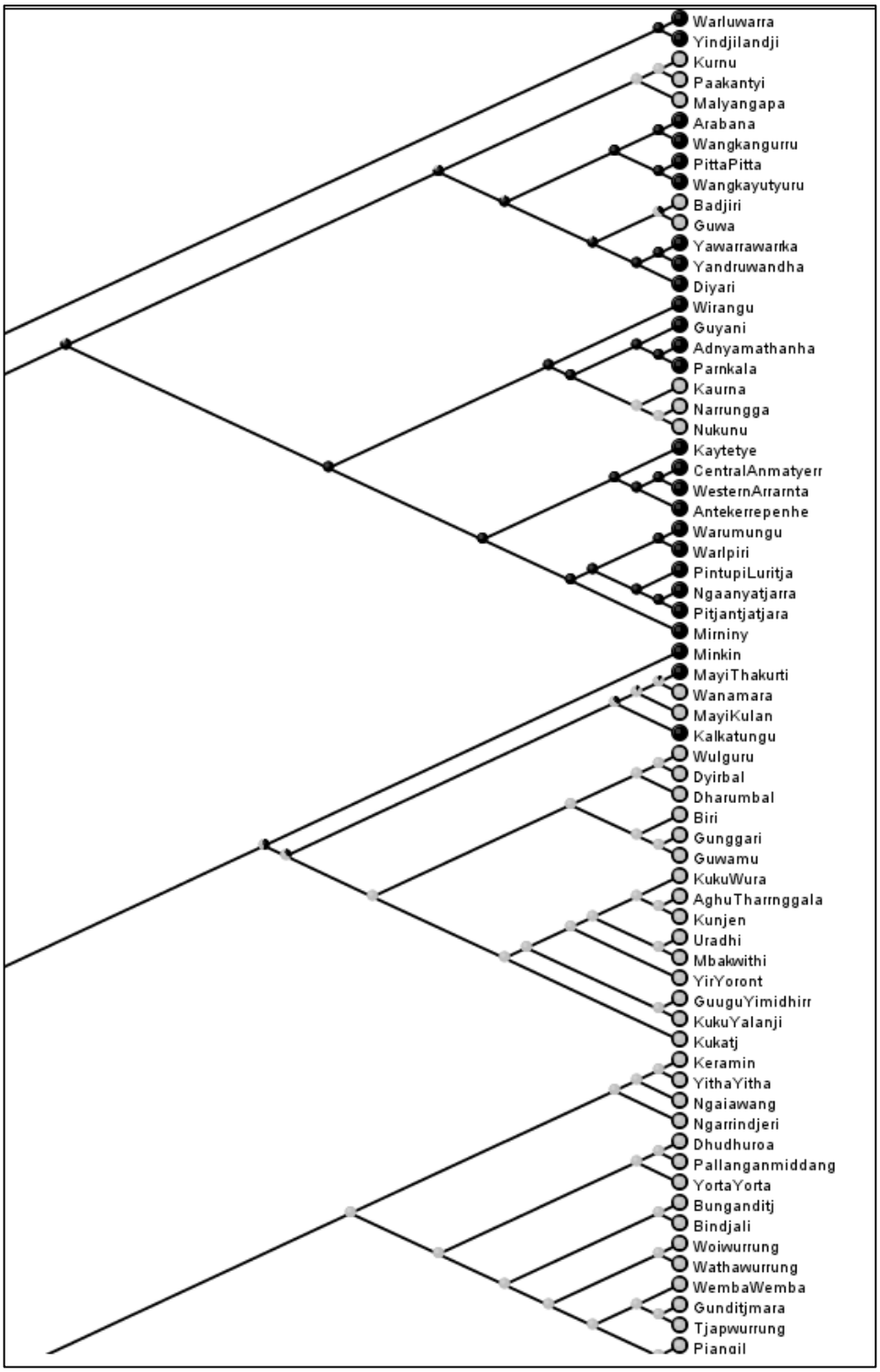


FIGURE 4.4 SUB-INCISION BY LANGUAGE (PRESENT IN BLACK, ABSENT IN GREY) SHOWING DISTRIBUTION ACROSS A NUMBER OF DIFFERENT LANGUAGE CLADES. THE PHYLOGENY WAS PRUNED TO THE 100 SOCIETIES WITH INITIATION DATA (A SECTION OF WHICH IS SHOWN HERE).

Using the same *Bayes Traits* method as earlier, independent and dependent models of the co-evolution of sub-incision with desert conditions were assessed. Input data is included in Appendix 4_SubIncision and results are shown on tables 4.3 & 4.4. There was very strong support for the dependent model (BF 22.2) and also support for causality. The restricted dependent model (rates of sub-incision gain with (=q24) and without (=q13) desert location held equal) had a worse likelihood (BF 6.0) than the unrestricted model. This finding strongly supports the conclusion that the rates are significantly different from each other. Analysis of the unrestricted model posterior distribution using *Tracer 1.5* (Rambaut & Drummond 2007) gave mean rates of 0.24 for q24 and 0.00 for q13, suggesting the difference between the two models is because the rate of sub-incision gain is significantly higher in desert locations (see table 4.5). Thus, results support the hypothesis that development of this painful rite is causally linked to arid, desert conditions.

As can be seen in figure 4.4, sub-incision has a close relationship to language. This was also seen in chapter 3; with a D value of -1.26, the trait is highly unlikely to be randomly distributed ($p<0.001$). The effect of this shared inheritance is excluded in the phylogenetic approach therefore the finding of a causal relationship between desert and sub-incision suggests geography might be playing an important role in its distribution. However, chapter 3's autologistic modelling indicated this was mainly influenced by language family ($\lambda=0.35$), with little effect from neighbour proximity ($\theta=0.01$). It's possible that this is because the trait is an environmental adaptation of linguistically related populations. They may be culturally adapted to particular ecological conditions and therefore tend to disperse into similar habitats; what might be termed 'habitat selection' (Towner *et al.* 2012)[10].

Some authors have suggested the distribution of sub-incision is a result of horizontal transmission from the centre. The rite seems to have moved northward towards Arnhem Land during the colonial era (Berndt & Berndt 1996: 196) and in the east its distribution appears to cut through the middle of some language groups, suggesting a process of gradual transmission (Dixon 2002: 15). Unfortunately this study does not encompass

[10] Another possibility is the dominant effect of language could be because sub-incision is unlikely to be acquired without an associated ritual heritage. Its close link to habitat may reflect its loss from groups moving out of the desert, rather than being gained by new groups moving in (that did not possess such heritage). However, the transition rate results do not really support this idea as the rate of trait loss without desert (q31=0.25) was almost the same as the rate of trait gain with desert (q24=0.24), see table 4.5.

Arnhem Land (which is not part of the Pama-Nyungan phylogeny) but it is notable that explanations point to the unique circumstances introduced by European invasion (Berndt 1951b). Also, it is not always clear whether *both* rite and mythology have spread northwards, as in some accounts only the latter is referenced (see chapter 2). In the east, I have not been able to verify a split language presence in the ethnography, but if this is the case it may reflect a strong influence from habitat, especially if the group is dispersed over a large area containing with both desert and non-desert terrain[11]. In central and eastern Australia at least, statistical analysis suggest habitat and language, rather than horizontal transmission, have been the most significant factors influencing sub-incision distribution.

Might there be a practical reason why sub-incision is associated with desert conditions? There is some persistence to the idea that the related practice of circumcision is associated with sandy conditions because it reduces infection under the foreskin (*balanitis*). However, review of the evidence suggests this is unlikely and the practice may even lead to more complications (Darby 2005). Sub-incision has also been linked to resistance from infection, due to the hardening of mucosa following the procedure, and other theories, such as contraceptive effect or increasing sensitivity during sexual intercourse, have also been considered. However, none of these ideas has empirical support or a clear rationale for why they would only apply in arid, desert conditions (Basedow 1927, Lobdell 1975).

Bringing this evidence together, there is a clear support for the association between costly rites and desert location. Firstly, their coevolution was strongly supported in the Bayes Factor analysis (table 4.3). Secondly, those societies with the highest cost rites tended to be in desert regions (figure 4.3). Thirdly, this environment was causally linked to evolution of the highest cost rite, sub-incision (table 4.4). The clear association suggests support for the hypothesis that costly rites are present in challenging environments because they facilitate the alliance formation required to survive in such conditions. If this is the case, it leads to the next question: which theories linking costly rites and alliances are best supported in the Australian case? One could be costly

[11] *Paakantyi*, a large language area, is a possible candidate. Another (more speculative) idea is that splits within languages might suggest the beginning of a fissioning process, with dialect communities possessing sub-incision rites more likely to form localised, exclusive groups, leading to the formation of distinct languages over time.

signalling; painful mutilations signal a commitment to the group that helps solve the 'free rider' problem of collective action. A theoretical objection to this is that it is unclear why a strong commitment to the group should necessarily be linked to possession of the physical attributes needed to perform the rite. A willingness to do so may *suggest* collective alignment, but a person strong enough to pass the ritual steps might still be less committed to the group than someone unable to. Furthermore, if acting as a genuine signal of fitness (Zahavi 1975), individuals failing the rite would be expected to suffer fitness consequences. Whilst there is some evidence of this in Australia (boys may have been killed if they failed to acquit themselves acceptably, Hayden 2003: 104) it seems that the majority pass through successfully and ceremonies do not purposefully distinguish one individual from another. Thus, contextual evidence does not provide strong support for the costly rites mechanism in Australia. Henrich (2009) suggested a different type of signalling may be involved in these rites. The performance of painful, high cost acts may be demonstrating a strong commitment to ideological beliefs that persuades others of their validity. The hypothesis may be important in explaining the presence of religious acts such as martyrdom and costly sacrifice, but seems less applicable to understanding initiations because these feature adolescents rather than religious leaders. Furthermore, Australian initiation rites take place in secret ceremonies and, although known and later visible to others, the painful mutilations that take place are not witnessed by the wider community.

Rather than signalling commitment to the group or its beliefs, costly rituals may be forming bonds between individuals through their action at a personal, emotional level. Glucklich (2001) considers the use of pain to be similar to psychotropic agents, facilitating entry to altered states which submerge individual concerns and promote unity with others. Extreme pain leads to over stimulation of the nervous system resulting in an altered state that is particularly dissociative, described as one of 'simple embodiment'. This 'pared-down self' is a highly receptive state from which spiritual rebirth, into the new community of adults, can successfully take place. In the Australian context, a potential weakness of this theory is that if pain is used to produce altered states, why is there no adoption of psychotropic agents that would produce similar effects?

The use of *Nicotiana* species ('native tobacco') and *Duboisia hopwoodii* (*'*emu poison bush') is fairly widespread across Aboriginal Australia (they are often collectively referred to as *pituri)*. However, despite their ability to alter conscious states (particularly *Duboisia*), they do not appear to have been used in a ritual context (Ratsch *et al.* 2010).

Taking a different approach, Whitehouse (2004), in his imagistic theory of ritual, examined the connection between extreme negative arousal and the production of enduring episodic or 'flashbulb' memories. Dysphoric, painful rituals trigger this arousal and the intensity of these recalled memories leads to strong emotional connections with those who went through rites with them. The bonding effect of such rituals helps to build strong alliances between participants. Whitehouse also suggests (2004: 81) that recalling such vivid, episodic events triggers enduring searches for meaning or 'trains of exegetical thinking' that, when combined with a stock of memories generated in rituals, leads to the development of highly elaborate bodies of knowledge. The acquisition of extensive ritual knowledge is a major feature of Australian rites which focus on what Eliade terms the 'mythical geography of landscape' (1973: 56). Features such as water holes and rock formations represent concrete traces of sacred wanderings and performances of the ancestors (see examples on figure 4.5). These journeys are represented by mythical cycles (also known as Dreaming tracks) that are re-enacted with songs, performances and (often painful) rites in multiple ritual stages over many months and sometimes years (Elkin 1934, Meggitt 1966). During these stages, novices develop intimate ties to the land, gradually uncovering their new identity through association with their ancestors (Eliade 1973: 84).

Whilst 'mythical', such knowledge is critically important to those inhabiting the Australian desert. As discussed in previous chapters, ancestral tracks can provide vital information on routes between water sources and productive foraging grounds (Elkin 1934: 171, Layton 1992: 55, 72), in one of the world's most hostile inhabited places (Gould 1980: 61). Lewis (1976), observing route finding among initiated Aboriginal men in central Australia over a three year period, noted that the spiritual world, manifested in sacred sites and Dreaming tracks, was their primary source of geographical knowledge. In a test of spatial orientation, sacred sites were known with a much higher degree of accuracy than cardinal points or secular locations. *Pintupi* men sang the Dreamings of every rock outcrop, creek-bed or plain 'hour after hour and all day' as they drove through their country (Lewis 1976).

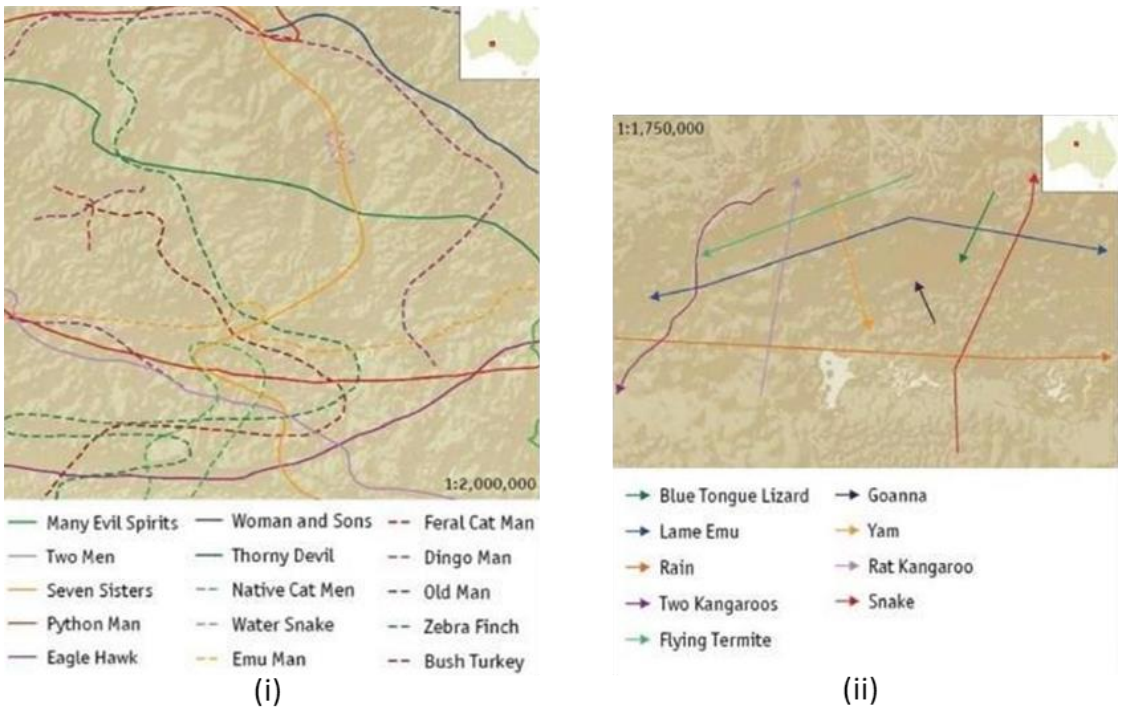


FIGURE 4.5 TRAVELS OF ANCESTRAL BEINGS IN CENTRAL AUSTRALIA; (i) GREAT VICTORIA DESERT, (ii) *WARLBIRI* COUNTRY (ARTHUR & MORPHY 2005).

Potentially then, as well as supporting alliance formation, painful rites may have been recruited as a way of 'hard-wiring' detailed, and critically important, geographic knowledge for Aboriginal people.

Of the four different costly rite theories considered, Whitehouse's imagistic theory appears to be best supported in the Pama-Nyungan case. Painful, dysphoric rites lead to cohesive alliances and the accumulation of complex, mythical-geographic knowledge. A further prediction of the theory is that cohesion formed by negative arousal rituals will, because it is based on memories of shared trauma with particular participants, tend to foster localised, exclusive communities (Whitehouse 2004: 73). In chapter 3, desert societies were found to be associated with high linguistic diversity and this might be expected in communities cohering closely together around dysphoric rites. Such rituals may have initially acted as isolating mechanisms, resulting in the accumulation of linguistic change and the separation of languages from neighbours. Water scarcity may also be an isolating mechanism, resulting in the need for quicker travel and therefore formation of more fragmented groups (Bouckaert *et al.* 2018). Perhaps both mechanisms acted in concert to increase linguistic diversity in desert regions.

Whilst strong within-group alliances may enable resource sharing in unpredictable environments, it is unclear whether this was the primary driver for development of costly rites. Sosis *et al.* (2007) did not find any link between costly rites and food sharing cross-culturally but it's possible that desert conditions may be different. For example, reciprocity may be more difficult to employ due to more dispersed populations and high variances in food availability (particularly of meat) may lead to a greater dependence on co-operation. Australian deserts are particularly challenging environments with, for example, a much lower range of edible species than the African Kalahari (Gould 1969). However, examination of the ethnography does provide contextual support for greater food sharing. Analysis of practices across the continent indicates little variation, with no particular elements of increased resource co-operation in desert regions (Keen 2004: 331). In the Western Desert, for example, kangaroos are divided into nine pieces amongst the hunting party and further divided amongst relatives when they return to camp. A very similar practice takes place in Arnhem Land which is some 2,000km to the north (Gould 1967, Altman & Peterson 1988). The lack of clear evidence for greater within-group co-operation over resources raises the possibility that knowledge acquisition could, in fact, have been the primary stimulus for the development of high cost rites. Arguably, this needs to be more extensive, and is of greater importance, in desert regions and perhaps greater levels of pain intensity were recruited to support its acquisition. Once acquired, such mythical-geographic knowledge could, in turn, be utilised as a co-operative mechanism. It is unclear whether it would lead to greater co-operation within-groups. This would depend on the extent to which the major Dreaming tracks were well known amongst most initiated men, something that is likely to vary between societies (and may anyway be difficult to establish). The co-operative benefit may be greater in terms of external alliances. Dreaming tracks are often shared across languages and territories (see chapter 3) suggesting that, as well as being a source of local knowledge, they may provide a mechanism for shared communication (McConvell 2001). This may be particularly useful, even critical, in times of severe resource scarcity such as droughts (Hayden 1993). These ideas are returned to in the Concluding chapter.

Women's ceremonies. The association between initiation ceremonies and women's contribution to subsistence was positively supported. The level of support was relatively modest (BF 3.3) but with positive indication of causality; the restricted model had a worse likelihood (BF 4.6) than unrestricted. Whilst this supports the conclusion that rates are different, analysis of the posterior distribution gave mean rates of 0.01 for q24 and 0.18

for q13, suggesting the rate of ceremony gain is actually *lower* when contribution to subsistence is high (table 4.5). To examine this unexpected result further, I analysed whether subsistence was a stabilising factor on women's ceremonies, testing whether the rate of ceremony *loss* was impacted by the presence of high subsistence. The dependent model was restricted (rates of loss with (=q42) and without (=q31) subsistence set to equal) and compared to the unrestricted model. The result was a BF difference of 4.9, suggesting these rates were also significantly different (table 4.4). Mean rates from the posterior for these transitions were 0.01 (q42) and 0.16 (q31) suggesting the rate of ceremony loss was lower with high subsistence (q42) than without (q31), as expected in the hypothesis. I interpret these findings as follows: high subsistence does not lead to women's ceremonies being acquired but, once they are (presumably for another reason), this becomes a more stable form from which the rites are difficult to lose.

One reason for the development of these rites could be to bridge difficult transitions to adulthood. In Australia, initiation of girls commonly involves a painful intervention or ordeal, followed by ceremonies involving dancing and various forms of body decoration. In this dataset, 15 attributes were associated with ordeals, including circumcision, tooth extraction and scarification, and 14 with ceremony and decoration. Thus, painful interventions are an important part of girls' rites and, when present, tend to be associated with higher levels of ceremony and decoration (Berndt & Berndt 1996: 181). In Brown's cross-cultural analysis she hypothesised that the presence of painful rites, such as genital mutilation or extreme tattooing, signals passage to an adult identity markedly different from childhood. As a test for this hypothesis, she suggests that, because child-rearing is often similar for boys and girls, such difficult transitions will be common to both sexes and, where painful rites exist for girls, they will be present for boys as well. Brown analysed this and found that male rites involving both genital mutilation and seclusion were correlated with the presence of painful female rites. In Australia, female genital mutilation does have a similar distribution to male rites of circumcision and sub-incision (see chapter 3, figures 3.15 and 3.16) as suggested by Brown's hypothesis. Perhaps then, the presence of girls' initiation ceremonies reflects differences in social organisation, related to kinship or residence after marriage, for example, which lead to more marked transitions from childhood to adulthood and require more extensive ritual practice to support them.

Another reason for the development of girl's initiation could be low levels of polygyny. In Hamilton's 1980 study of Western Desert societies, men relied heavily on women's procurement of small protein sources and production of grass-seed cakes, particularly in support of male ceremonies taking place over a number of days. This reliance may have given women leverage to develop a separate ceremonial life, including graded entry for girls and secret objects and knowledge, such as Dreaming tracks and ancestresses. During ceremonies 'solidarity can be constructed and expressed' to counter male influence, particularly in relation to marriage and polygyny. Hamilton suggests that keeping polygyny rates low prevents men from appropriating, in the form of additional wives, the female labour needed to support male ceremonial life. She also suggests that, while women's ceremonial life is important in neighbouring societies such as the *Arrernte* and *Warlbiri*, it is less distinct (and less secret) than it is for men. Potentially, this is because higher rates of polygyny in these societies allow males greater control over female labour and, in consequence, women's ceremonial life is more restricted. Thus, according to this theory, two elements are needed (high contribution to subsistence and low polygyny) to allow women's ceremonial life to flourish. Such a scenario fits quite well with the study findings; high subsistence does not lead to female rites directly, but once these have been acquired, because of low polygyny (or possibly marriage residence pattern), they are much more stable (difficult to lose) when linked to a greater reliance on female foraging and food production.

Elaborate ceremony. The third positive result was the association between elaborate male initiation ceremony and high population density in the test of Rossano's (2009) hypothesis that 'where more extensive inter-group relations are noted, more elaborate and demanding social rituals will also be present'. The level of support for the dependent model was modest (BF 2.1), just above the BF 2.0 threshold for considering it a valid association. There was no support for causation (the restricted model did not have a worse likelihood than the unrestricted model) so we are unable to say that high population density leads to elaborate ritual being acquired.

This weakly positive association may be linked to the distribution of two particular traits. As noted earlier, presence of either processional path or high stages tends to drive higher numbers of attributes overall. 92% of societies categorised as high ceremony (coded 1) possessed one or the other. Processional mainly features in eastern societies that have temperate or equatorial climates and generally higher population densities. High stages,

however, tends to be a feature of central (arid) or southern (arid and temperate) societies that are generally associated with lower population densities. On balance the association is slightly positive, but the presence of high stages in sparsely populated areas (and the elaborate ceremony associated with it) does not suggest strong support for the hypothesis.

It's possible that the categorisation of elaborate ceremony used in the study was too restrictive. Assessment was based on recording numbers of attributes, with a greater volume of these indicative of increased effort required to create the ritual setting, performance and body decoration. Whilst this is clearly demanding for group members, there are also demands on the novices themselves, particularly in the form of painful ordeals. Rossano suggests these are also important because they test the novice's ability to inhibit the 'natural defensive responses' important in stabilising inter-group relations. However, this analysis suggests painful rituals have a higher presence in arid areas of low population density, therefore inclusion of these traits in the assessment would likely lead to an even weaker result.

A further consideration is the type of ritual tested. Assessment was based on male initiation rites that are arguably the most significant ceremony in Australian life. Rossano considers these important but also discusses two other rituals that might be relevant: reconciliation and shamanism. The latter is largely absent in Australia but rituals of reconciliation are commonly used to settle disputes. As referenced earlier in regard to warfare, orchestrated exchanges of weapons and regulated hand to hand combat are often used to settle disagreements between neighbours. Such meetings might be regarded as 'ritualised' in that they follow prescribed, patterned behaviours. For example, different types of weapons are thrown in an agreed order and some groups make special white-tipped spears for exchanges to make them more visible to opponents (Petrie 1904). Unfortunately, ethnographic accounts are too infrequent to generate sufficient material for statistical analysis, but these exchanges may be a particular feature of eastern societies (in higher population areas), taking place during gatherings associated with food surpluses (Petrie 1904), generalised ceremonies or 'corroborees' (Mathews 1906) or bartering and exchange (Howitt 1904: 328). All these circumstances are likely to involve increased contact between neighbours. Thus, orchestrated exchanges, which contain the expression of emotions, are considered to be the rituals most likely associated with mediation of inter-group relations.

It does not seem likely that initiation rites were developed for this reason. Such rituals are arguably more effective at building *intra*-group coherence than the *inter*-group alliances that are the focus of Rossano's hypothesis. As discussed above, painful rites, acting through mechanisms of altered states or shared trauma, tend to build intimate ties *within* groups. Evidence from chapter 3 supports this because such rites tend to be associated with greater linguistic diversity. Localised, exclusive communities can act as isolating mechanisms that allow linguistic change to accumulate, resulting in the gradual separation of languages from neighbours. Furthermore, the current analysis provides little support for the link between elaborate initiation and high population density (where mediation of inter-group relations is most likely to be required). The processional trait may be associated with this, but it seems more likely to have developed as a platform for exegetical thinking; helping to build knowledge of ancestor narratives and developing intimate ties to the land they traversed.

Negative results. No link was found between costly rites and warfare in the study in contrast to Sosis *et al.*'s (2007) positive findings. This may be related to the nature of warfare in Indigenous Australia which tends to be associated with escalating cycles of revenge as opposed to territory. Raids take place by stealth in the early morning and, whilst enemy massacres are frequent, assailant casualties are often lower. Revenge raids by the enemy on the previous assailants then take place in a similar fashion. Thus, high-casualty open pitched battles are few, and this may lead to fewer circumstances when group members are required to make visible sacrifices on behalf of others. In turn, it may lessen the requirement for costly signals of commitment. A difference in design between the studies was assessment of costliness. Sosis *et al.* used graduate students to rank ethnographic descriptions, whereas the current study used physician assessments of pain and health implications for 28 separate procedures. This would be expected to provide a more accurate assessment of individual risk and hence commitment required to become a societal member. Interestingly, Sosis *et al.* predicted that costly rites would be associated with larger community sizes, hypothesising they would face greater free-rider problems because of an inability to monitor all members. They found the reverse to be true; there was a (non-significant) negative trend between costly rites and community size. This finding is consistent with linguistic evidence discussed above. Painful rites are associated with localised communities because they build intimate ties between group members. Thus, although the character of warfare may be different from other societies

(particular non hunter-gatherers), there is no support for this as a stimulus for the evolution of costly rites in Pama-Nyungan Australia.

There was no association between compound disposal and the presence of patrimoieties. Bloch & Parry (1982: 20) suggested the distinction between kin and affines is likely to be more marked if secondary rituals are present because later rites mediate kin/affine conflict by symbolising the body's eventual reversion to its original social state. In Australia, it was predicted these rites would be associated with patrimoieties because their connection to clan estates means female affines nearly always live away from their childhood home. That this was not observed could suggest that, whilst distinctions maybe less marked, kin/affine conflict is still present in other cases *i.e.* matrimoieties or sections. Australian kinship is complex and, to capture this information precisely, detailed reviews of each society would be required that are beyond the scope of this study. Alternatively, there may be other reasons for the rites. They are more common in the north, and also practiced in south-east Asia including parts of Indonesia, suggesting the tradition may have diffused from there to Australia (Arthur & Morphy 2005). In chapters 2 & 3, north/south distributions were identified for mortuary rituals that lend weight to this idea. Secondary rites arriving from the north may have been replaced by tree disposal (in the east) and grave goods (in the centre and west), perhaps because wider foraging ranges limited the feasibility of travel to specified ceremonial sites. The rites used to replace compound disposal may provide evidence of what was most important about the ritual and therefore preserved. Secondary rites maintain the corpse in a liminal state, sustaining the memory of the dead for a longer period and, similarly, items placed on graves and tree disposals may create focal points for mourning. The lack of evidence for association with kinship may indicate the primary focus of compound disposal is one of remembrance, rather than mediation of social conflict.

This idea is consistent with a second negative finding for mortuary rites. There was no association between grave markings and sedentism as suggested by the hypothesis that such identification helps legitimise claims over resources (Saxe 1970, Goldstein 1981). The finding supports Littleton's (2006) conclusion that burial grounds in the Murray basin were chosen for their favourable landscape features (such as proximity to water) rather than for territorial identification. It further suggests that rituals associated with maintaining the connection of the deceased to the living (grave markings and compound disposal) primarily function as points of remembrance. These acts prolong relationships

with the deceased, helping gradual re-establishment of society after the abrupt change in social order triggered by their death (Hertz 1960 [1907 & 1909]).

Lastly, there was no link between elaborate ceremony and high marriage age difference between males and females. The test was suggested by the hypothesis that ritual serves to mask the underlying reality of relationships, thereby maintaining the advantage of particular groups. In Australia, long elaborate initiations were theorised to support the monopolising of women by elder males, ensuring the forced bachelorhood of young men and the increased authority of older men (through belief in their religious power). Results suggest this is not the case. Furthermore, since polygyny rates (percent of males with more than one wife) tend to increase with increasing marriage age difference (Binford 2001: 299), it seems unlikely that ritual is used in this context either. It's possible that, because data is averaged over the whole society, it masks the fact that some males benefit *i.e.* have more wives, than others. There is not sufficient material to address this point directly but Keen *et al.* (2006) suggest the main factors leading to high polygyny rates are plentiful resources and an asymmetric kinship system. Men with very high numbers of wives appear to have built on their inherited advantage *e.g.* being the oldest of a set of maternal half-siblings with multiple potential wives available, enhancing this position by means of their negotiating skill and ability to make appropriate exchanges. It is also noteworthy that, except in the later stages of some societies, initiation rites are compulsory for all boys, thus limiting the extent they can be used to differentiate male status. For this reason, I did not examine the use of painful rites as a form of mate competition *i.e.* the willingness to endure pain signalling superior resistance to pathogens or overall genetic quality. Results of these studies have, in any case, been largely unsupportive cross-culturally (Sosis *et al.* 2007). In addition, as already discussed in this study, painful rites are associated with desert habitats, and these tend to have relatively low polygyny levels.

Conclusion

In this chapter I considered what influences could have led different rituals to evolve, testing those theories most relevant to the Pama-Nyungan case. The association between costly initiation rites and desert location had the most positive results and, for three reasons, Whitehouse's imagistic theory provides the best framework for explaining this finding. Firstly, it has a better fit to the available ethnography than the other theories. Both costly signalling and credibility display are less easy to explain in the Australian

context and, if pain is being used to create altered states (Glucklich's theory), it seems surprising that available psychotropic agents would not be similarly employed. Secondly, the theory provides a mechanism for the acquisition of extensive geographical knowledge that is a particular focus of, and requirement for, life in desert societies. The other theories do not suggest such a mechanism. Thirdly, it is a specific prediction of the theory that, because rites create shared memories of trauma between individual participants, they will lead to the formation of localised, exclusive groups. The finding in chapter 3, that costly rites were associated with linguistic diversity, provides positive evidence for this because the formation of more exclusive communities would be expected to lead to increased language separation.

All of the costly rite hypotheses considered in this chapter (including Whitehouse's) focus on the benefits such rituals provide to within-group alliance formation. However, the importance of mythic-geographic knowledge to Australian desert societies, coupled with the lack of ethnographic support for increased resource co-operation (or increased warfare), raises the intriguing possibility that knowledge acquisition, not alliance formation, may have been the primary stimulus for the development of increasingly painful rites. The use of such rituals to support knowledge development has not, to my knowledge, previously been considered as a *primary* driver of costly initiations. However, at their simplest, it is what such rituals are designed to do *i.e.* prepare the novice for adulthood. Since survival in the desert requires deep geographical knowledge, intensely painful rites may have been developed as a novel solution to making this happen. In the concluding chapter to follow, this idea is developed in more detail. I also consider to what extent the overall findings for Pama-Nyungan ritual might be generalizable to other cultures and, more broadly, to the role of ritual in human society.

Conclusion

The intensity and elaborateness of Australian ritual is well known and has been extensively discussed here. That such complex and costly rites often take place in arid, inhospitable habitats with limited resources makes their presence especially notable. The objective of this study was to understand why such rituals happen. The analysis began broadly, examining, in chapter 2, ritual diversity as a whole, followed by higher resolution analyses of individual traits in chapter 3, and comparison with ecological and sociological influences in chapter 4.

The key findings are, firstly, that a statistical, phylogenetic analysis of ritual is feasible. Results suggest cultural inheritance has significantly influenced initiation ritual and rock motif diversity, but has had less impact on mortuary ritual, where diffusion may have been a more important factor. Secondly, the development of costly initiation rites (and selected other ritual traits) seems to have played a key role in Pama-Nyungan expansion. Thirdly, whilst costly rites likely supported closer within-group alliances, their role in facilitating knowledge acquisition may have been at least as important. These findings are discussed in more detail below.

Ritual advantage and Pama-Nyungan expansion

The close relationship between language and initiation at both the holistic level (chapter 2) and the individual trait level (chapter 3) provides positive support for the hypothesis that ritual was an important catalyst for Pama-Nyungan expansion. This has been suggested by a number of authors (Evans & Jones 1997, Evans & McConvell 1998, McConvell 2011), however their hypotheses point to the development of large-scale ceremonies as the key advantage. In contrast, the analysis in chapter 3 suggested traits associated with painful rites, rather than ceremony, had the most significant effect on language expansion, and therefore may have been the most important features. The importance of these rites was further highlighted in the results presented in chapter 4. The link between costly ritual and desert conditions was by far the strongest association in the analysis and, importantly, there was also support for causation in the case of the most costly rite, sub-incision. Occupation of the desert likely led to the acquisition of this practice (rather than *vice versa*). Adopting such increasingly costly rites may have been

advantageous because they facilitated closer within-group alliances and the accumulation of greater volumes of geographic knowledge (discussed further below). These findings lead to the proposal of an alternative hypothesis for Pama-Nyungan expansion: that the advantages gained from costly initiations supported entry into new environments previously considered too harsh to occupy. In support of this idea, some authors suggest the timing of new site occupations in arid, central Australia corresponds to likely Pama-Nyungan timescales (Veth 2000, Smith & Ross 2008). Furthermore, the modelled pathways of language and ritual change presented in chapter 2 suggest expansion is more likely to have taken a north to south route through arid regions, rather than westerly, via more productive coastal habitats.

Costly rituals beyond the desert

Arguably, the desert societies most strongly associated with costly rites have the most to gain from closer alliances and knowledge of the landscape. Assuming a population density of 1 person per 100 square km (chapter 4, table 4.1) and an average Pama-Nyungan foraging size of 12 (Binford 2001), one band might range over 1,200 square km[12] and need to be familiar with this terrain to find food and water. However, Pama-Nyungan expansion extended through other habitats as well as the arid centre; might ritual have supported this too? Such processes could have been similar but of less intensity. Australia is a very dry continent and whilst desert societies make up 24% of linguistic groups (73 societies), those classified only as arid (Kottek *et al.* 2006) make up a further 24%. Close alliances and geographic knowledge, such as routes between water sources, were likely of considerable value here too. The painful rites common in the arid steppe regions of eastern Australia, such as tooth extraction and fire ordeals, may have served a similar purpose. Fire ordeals were linked to increased language diversity in chapter 3, suggesting a role in Pama-Nyungan expansion.

As well as costly rites, expansion may have been driven by other social and ritual innovations, perhaps resulting in a series of pulses and pauses as hypothesised for the Austronesian expansion (Gray *et al.* 2009). Ritual involvement in a south-eastern pulse is possible, associated with the development of a different religious system involving a supreme creator being (as opposed to multiple totemic ancestors elsewhere). This may be linked to differences in rock motifs, and higher numbers of initiation stages, both of

[12] In the UK, about 4 times the area of the Isle of Wight.

which were associated with language diversification in chapter 3. Another pulse hinted at is the eastern coastal region. Traits associated with this distribution *e.g.* female finger removal, turtle rock motifs and tree disposal were linked to language diversification. This is also an area where seasonal surpluses and large group gatherings have been documented, suggesting high population densities leading to fissioning into separate linguistic groups.

Ritual advantage in other hunter-gatherers?

Pama-Nyungan is the largest hunter-gatherer expansion for which both ethnographic data and a language phylogeny are available, therefore conclusions from this study may provide insight into cultural changes behind similar population shifts and expansions. Since we have been hunter-gatherers for over 95% of our history, such population changes are likely to have occurred many times in the past. Examining the factors behind them can help us understand more about the cultural innovations that have shaped human history. More recent expansions, such as Indo-European, Bantu and Austronesian, appear to have been driven by known factors such as agriculture and technology. The results of this study suggest the development of 'high intensity' initiations, in the form of painful rites, multiple stages and use of symbolic objects and imagery could have been an important innovation leading to hunter-gather expansion.

Insight into older population shifts relies primarily on archaeological data, and one such important change is the Upper Palaeolithic revolution from around 40,000 to 10,000 years ago. This period of rapid cultural innovation is also associated with expansion into previously uninhabited regions such as the Arctic (Bar-Yosef 2007). Evidence of increasingly organised settlements, specialised tool types, exchange networks, bone and antler objects, and cave paintings, such as those at Lascaux and Altamira, emerges during this period. More complex ritual may also have developed at this time. Burials begin to be associated with grave goods, purposefully arranged bodies, red ochre and other body decorations. Carved figures and engraved stones begin to occur and examination of cave locations, paintings and engravings suggests at least some may have had a ritual function (Bahn 2011). Evidence of image retouching, the placement of objects in niches and the physical inaccessibility of some sites, supports this viewpoint. One theory is that cave sites may have been used for adolescent initiations (Pfeiffer 1982, Goody 2004). The difficult journey, unfamiliar acoustics and rock formations, and apparent movement of painted animals in flickering light all provide the ingredients for creating a liminal ritual

state. Whilst the use of ethnographic parallels has a chequered history in rock image interpretation (Bahn 2011), the Pama-Nyungan evidence, albeit from a much later period, suggests similar 'high intensity' initiations could well have played an important role in hunter-gatherer population expansions such as the Upper Palaeolithic.

The statistical method BiSSE (Maddison *et al.* 2007), used in chapter 3, may be a useful tool for analysing the reasons behind other population expansions where a language phylogeny is available. The impact of particular agricultural innovations (in Indo-European and Bantu expansions) and sailing technologies (in Austronesian) could be examined using this method. The complex technologies required to successfully hunt sea animals could be analysed for the Eskimo-Aleut. Although there are challenges with phylogenetic reconstruction (Berge 2017), comparison with Pama-Nyungan could be especially interesting in this case because both expansions are associated with challenging habitats and are unrelated to the development of agriculture. Arguably, survival in arid conditions is more likely to benefit from strong alliances and geographic knowledge (particularly routes between water sources), with life in the Arctic more reliant on practical hunting skills, since vegetable foods are relatively scarce (and seasonal). This difference may be reflected in their initiation and marriage practices. In Inuit societies (a major branch of Eskimo-Aleut), boys marry once they become productive hunters and generally there is little ceremony associated with the end of adolescence and marriage (Mol 1982). Among the Pama-Nyungan, marriage tends to follow multiple initiation stages and painful ordeals. This preliminary observation, if borne out by more detailed analysis, might provide comparative supportive for the findings of this study *i.e.* that painful rites build alliances and ritual knowledge. These may be necessary for Pama-Nyungans but not the Eskimo-Aleut, where practical hunting skill seems to be the key requirement for attaining adulthood.

The impetus for costly rituals: alliances or ritual knowledge?

The link between costly initiation rites and desert habitat was by far the strongest association in chapter 4's results. As resources are scarce and unpredictable in these environments, the finding suggests costly rites may have been employed to facilitate closer within-group alliances that, in times of scarcity, would enable higher levels of resource co-operation between group members. Various theories have been put forward to explain how this might happen which were reviewed in chapter 4. For three reasons, Whitehouse's imagistic theory had the best alignment with the study results. Firstly, other

theories (costly signalling, credibility display and altered states) were less easy to explain in the Australian context. Secondly, the theory provides a mechanism for the acquisition of extensive knowledge that is a particular focus of life in desert societies. Thirdly, it predicts that, because rites create shared memories of trauma between participants, they will lead to strongly localised groups. The finding in chapter 3, that costly rites were associated with linguistic diversity, provides evidence of this last point because the creation of highly localised communities would be expected to lead to language separation.

Whilst the imagistic theory had strong support, review of the ethnography did not indicate that food sharing (or, another collective challenge, warfare) was particularly different in desert societies compared to those in more temperate regions. What does appear to be different is the large volume of mythical-geographic material that is a feature of desert societies. Meggitt (1966) notes, for example, that one of many mythical cycles of the *Walbiri* contained over 200 different songs. Various anthologies attest to the wide range of mythical narratives associated with central, arid Australia (Moyle 1966, Ellis 1966, Strehlow 1972, Berndt & Berndt 1989). However, it is important to note that these societies tended to be the focus of more detailed anthropological fieldwork (mainly because they were less impacted by European expansion) so there may be a bias toward more fulsome accounts of their ritual knowledge. Nonetheless, the consistency with which this difference is observed suggests it may have some validity. Through connecting and organising Indigenous Australian relationships with the land such knowledge, whilst 'mythical', can be a source of practical information for those inhabiting the Australian desert (Elkin 1934). Lewis (1976) noted, in his observations of route finding among initiated Aboriginal men, that the spiritual world was their primary source of geographical knowledge. Intriguingly, this leads to the question of whether accumulating such knowledge, rather than forming alliances, might have been the primary impetus for developing increasingly costly initiation rites in desert societies.

As far as I am aware, the hypothesis of knowledge production as the *primary* stimulus for the development of costly rites has not been explicitly considered within a testable, analytical framework. It is therefore worth developing the idea in more detail. To do this I firstly revisit the mechanism, initially discussed in chapter 4, by which painful, traumatic rites might lead to the accumulation esoteric knowledge. I then compare this mechanism

to the operation of Pama-Nyungan ritual. Lastly, I examine, in preliminary terms, other societies whose rituals maybe orientated around knowledge production.

Accumulating ritual knowledge: memory and transmission

In the absence of written texts, maintaining elaborate and extensive bodies of knowledge within a society requires it to be both personally memorable and transmittable to others. The emotional character of rituals and their capacity to induce analogical thinking helps meet these aims. People are known to search for symbolic, portentous details in the process of recalling emotional, life-changing events (Pillemer *et al.* 1986). The surprising, traumatic nature of a ritual actively triggers such a search and the (often puzzling) practices themselves actively invite analogical interpretation. Barth (1975) used the concept of 'analogical codes' in his analysis of *Baktaman* ritual in the New Guinea interior. Numerous associations, such as the miracle of morning dew and the growth of taro, are introduced during severe rites, including being beaten with stones and dehydrated for long periods. These revelations take place over seven different stages of initiation that are rarely performed, sometimes just once a decade. Whitehouse (1992) suggests the linking of rite and analogy is both a powerful mnemonic device for maintaining ritual knowledge over this long period, and a way of priming exegetical thought and revelation that transcends the limitations of verbal communication.

Analogies seem to play a central role in human induction and reasoning, particularly when information is difficult to convey using other means (Gentner & Holyoak 1997). Searching for structural alignments between domains, and the higher-order forces behind them, allows the formation of stable new categories and schemas. They are stable in the memory because they rely on already understood relations *i.e.* the way the world is. The idea is similar to the concept of minimally counter-intuitive narratives enjoying a memory advantage that favours their onward transmission (Boyer 1994). Whilst supernatural elements are normally integral to ritual and religion, minimising their frequency compared to those elements consistent with the properties of ordinary objects, seems to favour the narrative's longevity (Norenzayan *et al.* 2006). Looked at this way, perhaps the use of analogies helps to 'normalise' (and therefore minimise) the counter intuitiveness of a concept. Whilst supernatural beings might be responsible for a thunderstorm (what some might regard as a counter-intuitive concept), the reasons for it happening, such as the Gods being angry or fighting, aligns with already understood ontological relations (the way people behave), making it a conceptually more intuitive act.

To examine experimentally whether ritual participation might lead to increases in such analogical thinking, Richert *et al.* (2005) measured objective (galvanic skin response) and subjective (questionnaire) emotional responses of 53 participants to simulated rituals involving prescribed ceremonial actions and high intensity sound and lighting. Those who had a high emotional response recorded a significantly larger volume of interpretations and analogies to explain the ritual compared to those with a low response. In interviews conducted two months later, the difference between the two groups expanded, suggesting high arousal induces longer-term searches of understanding or ruminations on 'what it all means'. These differences were found even without the personal consequentiality present in a real ritual, something that would be expected to further increase the volume and depth of reflection (Richert *et al.* 2005). In their study of participants at the San Pedro Manrique fire walking ritual in Spain, Xygalatas *et al.* (2013) found memories of the event were greater two months after it took place, compared to those at the time. They suggest suppression of strong emotions may have impaired memory retention of the ritual but that subsequent reflection and discussion between participants increased its salience over time.

As well as stimulating reflection and memory, the emotional character of rituals can help to ensure their onward transmission. Features promoting both negative emotions (pain, fatigue, darkness) and positive ones (music, dance, some altered states) may all suggest proximity to sources of other worldly power and the belief that participants are in the presence of supernatural agents (Richert *et al.* 2005, Glucklich 2001). Fear of this power provides a motivating force to reproduce the ritual and gain some sort of mastery over problems of ritual exegesis. The consequences of failing to remember the rites or interpreting them incorrectly may be dire, leading elders to become deeply committed to their accurate maintenance and transmission (Richert *et al.* 2005).

The Dreamtime: ritual emotion and analogy

Pama-Nyungan initiations possess many of the characteristics associated with maintaining elaborate and extensive bodies of ritual knowledge. Most importantly, their highly emotional character (already extensively discussed) is likely to motivate onward transmission and induce the analogical thinking associated with stabilised memory.

A number of other mechanisms also support onward transmission. Prior to ceremonies, novices may undertake extensive travel through the group's territory, building wider

social networks and increasing their knowledge of ancestral journeys. The rites themselves tend to be long multi-stage processes taking place over a number of years both before and after puberty. Each stage has wide community participation so, as well as developing understanding for the novice, other group members have constant exposure to ceremonies. This supports on-going reproduction but also provides the opportunity for new creative elements to be added, further priming the processes of analogical thinking.

Other practices are likely to aid memorability. The mythical cycles are enacted as they are sung and this takes place in a prescribed order. Each verse is normally repeated, although the archaic language used may make recall more difficult (Layton pers. com.). Transmission is also supported through the use of ritual objects, such as bull-roarers, string crosses, *churinga* boards, and imagery such as rock motifs and body painting. At initiation, a string cross representing the patrician is pressed heavily against the chest of a *Walbiri* youth to make him receptive to the spirit of his ancestors (Morton 1987). Already initiated men may actively participate in this ancestral reconnection through further painful procedures. *Arrernte* men, for example, sometimes submit to further sub-incision procedures up to the age of 35 (Spencer & Gillen 1899: 255).

The Dreamtime narratives themselves employ analogical representation through positing the structural alignment between earthly and ancestral domains. The way higher order forces created the landscape is similar to the way one might envisage a supernatural human-animal agent doing so. Ancestral journeys are full of analogical associations, for example, a formation of boulders are the eggs laid by a lizard ancestor and a creek bed is the winding path of an ancestral python (Layton 1985). These representations provide a natural structure for embedding landscape features into memory. They also create a schema for adding further analogical representations, perhaps incorporating actual events, characters and features into the narrative. Such features may be useful to know in themselves or may create further cycles of interpretation.

It is perhaps difficult to convey the depth and intimacy of Aboriginal people's connection to the land that the ritual process is able to forge. Establishing such deep connectivity provides a powerful way of making sense of the world. During their Dreamtime journeys the ancestors sang the names of the land features as they created them. Such naming acts as a claim to the site and, in ceremonies, the novice learns and later sings these songs, reinforcing their ancestral connection and, through this, their own claims to the land (Munn 1971). The connection is enhanced through proximity to the ancestral world.

As discussed above, painful rites signal its presence and ritual objects and imagery are imbued with its power. They establish an intimate closeness to the Dreamtime and constant reference is made to the ancestral side of the time barrier; the country of the present becomes 'redolent with the transient beings who have occupied it' (*ibid*). Throughout these long cycles of initiation, the youth constantly absorbs knowledge and ancestral power into his body so that, gradually, it comes to be identified with the ancestor's body (Morton 1987). The ultimate aim is becoming or perhaps, being re-incarnated as, an ancestor, thus achieving oneness with the land.

Characteristics of Pama-Nyungan ritual: genital mutilation

Analysis of specific rites may provide further insight into the importance of ritual knowledge. In particular, the practice of genital mutilation and the unusual practice of sub-incision. Although this procedure is painful, physician assessment ranked the intensity of pain as similar to neck scarification and fire ordeals. Why then were genital mutilations adopted in more arid conditions? There are unlikely to be any practical benefits (as discussed in chapter 4), nor are they associated with particular environmental conditions (they are recorded elsewhere in both arid and equatorial habitats). Might these rites have diffused to Australia from a neighbouring country? Sub-incision is rare in the ethnographic record but the related practice of circumcision is more common. According to Murdock's data (1967), it is present in 45% of European, Asian and North African societies (predominantly due to widespread adoption in Muslim communities), 0% of (Indigenous) North and South American societies, 55% of Sub-Saharan African and 26% of Pacific societies. In this region it is common in Polynesia *e.g.* Samoa, Tonga and in some Melanesian islands *e.g.* Fiji. Whilst not recorded by Murdock, is also seems to fairly widespread in eastern New Guinea (Kelly *et al.* 2012). It is not, however, a feature of northern Australia, which suggests independent development, rather than diffusion, is a strong possibility. It may have spread from New Guinea and been subsequently lost in northern Australia but, since it seems to be entirely absent from this region, this appears unlikely.

Assuming there are no practical benefits, psychological or symbolic associations seem the most plausible explanations for the independent development of these rites. The genitals are associated with powerful new forces of pleasure and fertility that require appropriate direction during adolescent initiation (Glucklich 2001). Symbolically, genital sub-incision may represent the combination of male and female organs required for fertilisation to

take place. In some societies, the penis represents the fertility earth mother figure the rainbow snake, and the sub-incision cut is her uterus (Berndt & Berndt 1996: 176). Increase rites are common throughout Australia but tend to be more elaborate in the arid centre (*ibid,* 272). Rites are typically linked to communication with the ancestral form of the species, aiming to draw on their power to increase fertility and abundance. In this context, Singer & De Sole (1967) noted the marked similarity between the sub-incised penis and the kangaroo's bifid penis, suggesting that, as the primary game animal in central Australia, the practice may have originated as a symbolic association with the animal's fertility. Whilst there is no consensus view (and such puzzling symbolism is, of course, common in ritual), some kind of symbolic sexual-fertility link seems plausible. The various associations suggested, whether linked to human reproduction or kangaroo fertility, are essentially analogical in nature. Arguably, the symbolic act of sub-incision creates alignment between human ritual action and the higher-order (ancestral) powers that support continued fertility. Thus, the development of this particular rite (as opposed to other painful rites which could have been used) may follow the same schema of ancestral power that formed the features of the landscape. The consistency between analogies may have helped to embed the practice (and associated narrative) in the memory and support its onward transmission.

Female genital rites have a similar central, desert distribution to male sub-incision and circumcision (see chapter 3), suggesting alliance formation or ritual knowledge may be important here too. Results from chapter 4 indicated a positive association between the presence of these ceremonies and higher women's contribution to subsistence. This tends to be the case in more arid conditions, where large game is scarce and plant-based diets and smaller protein sources (foraged mainly by women) make up a larger proportion of the diet. Hamilton (1980) suggested this reliance may have given women leverage to develop a separate ceremonial life, including graded entry for girls and secret objects and knowledge, such as Dreaming tracks and ancestresses. Thus, as with male rites, they may be similarly linked to accumulation of mythical-geographic knowledge. However, there is more contextual evidence for closer female alliances in (at least some) desert societies featuring painful initiation rites. Thus the impetus for developing these rituals may have been different. During the ceremonies 'women's solidarity could be constructed and expressed' as a way of countering male influence, particularly in relation to marriage and polygyny (Hamilton 1980).

In summary, the characteristics of Pama Nyungan initiation ritual, its emotional salience and the analogical structure of its Dreamtime narratives and painful rites, show a strong similarity to the ritual ingredients required (as set out by Whitehouse and others) to maintain elaborate and extensive bodies of knowledge within a society. This alignment, together with the practical importance of mythical-geographic knowledge in desert societies, and the lack of ethnographic support for closer alliances *e.g.* resource co-operation, suggest that acquiring ritual knowledge could have been the *primary* impetus for the development of costly male initiations. However, whilst less information is available for women's ceremonies, there is clearer support for closer alliance formation in desert societies suggesting that, in contrast to men, this could have been the impetus for developing costly ritual.

External alliances and 'cycles of innovation'

In concluding that accumulation of mythical-geographic knowledge may have been the primary stimulus for increasingly costly male rites, I do not mean to suggest that the benefits gained from alliance formation were unimportant. The evidence from language diversification in chapter 3 suggests societies with costly rites did form closely bonded localised groups and these are likely to have been beneficial in managing variable resources. In addition, the mythical-geographic knowledge itself, once acquired, is also a potential co-operative mechanism. As discussed in chapter 4, it might lead to closer alliances within linguistic groups if, for example, knowledge of different Dreaming tracks are held by different initiates. Other aspects of the ceremonies themselves suggest initiation plays a role in sustaining within-group connections. In many societies, the male novice embarks on an extensive journey prior to ceremonies, reinforcing extended kinship networks and meeting potential wives. Whilst sufficient comparative data was lacking in this area (see chapter 1), the journey guide and person carrying out the initiation rite often have specific relationships to the novice *e.g.* their mother's brother or future father-in-law. Furthermore, the co-operative benefits of initiation may extend beyond the group, facilitating relationships between those speaking different languages. Dreaming tracks are often shared across territories (Elkin 1934, Meggitt 1966), suggesting that, as well as being a source of local knowledge, they may provide a mechanism for shared communication (McConvell 2001). Other evidence supports the existence of inter-group relationships such as interchangeability between kinship systems (Maddock 1974:

89) and relatively high levels of multilingualism allowing communication between societies (Elkin 1979: 65).

Such commonality may be facilitated through the holding of large gatherings. These are frequently referenced in the literature; I noted 23 gatherings of over 100 attendees in the ethnographies reviewed. Some meetings had over 500 attendees and one was around 3,000 (Fraser Island, Howitt 1904: 606). Event descriptions sometimes mention different language groups being represented and population data also suggests this. Although numbers are difficult to estimate for mobile hunter-gatherers, Pama-Nyungan linguistic group sizes from the Binford database (2001) range between 80 and 3,500 (mean 800) suggesting more than one language is likely to have been represented when gatherings were large. Ethnographies indicate a wide variety of activities took place at these events: initiations, increase ceremonies, resolution of disputes, orchestrated battles, exchanges of items, and more generalised 'corroborees' without specific aims (or at least not ones ascertained by the ethnographer). All of these activities may, to a lesser or greater extent, have supported relationships between linguistic groups.

Although the benefits of such alliances may have been significant, their formation does not appear to have been the *primary* stimulus for evolution of elaborate or costly ritual. Results from chapter 4 (test #1) did not suggest a strong association between inter-group relations and elaborate ceremony. Furthermore, if rites were acquired to facilitate relations between groups, it is unclear why these would need to be more costly in desert versus temperate or equatorial regions (since the latter are likely to have more contact with external neighbours). However, the usefulness of these rites in supporting inter-group relations may have influenced their subsequent development. The benefits of such alliances, including reduced conflict, exchange opportunities, marriage partners *etc.* (Evans & McConvell 2008) may have stimulated further ritual innovation. As discussed earlier, the range and volume of Australian mythical material is particularly notable. Perhaps ritual's initial role in creating intimate ties to the landscape expanded due to its further benefits as a shared medium of communication. This would require incorporation or development of new narratives to align with those of neighbouring groups, creating a positive cycle of knowledge production or 'cycle of innovation'. As discussed in chapter 2, mythical narratives were known to be actively transmitted between societies, providing further evidence of their importance as modes of shared communication.

Ritual knowledge in other societies

The Pama-Nyungan results suggest the link between costly rites and esoteric ritual knowledge (hypothesised by Whitehouse) might be testable comparatively. The association has already been referred to in the case of the *Baktaman*, and severe initiatory rites are common in other Melanesian societies that also feature extensive ritual exegesis (Whitehouse 1996, Gell 1980). Examination of Sosis *et al.*'s (2007) cross-cultural dataset indicates severe rites are particularly common in hunter-gatherers. Out of 60 societies analysed, 13 had very costly rites (Sosis *et al.* scores >10) and 6 of these were hunter-gatherers. Interestingly, 4 of the 6 were in challenging habitats, such as the *Blackfoot* (Great Plains desert) and the *Ona* (Tierra del Fuego tundra). This could be because hunter-gatherers have tended to be pushed into marginal environments by the expansion of agriculture or, as I have hypothesised for Australia, because costly rites facilitate embedding of the mythical-geographic knowledge required to survive in challenging conditions. It is notable however that Inuit hunter-gatherers in the Arctic have minimal initiation rites. As discussed earlier, there may be more reliance on the acquisition of practical hunting skills for survival than on detailed knowledge of the terrain.

Another example of the accumulation of esoteric ritual information is within secret societies. Their key characteristic (the secret) is restricted access to ritual knowledge and the various powers that may flow from this (Hayden 2018: 7). Another key element is that such knowledge tends to be oral, in order to preserve its secrecy (Brandt 1980). For the *Mende*, in Sierra Leone, admission to the *Poro* for men and *Sande* for women, is a complex process involving up to 30 different initiation stages. Increasing power is acquired with each stage (controlled through ritual knowledge and the ownership of masks) and rites are particularly severe. For boys they include circumcision, scarification and several weeks spent in isolation with little food (La Fontaine 1985, Højbjerg 2004). The *Hopi*, in present day Arizona, possess an intricate symbolic system linked to a complex seasonal calendar. There are numerous rituals, for both boy and girls, with a number of painful rites including whipping and being forced to adopt a cramped posture over a four day period (La Fontaine 1985).

These selected examples suggest the link between severe rites and accumulation of ritual knowledge, particularly in its oral form, could be examined cross-culturally. Richert *et al.* (2005) postulated that the extent of exegetical reflection promoted by a ritual could be

quantified by measuring its volume (number of analogies used) and depth (number of comparisons across domains, and whether these were concrete or abstract). Extensive ethnographic material would be required to do this[13], with careful consideration given to ensuring consistent measurement between societies. I am not aware that any such analyses have been completed but, as well as examining the link between severe rites and ritual knowledge, other parameters could be incorporated into such a framework *e.g.* subsistence type, environment, warfare and hierarchy, to determine the most likely impetus for developing costly rites. In Australia, I have suggested these rites enable the accumulation of ritual (mythical) knowledge that helps to embed the practical (geographic) knowledge required for survival. However, the findings for other societies (particularly non hunter-gatherers) may well be different. Accumulating elaborate knowledge in secret societies is likely to serve other purposes. For example, as a way to demonstrate supernatural power or form shared representations of meaning that contribute to closer solidarity between members. Such outcomes may have further (ultimate) aims, for example, the promotion of self or member's interests (Johansen 2005) or, as in the case of the *Poro*, political control (Tefft 1980). The coalescence of different advantages could also be important, creating, as I have hypothesised for Pama-Nyungan, 'cycles of innovation' leading to extensive bodies of ritual knowledge.

Conclusion

Results from this study suggest that ritual, when broken down into suitable, relevant traits, can be a tractable topic for statistical analysis. In particular, a phylogenetic approach can yield useful insight into the influence cultural inheritance may have had on different ritual forms. The novel use of BiSSE also highlights a statistical method that may be useful for other cultural analyses, such as assessing the effect particular social, technological or environmental traits may have had on linguistic expansions. In particular, it could be used as a way to test whether painful rituals are associated with strongly localised groups in other societies, as hypothesised by Whitehouse (2004).

The application of such statistical methods enables ritual theories to be rigorously tested. In this study, such testing confirmed the role of initiation rites in Pama-Nyungan expansion and, by extension, its possible importance for other hunter-gather expansions deeper in human history. Hypothesis testing also supported the connection between

[13] For example, only a few individual Australian societies are likely to have sufficient depth in ethnography to meet this objective.

costly rites and the occupation of desert habitats. Further contextual analysis suggested the impetus for developing these rites may have been the accumulation of mythical-geographic knowledge, rather than alliance formation. This idea was first put forward in chapter 4 and I have developed it in more detail here because the significance of ritual knowledge as an ultimate driver of ritual practice (as opposed to a consequence of the ritual process) does not seem to have been explicitly theorised within a testable framework before.

In the Introduction, I highlighted two contrasting theoretical approaches to ritual: the cognitive or psychological and the sociological. This thesis has focused on the latter, however, the importance of ritual knowledge, and its association with deeper ideas of meaning, is closely related to the psychological idea that ritual's role is to help us make sense of the world. In Australia, an intense ritual process forges an intimate connection to ancestors and the landscape. Whilst, as I have argued, this may have a practical, geographical benefit, it also provides a powerful framework for understanding why the world is as it is. As discussed in the Introduction, this need maybe deeply rooted in the human capacity for teleological thinking *i.e.* because life exists it must have purpose (Guthrie 1993, Barrett 2004). The powerful, other worldly forces behind this purpose are accessed through ritual because verbal communication is inadequate for the task. In fact, such communication might trivialise and de-sacralise the revelatory nature of the process (Whitehouse 1992). The characteristics of ritual, its emotional salience suggesting proximity to powerful ancestral forces, and its analogical structure priming exegetical thinking on 'what it all means', constitute a mode of communication that transcends the normal, providing societies with a powerful way of making sense of the word.

Of course, assuming ritual knowledge to be the end in itself of ritual practice does not explain why rituals in some societies are more costly than others. If this were the only aim of ritual, we would need to explain why some societies require deeper ideas of meaning than others, which does not seem to be a particularly fruitful line of enquiry. I would argue that sociological theories (of the type examined here) are more likely to have the analytical power to explain such differences. Nevertheless, a more explicit consideration of the benefits of accumulating ritual knowledge, as highlighted here in the Pama-Nyungan case, may help to unify psychological and sociological approaches in future analytical studies. Whilst the latter has been the primary focus of quantitative ethnographic research, incorporating measurement of ritual knowledge and exegesis into

the testing framework may provide an important new dimension to ritual analyses. In turn, this may lead to a more holistic consideration of the reasons behind the evolution of this quintessentially human practice.

Appendix – table of attachments

Excel files (supplied as six electronic attachments to this thesis)	**Worksheets included in files** (and referenced in thesis text)
Chapter 1:	
Appendix 1a	References, Allocation, 27SelectedTraits, Ceremony, GirlsInitiation, ScoreMarkingsOrdeals, CostlyRites, Warfare
Appendix 1b	24SelectedTraits, Allocation, MortuaryData, GraveMarkings
Appendix 1c	Allocation, RockMotifData
Chapter 2:	
Appendix 2	RegionalData
Chapter 3:	
Appendix 3	InitData, MortData, RockData, Dvalues, Autologistic, BiSSE, Climate
Chapter 4:	
Appendix 4	Test#1Ceremony, Test#2Warfare, Test#3Desert, Test#4MarriageAge, Test#5GraveMarking, Test#6GirlsInitiation, Test#7CompoundDisposal, SubIncision

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