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Research Article

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Abstract: We present an interdisciplinary collaboration whereby linguistic data are explored with the aim of gaining new insights on archaeological features to enrich investigations of the past. Archaeology on its own relies on a very discontinuous record and here we argue that a fuller use of linguistic resources can offer more nuanced insights of the cultural context, and thus a more comprehensive reconstruction of both archaeological histories in general and archaeological features specifically. Languages, as complex human artefacts, often develop vocabularies that reflect speakers' need to communicate about everyday objects and actions. Therefore, it makes sense to turn to lexicographic and semantic data as sources of additional clues about various aspects of the past. To date, this kind of collaboration has either focused on aspects of culture that leave little trace in the archaeological record or on aspects of material culture that informs wider histories of migrations and contacts. Collaboration has also, more often than not, had the goal of answering linguistic rather than archaeological questions. The novel approach we propose here is a focus on a domain which *does* leave a substantial trace in the archaeological record and that falls in the realm of mundane aspects of the universal human experience – i.e. domestic fire use – with the aim of gaining a more nuanced and culturally grounded understanding of *archaeological features* and their investigation. This article is a demonstration in principle for the potential of this approach, illustrated here with a pilot study of combustion features on the Australian continent. Having collected fire-related words in a sample of dictionaries of Australian Indigenous languages, we explain how and why the information they encapsulate can support archaeological studies.

Keywords: archaeology, linguistics, fire, hearth, indigenous language, Aboriginal Australians

1 Introduction

“The knowledge is contained within the land, and the best way to access it is through the language” (Magan, 2020, p. 7).

Archaeologists work with the fragmented material record relating to past human social life, and as such their capacity to investigate and interpret material remains depends largely upon their ability to produce culturally meaningful interpretations of the features and eco/artefacts they observe. In this Australian-based study, we show how information encapsulated in language and more specifically lexicography (study of a language's vocabulary) offers valuable additional clues to orient archaeological explorations and interpret archaeological

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data. Exploiting this synergy seems relatively simple in theory and indeed has a long history (Blench, 2014; and see discussion below) but has only been applied to a limited extent in Australia (e.g. Gould, 1971; McConvell & Evans, 1997; McConvell & Smith, 2003) and has not, to our knowledge, been implemented before in a systematic manner to investigate *archaeological features* (i.e. non-portable results of human activity in a site, observed as a collection of one or several associated stratigraphic contexts). For such an approach to emerge, linguists and archaeologists need to work in close and active collaboration, with linguists harvesting data on questions relevant to a given team of archaeologists, who in turn can consider incorporating precise language-based observations into their research processes. This article offers a demonstration in principle in the form of a pilot study looking at linguistic lexicography about combustion features on the Australian continent and its potential to inform archaeological investigations of these features. Before exploring our initial findings, in the rest of this introduction, we contextualise the hearth theme and discuss the epistemological underpinnings of the proposed approach.

1.1 Hearth and Fire in Australia

The so-called “hearth” is one of the most frequent and informative features found in archaeological sites in Australia, yet it remains one of the more vaguely and variably described (Holdaway, Davies, & Fanning, 2017; Prossor, Denham, Brink, Troitzsch, & Stern, 2022; Whitau, Vannieuwenhuysse, Dotte-Sarout, Balme, & O’Connor, 2018a; Ward & Friesem, 2021). According to the Cambridge dictionary¹, a hearth is “the area around a fireplace or the area of floor in front of it.” Similarly, in archaeology the term “hearth” is generally used to describe a spatially discrete feature showing the remnants of a purposeful fire, including material used to shape the fire feature and evidence of combustion including material (mostly organic) burned within it (Mentzer, 2017). The term hence encompasses a variety of attributes and fire functions: from a short-term heat and light campfire to a successively re-used, earth-oven structure, or even a smoking fire for ritual or medicinal purposes (Binford, 1967; Mallol & Henry, 2017). Generally assumed to be an *in situ* feature, “hearths” are used to identify sites, living surfaces, and activity areas, and to evaluate depositional environment and integrity, as well as being prime sources of datable carbon and identifiable floral materials with which to assess past human behaviour (Black & Thoms, 2014). In considering current limits to the description, recording and interpretation of archaeological “hearths” in Australian archaeology, we ask whether this might be related to limited socio-cultural understanding of the domestic uses of fire and fire-related concepts and practices by past and present indigenous Australians. Here we distinguish *domestic* uses of fire as related to daily life activities in residential sites (from *domus* – “house”) from landscape management uses of fire as applied by Indigenous Australians (also known as “fire-stick farming,” see below), and we use the more generic term “combustion feature.”

Until recently, relatively little knowledge has been available through scientific literature – be it in linguistics, anthropology, or archaeology – about domestic fire-related techniques in Indigenous Australia (but see Byrne, 2022; Carah, 2017; Dotte-Sarout, Carah, & Byrne, 2015; Gould, 1971; Gott, 2002; Holdaway *et al.*, 2017; Prossor *et al.*, 2022; Whitau, 2018; Ward & Friesem, 2021). In spite of the demonstrated linguistic proximity of “fire” with “place,” (Evans, 1992a) where a dwelling is defined by a hearth, in Australia, it has been the multi-millennial practice of land management by means of controlled burning that has attracted the most research attention (Adone & Brück, 2019; Bowman *et al.*, 2004; Fletcher *et al.*, 2021; Gammage, 2014; Garde *et al.*, 2009; Hallam, 1975; Jones, 1969; Kimber, 1983; Yibarbuk *et al.*, 2001). Perhaps, as Hallam (1975, p. 43) implies, this is because the temporal nature of individual hearths is short “but *the* hearth, the home, the land” is constant (original emphasis). Nevertheless, fire may be the crux of usage and rights in land such that, as recorded for instance in the SW of Australia, the word *kalla* means both fire and property: each family had its own territorial division, “its own *ka-la* or ‘fire-place’” (Austin 1841–43 in Hallam, 1975, p. 43). *Kalla* also forms the basis of the word *kallabudjor* meaning property in land, and in *kallip*, denoting a knowledge of a particular range of country (Bradley, 1994; Kimber, 1983; Moore, 1842, p. 39).

¹ <https://dictionary.cambridge.org/dictionary/english/hearth>.

Domestic, albeit temporary, uses of fires are required to fulfil daily human needs and indeed fire has long been recognised as a key, if not defining, technology in all modern human groups. In addition to providing a powerful means of altering the environment, it is a source of light, warmth, and protection, with the controlled use of fire and emergence of cooking linked to positive effects on human biology, cognition, and co-operation (Gowlett, 2016; Gowlett & Wrangham, 2013; Wrangham, 2017). Poruciuc (2020) also highlights the sacredness of hearths and fireplaces throughout Eurasian and northern African prehistory from the ancestral vocabulary associated with these. In Australian linguistics, Evans (1992a) used the rich semantic networks surrounding the intertwined concepts of “fire” and “camp” as the basis to illustrate the cultural implications of semantic extensions and polysemy. A preliminary study by Ward and Friesem (2021) identified some of the lexical density around “fire” and “hearth” in some Australian indigenous languages and how investigations around vocabulary could be a first step in refining this understanding to better apprehend combustion features, their excavation, sampling, analysis, and interpretations. Here we build on that investigation, working across linguistics and archaeological sciences, to further explore the vocabulary associated with domestic fire in the indigenous Australian languages and how this may inform archaeological questions.

1.2 Language and Material Culture

It has long been recognised that reconstructions of the vocabulary of ancestral languages can reveal probable aspects of past cultures – pertaining to lifestyles, techniques, or ways of thinking – that are less amenable to archaeology (e.g. Ehret, 1976; Evans, 1992a,b; Kirch & Green, 2001; Ross, 2017). This insight forms the basis of *Wörter und Sachen* (German for “words and things”) (Pejros, 1997), an approach introduced mid-nineteenth Century by Jacob Grimm and extended by later scholars, which aims to reconstruct socio-cultural aspects of past societies by extrapolating from reconstructed vocabulary (Koerner, 1988). For e.g., the reconstructed lexicon of Proto-Oceanic (Ross, Pawley, & Osmond, 1998, 2003, 2008, 2011, 2016) includes specialised terminology relating to canoe technology and the organisation of human kinship; aspects of life that leave little trace in the archaeological record. Hence, the linguistic evidence often makes it possible to build a richer picture of the likely socio-cultural context – keeping in mind that the reliability of these kinds of socio-cultural inferences is heavily dependent on the quality of the lexical reconstructions, which within the Australian context, is inherently problematic.

In this pilot study, we use contemporary linguistic data rather than reconstructed vocabulary, so we are not faced with the problem of reliability of reconstructions, but, as aptly summarised by both Epps (2015) and Magan (2020), there are many reasons why not all words in a modern language represent good evidence of what speakers used to do in the past. For e.g. a recently borrowed or innovated word will tell us little about the remote past; conversely, some words get lost, and/or their meanings change, so that today’s words are not an accurate or complete guide to past vocabularies. Nevertheless, with caution, we can apply the “words and things” assumption to our contemporary data. We might for instance assume that the existence of a word for, say, a particular type of fire-starter, is a good indication that the corresponding item has had some form of practical existence to speakers at one point in the history of languages (Ehret, 1976; Evans, 1992a). Even if we are unsure about time depth, there are likely to be clues on domestic activities related to fire in our data that have thus far been missed in the archaeological record, and new lines of inquiry may be inspired by the insights that can be gained from this type of investigation. In the approach we propose here, we are not using the language data to reconstruct aspects of the past but rather gaining insights on practices currently encoded in languages of different regions to help guide archaeologists in their investigations.

1.3 Language and Archaeology

To date, linguists and archaeologists have primarily collaborated to develop prehistoric cultural and linguistic correlates to explain migrations and change in past populations (e.g. Bouckaert, Bownern, & Atkinson, 2018;

Blench & Spriggs, 1998, 1999; Blench, 2014; Ehret, 1976; Erard, 2016; Kirch & Green, 2001 or McConvell, 1990). Using a method labelled “linguistic stratigraphy” (Ehret, 2000), historical linguistics can, on their own, reconstruct the chronological ordering of certain language changes, and therefore of mergers and splits between groups of speakers. This is possible because speakers constantly change the sounds they use in their languages, and often they do so in systematic ways (Campbell, 2013; Hock, 2021). For instance, all instances of the *r* sound in a language may turn into an *l* sound over time, sometimes in as little time as a couple of generations. Systematic comparisons of large sets of vocabulary items between languages in the same family allow us to identify regular patterns of sound correspondence between languages, and to make hypotheses about which languages are conservative and which have undergone regular sound change. Regular sound change is what we described above – i.e. when all instances of a sound change in the same way (at least in a particular context) – and this is what we often find in the data. This type of systematic analysis can also reveal the relative chronology of some of the sound changes, and this in turn can reveal the relative dates of introduction of new words, for e.g. borrowings from another language.

In Australia for e.g., languages of the Ngumpin–Yapa group, which belongs to the larger Pama–Nyungan family, have a type of *l* sound², where other Pama–Nyungan languages around this region have an *r* sound. McConvell and Smith (2003) have used this sound change, combined with archaeological evidence, to propose a date for the split of the Ngumpin–Yapa group from other languages in the Pama–Nyungan family. That is, the change from *r* to *l* is hypothesised to have occurred after the Ngumpin–Yapa group split from other Pama–Nyungan relatives, which is why all the former have *l*, while the latter have *r*. Therefore, any Ngumpin–Yapa word featuring an *r* sound is assumed to have been borrowed into this group *after* the *r* > *l* change (otherwise, the *r* in these words would have been turned into *l* too). As it happens, Ngumpin–Yapa words for “muller” feature *r*, and there is additional evidence that they were borrowed into the group from other neighbouring Pama–Nyungan languages. At this point, based on purely linguistic evidence, we have a relative chronology: we know that the Ngumpin–Yapa group split from neighbouring groups before the word for muller was borrowed into the language. From here, archaeological data are used to anchor this relative chronology to an actual date, based on archaeological evidence showing that seed-grinding practices intensified in this part of the continent around 3000–4000 BP (McConvell & Smith, 2003, p. 187). Therefore, the Ngumpin–Yapa group has been autonomous from other Pama–Nyungan groups for at least this amount of time.

This type of combination of linguistic and archaeological evidence has been crucial to establish the history of population movements in several parts of the world, particularly in the Pacific (Blench, 2014; and recent example of Hermann & Walworth, 2020). Methodologically, this uses classical linguistic reconstructions, framed chronologically by association with archaeological evidence. Our approach differs from these kinds of collaborations, instead using *contemporary* semantic and lexical records (rather than historical reconstructions) to access knowledge on culturally grounded practices – here focused on hearth-related practices –, with the aim of informing archaeological investigations and/or interpretations. Vocabulary, whether remembered by speakers or accessible via historical records, can at best allow an approximate reconstitution of precise sociocultural knowledge. Across the continent, Indigenous Australians know how their ascendants lived in the past, and what their habits and techniques were with respect to hearth and other domestic usages of fire. In many locations, these habits and techniques remain in use today. Ultimately, we believe that attending a “bush oven” demonstration by, say, a Dalabon person in Arnhem Land, is more instructive than extracting information from dictionary definitions, and therefore future work will involve collaboration with representatives of some Australian groups willing to share their living knowledge (e.g. for the Noongar language via the Noongar Boodjar Language Centre) (Garde *et al.*, 2009 on land-management fire). However, to investigate and establish the proof-of-concept for our proposed approach, it was necessary to start with a review of several languages from published dictionaries and sources – as is usual in linguistic comparative analyses (i.e. Schapper, San Roque, & Hendersy, 2016). Even as the research develops, dictionaries will likely remain a core source of data from a larger number of language groups due to limited time and resources.

² Specifically, a retroflex *l*.

Table 1: Language groups, ecological zones (as per www.dcceew.gov.au/environment/land/nrs/science/ibra/australias-ecoregions) and associated references used to investigate words around fire for each of these

Language group	Ecological zone	Reference
Alyawarr	Desert and xeric shrubland	Green, Blackman, and Moore (2019)
Arrernte	Desert and xeric shrubland	Henderson and Dobson (1994)
Dalabon	Tropical and subtropical grassland, savanna, and shrubland	Evans, Merlan, and Tukumba (2004)
Jawoyn	Tropical and subtropical grassland, savanna, and shrubland	Merlan and Jacq (2005a,b)
Kaytetye	Desert and xeric shrubland	Ross and Turpin (2011)
Kayardild	Tropical and subtropical grassland, savanna, and shrubland	Evans (1992b)
Martu	Desert and xeric shrubland	Blyth (n.d.,a,b)
Pitjantjatjara	Desert and xeric shrubland	Goddard (1992)
Pintupi	Desert and xeric shrubland	Hansen and Hansen (1974)
Yolngu	Tropical and subtropical grassland, savanna, and shrubland	Bowern and Zorc (2012)

2 Methodology – Language and Knowledge

To demonstrate the potential of our enterprise, we carried out a pilot data collection through ten well-documented Australian languages from central and northern Australia (Table 1), systematically harvesting lexicographic resources for these languages for all domestic fire-related vocabulary. We included words for physical fire and its derivatives (e.g. ashes, smoke) as well as words related to the functions and types of domestic fire (e.g. heat, cook), methods of fire-making (e.g. firesticks) and types of combustibles (e.g. type of wood, species identified as combustible). Beyond words, we also collected illustrative examples, and notes containing additional ethnographic observations. The data were organised into semantic subfields (types of fire, functions, techniques, etc.), and reviewed for its potential in informing investigations of combustion features in Australian archaeology. An overview of the results is presented below, with the complete dataset available on request.

For our pilot study we focused on ten languages. This sample, to be expanded significantly in the future³, was selected based on the following criteria:

- Availability of rich lexical sources, typically extensive published dictionaries, at the time where the sample was constituted. Digital sources were privileged because these are more readily accessible, as well as automatically searchable. Table 1 lists all the sources used.
- Distribution across several regions and linguistic-genetic (as distinct from DNA genetic) families (three families are represented: Gunwinyguan, Tangkic, and Pama–Nyungan, with the latter represented by three dialect continuums) (Figure 1).
- Availability of the published archaeological data around combustion features for the regions the languages are associated with. These references are cited below in the context of the linguistic data in both the results and discussion.

It is unsurprising that the sample only includes languages from the northern half of the Australian continent, and largely from arid desert ecological zones (Table 1). This reflects the scarcity of documentation for languages further south, and the fact that many indigenous languages are already dormant due to the impact of colonisation.

It is also important to keep in mind that published linguistic data are (most of the time) data that have been collected and compiled by settler linguists. This introduces a general bias as intermittent visitors with varying degrees of familiarity with local perspectives and practices may have been oblivious to some important aspects of local languages/culture. This bias may be aggravated in the case of domestic fires by the

³ Recently the Walpiri dictionary has been published (Laughren, Hale, Nungarrayi, Jangala, & Hoogenraad, 2022), which is now the most comprehensive dictionary of an Australian language, but it was not available at the time we carried out the pilot study and will be included in the next stage of the project.

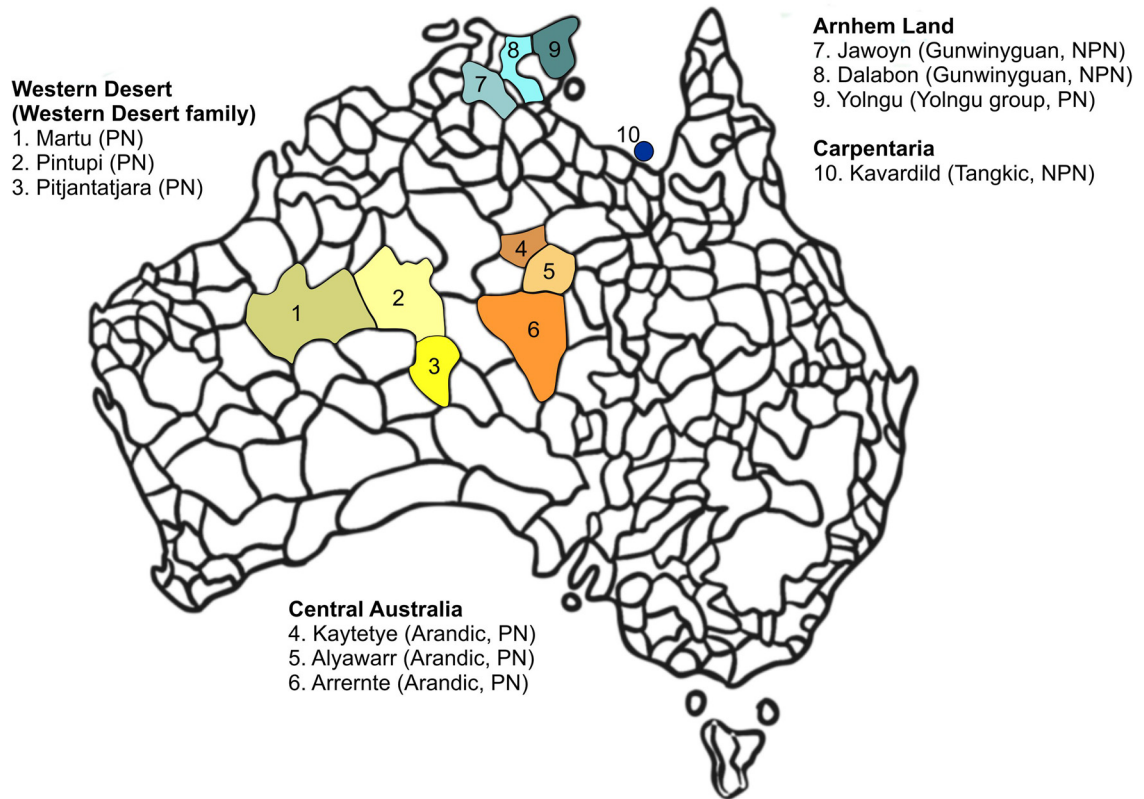


Figure 1: Map of the languages included in our sample. The exact number of indigenous Australian languages at the time of invasion, and the detail of their boundaries, are debated.

historical gender bias in language documentation from western scientists (Eriksen & Hankins, 2015; Ponsonnet, 2018). Until more recent decades, a majority of linguists were male, and more often worked with male speakers. In communities where many domestic activities are the duty and concern of women (Berndt, 1974; Cowlishaw, 1979; Hamilton, 1980; Kaberry, 1937), this may have resulted in significant gaps in linguistic documentation. Indeed, to date, a fair amount of scholarly publications discuss technologies and practices around controlled burning of country (Bardsley, Prowse, & Siegfriedt, 2019; Gummage, 2014; Kimber, 1983; Pyne, 1991; and references therein), a traditionally male activity promoted among many indigenous communities (see Eriksen & Hankins, 2015 for a discussion). In contrast, it is likely that daily domestic fire would often have been the expertise of female group members, or perhaps considered as a gender-neutral mundane activity, not always worthy of specific attention (Pyne, 1991; Eriksen & Hankins, 2015). Hence, technologies and practices around domestic hearths or ground ovens have to date attracted much less attention from linguists (Ponsonnet, 2018). Above and beyond these biases, we are aware that ten languages make a very small sample and the results discussed here are first and foremost interpreted in regard to demonstrating the pertinence of our proposed approach for a future, more extensive analysis. A full-fledged investigation will require a much broader linguistic corpus, first hand data collection based on collaborations with speakers' communities, including for the consideration of associated archaeological examples of combustion features.

3 Results – Linguistic Observations

This section presents the main linguistic observations from the data. These indicate which semantic distinctions can yield information, and therefore where further linguistic investigations could be fruitful. We also

highlight some connections with archaeological questions, including some specific archaeological hypotheses. We start with an overview of the words for “fire” and their colexifications (discussed below); then explore a number of salient “themes” relevant to archaeological investigations (summarised in Table 2). Not every aspect of these linguistic observations translates into specific archaeological hypotheses, but they do offer informative background. Emerging archaeological hypotheses are further explored in the discussion.

3.1 Words for “Fire” and “Flame,” and Their Semantic Associations

The most obvious starting point for our investigations was words for the concept of “fire” itself. Perhaps unsurprisingly, all the languages in our sample have at least one and, usually more than one, word meaning

Table 2: Themes identified in the data, and concepts lexicalised under each theme across the ten sampled language groups

Words for “fire” and “flame” (all languages), occasionally with specific aspect	No. of words	No. of language groups
– Fires of different sizes (large, small)	61	10
– Small grass fire lit by children	2	1
– Smoky fire	1	1
– Cooking fire	2	1
Parts and derivatives of fire		
– Ashes	22	6
– Smoke	13	7
– Charcoals	27	8
– Sparks/crackles	8	4
– Light/shine/glow of fire	10	5
– Smouldering	10	4
– On fire (burn)	16	7
Other physical aspects of fire and hearths		
– Fireplace/firepit	8	3
– Hearth/campfire	3	3
– Oven/ground oven	7	4
– Cooking hole	3	2
– Remains of fire	4	1
Functions of fire		
– To cook/cooking methods (examples given below)	67	9
– To warm by fire – including positional terms	23	6
– Heat in fire/boil	11	6
– Burn/burnt/scorch/singe	29	6
– To dry	1	1
– Uses of smoke	5	4
– Things made using fire	4	3
Methods of making fire		
– To prepare a fire	11	6
– To light a fire/set fire to	57	7
– To stoke/adjust fire	16	7
– To extinguish a fire	6	4
– Firesticks and verbs describing their use	33	9
Types of combustible		
– Firewood/plants used for firewood	55	8
– Kindling/plants used for kindling	20	8
– Fire drill/plants used for fire drill, etc.	11	5
– Plants used in ovens	6	1
– Plants used for torches	2	2

“fire” or “flame” (Schapper *et al.*, 2016). Many of these words mean both “fire” and “flame.” In total we found about 60 words with at least one of these meanings (i.e. semantic association) across ten languages.⁴ Some of the “fire” and “flame” words in our sample denote specific types of fires, namely:

- Fires of different sizes (large, small)
- Small grass fire lit by children
- Smoky fire
- Cooking fire

We also considered what linguists call the colexifications of words for fire, i.e. what other meanings these words have (François, 2008). It is in the nature of human languages to use the same word form (i.e. the same sequence of sounds) for a range of meanings. For e.g. in Italian, the same word form *lingua* is used to refer to both “tongue” and “language.” In line with this tendency, a majority of “fire” and “flame” words have more than one sense (i.e. meaning) in our sample (in linguistics terms, such words colexify different senses). Such shifts in semantic categorisations are also valuable in deciphering intangible elements of past cultures, “things rarely amenable to archaeology’s ministrations” (Ehret, 1976, p. 10). As pointed out by Evans (1992a), semantic associations encapsulated in words can be indicative of cultural practices which channelled the linguistic association of different concepts within one and the same word (Evans & Wilkins, 2000).

An exhaustive analysis of the colexifications of all the words for “fire” and “flame” in our sample represents a distinct project in itself. As a starting point for further investigations, Table 3 offers a structured list of additional concepts that are colexified by a word meaning fire or flame in at least one language from our corpus. The majority of the colexifications listed in Table 3 occur in one or two languages only. The colexification of fire with “burning material,” however, is vastly more frequent, mostly represented by words that also mean “(fire)wood”⁵: Schapper *et al.* (2016) already reported over 45 Pama–Nyungan and 38 non-Pama–Nyungan, almost all of which colexify “fire” and “firewood,” a pattern they interpret as likely inherited from proto-Pama–Nyungan. This is attested for nearly 20 words in the 11 languages we consider. Other frequent colexifications relate to various aspects of fire making (firesticks, fire drill, matches), as well as to what are probably salient domestic functions of fire (heat, light).

We also observe that a higher number of colexifications pertain to the material or daily aspect of fire-making and practical use of fire. By contrast, colexifications with abstract concepts are rarer. The semantic association of fire with language, for instance, is only attested in Yolngu (Arnhem Land) in our sample, and is most likely indirect, mediated by the resemblance in shape between flames and tongues. The connection between fire and greed or want is likely a side-step from the more common (and in fact quasi-universal) association of heat and fire with anger (Kövecses, 1995; Ponsonnet, 2022; Ponsonnet & Laginha, 2020, p. 40); it is only attested in Arrernte (Central Australia). The relation with “taboo” kin can be interpreted as an allusion to the dangers of taboos and sacrality (given that fire is dangerous too); this is only attested in two Central Australian languages, Alyawarr and Kaytetye.

Altogether, in our modest sample, words for fire (or flame) more often colexify concepts in the domain of material used to create fire, specifically relating to woody/plant resources, as well as immediate results (and perhaps primary function) of fire, i.e. heat and light. Interestingly, there is no colexification of fire with different types of combustion features (e.g. shallow pit, ground oven, etc.), as each of the latter are nominated by its own specific word that clearly records the diversity of combustion features beyond the simple “hearth” (see below). However, this observation may also be related to our small dataset.

⁴ We cannot give an exact number of words here because it is sometimes difficult to decide whether two slightly different forms (with slightly different sequence of sounds) should be treated as different words, or as variants of the same word.

⁵ It is worth noting here that although some languages (e.g. Yolngu) have a general word for wood, others (e.g. Kaytetye) rather have words for types of wood (wood that is soft; wood made from a certain type of tree, etc.) but no word for wood in general other than the word for fire(wood) which appears to stand as the primary type.

Table 3: Colexifications of words meaning “fire” or “flame” in our sample. The asterisk means that the colexification occurs in more than two different languages

Parts and properties of fire:	Coals Heat/hot* Light* Smouldering Spark
Things made of or with fire:	Sun Torch
Things akin to fire in functions:	Electricity Gun
Things (or actions) with which fire is made:	Burning material (most often, [fire]wood)* Firesticks* Matches* Rubbing (verb “rub”)
Body part:	Tongue
Bodily affection:	Fever
Abstract extensions:	Language, word Greed, desire
For “fire” words in respect registers only, important kin categories:	Pair of female cousins in a respect relationship Woman with special role in initiation

3.2 Parts and Derivatives of Fire

In addition to words for fire and flames, we also noted words that describe products that derive from fire, for instance ashes or coals, or parts of a fire, such as smoke or light. Aspects of fire specifically described in our lexicographic dataset include the following:

- Ashes
- Smoke
- Charcoals
- Sparks/crackles
- Light/shine/glow of fire
- Smouldering
- On fire (burn)

As is the case for fire/flame and firesticks/drills, the majority of languages studied here have at least one and usually several words for charcoal, ashes, and smoke. From the limited dataset and until further investigation with native speakers, it is not yet possible to assess whether different words in the same language group reflect nuanced differences in function and/or value associated to different types of charcoal, ashes, or smoke, to vegetal or other organic source matter. These are questions that would be meaningful to tease out as a way to inform archaeological analyses of domestic fire remains that may be characterised by a dominance of larger charcoal from specific types of wood for instance or on the contrary by thinner deposits of ashes without much charcoal remaining (see discussions of examples in Byrne, Dotte-Sarout, van Leeuwen, McDonald, & Veth, 2021; Prossor et al., 2022; Whitau et al., 2016). Beyond essential considerations of taphonomy and depositional contexts, notions of specific production of charcoal, smoke, ash, or other derivative of fire encapsulated by lexicography can help to more precisely identify combustion features in the archaeological record.

3.3 Other Physical Aspects of Fire and Hearth (Including Words for Cooking Technologies)

Another category of fire-related vocabulary we harvested from our sample identifies words that relate to what is typically understood as a hearth according to Alpers-Alfil’s (2017, p. S259) definition: “an anthropogenic

combustion area variable in structure, size, and depth that preserves the remains of burned materials.” These words cover the following meanings:

- Fireplace/firepit
- Hearth/campfire
- Oven/ground oven
- Cooking hole
- Remains of fire

To illustrate the range of physical aspects described, Yolngu Matha features the words *bulmuyuk* and *ɲultji* (synonyms) for the “fresh remains of a fire.” Other Yolngu Matha words relating to the remains of fire include *dhurrmuru*, remains including hot ashes (and sand), and *gulayɲu* for smouldering trees or branches after a bush fire.

It is notable that half the languages in our sample have a noun (or sometimes two) for “ground oven” (e.g. *bul* in Jawoyn, Arnhem Land), which refers to relatively specific techniques to bake fish and game with hot stones in an excavation in the ground. In our dataset, words for ground oven are concentrated in Arnhem Land, which could indicate a regional difference with the desert areas where words relate rather to “cooking holes,” although this requires the examination of a larger sample. Indeed, ground-oven cooking techniques are culturally emblematic among certain Arnhem Land groups at least (e.g. Dalabon, observation from Ponsonnet’s own field work). Languages in central Australia tend to have words for “cooking holes” i.e. cooking in hot earth (e.g. *arlpa* in Alyawarr and *tjulururpa* in Pintupi). Hansen and Hansen (1974) note in their entry for the Pintupi word, *tjulururpa*, that cooking holes are regarded as sacred in this region because they contain the spirit of the kangaroo cooked there. Much closer and on-country collaborative investigations with speakers are needed, including a larger linguistic dataset, before any regional trends can be asserted. Nevertheless, this pattern demonstrates how linguistic data may provide a working hypothesis to guide archaeological investigations both in paying attention to the variability of combustion features during excavation and recording, and in proposing interpretations for the function of different stratigraphic signatures of combustion events.

3.4 Functions of Fire

Functions of fire tend to be encoded by verbs rather than nouns. They are indicative of daily uses of domestic fire as well as of some more specialised technologies, for e.g.

- To cook/cooking methods (examples given below).
- To warm by fire – including positional terms
- Heat in fire/boil
- Burn/burnt/scorch/singe
- To dry
- Uses of smoke
- Things made using fire

An example of use of smoke is found in Pitjantjatjarra/Yankunytjatjarra (Western Desert), where the word *puyu* means smoke and *puyutjunanyi* (from *tjunanyi* “put”) is defined as “put in smoke, apply smoke, e.g. to soften leaves, or as a medical treatment.” In this case, the ethnographic information is distributed between the word itself, and the accompanying detailed definition. The same observation applies in the same language regarding things made using fire: the word *urtjan(pa)*, is glossed as “spear-bush (*Pandorea doratoxylon*),” described as “a multi-stemmed drooping shrub. The stems are used for spear shafts. They are stripped of bark, warmed over a fire and straightened by bending [...]” Hence, future research might explore in more depth words related to function of fire as a technique to create objects, and language groups or regions that show this. For archaeologists, this emphasises that identifying one or several “hearth(s)” in an archaeological site cannot be reduced to one obvious activity (such as light or warmth). Rather, such feature(s) might relate to

specialised tasks performed on site using fire (tool making; smoking, other), either through a multipurpose combustion feature or several specialised features (which could leave different types of remains, i.e. smoking fires using very small branches and green leaves will tend to produce more ash and less charcoal) – highlighting the importance of spatial and comparative analysis of all artefacts and ecofacts.

3.5 Methods of Making Fire and Types of Wood and Combustibles

A last semantic domain includes words related to the making or maintenance of fire, including

- To prepare a fire
- To light a fire/set fire to
- To stoke/adjust fire
- To extinguish a fire
- Firesticks and verbs describing their use

Unsurprisingly, all the languages in our sample have one, or often several, words for firestick or fire drills, confirming the universality of the method across the continent (see also discussion). One consideration, however, is that authors of dictionaries may themselves not distinguish between firestick/fire drill, i.e. a hardwood stick used to make fire by friction, and firebrand, i.e. a lighted stick used to start new fires.

Words around a dying or extinguished fire appear to relate as much to bushfire as domestic fire. The former is sometimes identified through the dictionary context such the Yolngu Matha word *guay/u* for smouldering trees (after a fire) or conversely the Alyawarr word *ilwerneyel* to put out a fire because people are departing (camp or temporary camp). The only example of a method for putting out the fire is the Pintupi word *purruna(la)* that relates both to the raking of the burning embers of a fire together, and to the covering of a fire with dirt with the intention of partially extinguishing it. From an archaeological perspective, it is useful to know whether fires were extinguished by sediment, water, kicking, or scattering the fire, or some other means as these are likely to leave different (micro)traces in the sedimentary record and across the spatial extent of a site.

Closely related to this are more specific words relating to the types of wood and combustibles used to make fire, including

- Firewood/plants used for firewood
- Kindling/plants used for kindling
- Fire drill/plants used for fire drill, etc.
- Plants used in ovens
- Plants used for torches

Several of the dictionaries we consulted, including Yolngu, Dalabon, Kaytetye, Jawoyn, and Arrernte, name or identify specific species for firewood, qualifying some of them as good and some as bad. Again, this information is not encapsulated in the words themselves, but in the ethnographic information associated with their entries to provide examples of the uses of the word. The inclusion indicates that when a species is a good or readily combustible, this property is part of common knowledge. Ethnographic information indicates that specific species from widespread or diverse Australian genera are good, e.g. *Acacia* spp., *Eucalyptus* spp., and mangrove (generic) (various languages). Some taxa, such as beefwood (*Grevillea*) are identified by Arrernte people as “too spongy” or bad, with the particular case of an expression to qualify undesirable firewood, *ltyentye-ltyentye*, “spongy and not good for firewood, like beefwood.” This is typically the kind of information that directly relates to the proposed patterns of avoidance identified in archaeological analyses of fuelwood collection regarding Proteaceae wood (*Grevillea* and *Hakea*) (see discussions in Byrne, 2022; Dottesarout et al., 2015; Whitau, Dilkes-Hall, Vannieuwenhuyse, O’Connor, & Balme, 2018b).

4 Discussion: Archaeological Implications

In the following discussion, we explore how linguistic data, such as those presented here, can be usefully combined with archaeological techniques to guide field collection and analytical interpretations in Australia. Our pilot study reveals that linguistic semantic data and lexicographic documentation can inform archaeological queries on two broad aspects. The first aspect relates to loci of information within language that illuminates archaeological understandings of the past according to culturally relevant perspectives. The second aspect relates to the value of linguistic data to more targeted investigation of combustion features, especially to identify types and functions in more precise ways than the proverbial “hearth.” It appears evident that lexicographic documentation and language can be an apt entry point into cultural knowledge and expertise to be used in future collaborations with Indigenous communities around fire-related practices, and between archaeologists and linguists to explore nuances in their respective datasets.

At the same time, limitations in both the linguistic and archaeological records need to be acknowledged. This includes bias in what and how language is recorded, with potential “differentiated shades of meaning” in the technical vocabulary that recorders have not always been able to follow (Hallam, 1975, p. 38). From an archaeological perspective, there will always be issues associated with preservation bias, post-depositional reworking, and diagenesis, with some aspects of fire simply elusive in terms of leaving a trace (e.g. smoke in the open environment). We take these limitations into consideration when discussing the potential and new perspectives offered by our proposed approach.

4.1 Loci of Information

A first locus of information is the sheer existence of certain words in some languages (and their absence in others). For instance, all languages in our sample have words for firestick, and there is no other name for fire-making instruments. This reflects the universal use of this technology in the parts of the continent that we surveyed, and is consistent with previous documentation as one of the most widely distributed methods of fire-making across Australia at the time of colonisation, with one archaeological example documented and dated to the first millennium BP (Figure 2) (Whitau *et al.*, 2016). On the other hand, there were no identified words for starting a fire through the method of percussion, which might be related to the regional bias of our linguistic dataset (compare Figures 1 and 2). This method involves striking two stones together such as flint and ironstone to create small, heated shards that spontaneously ignite producing high-temperature sparks, directed onto tinder to set it alight. Elsewhere this method is thought to pre-date wood-on-wood techniques (Hough, 1890; Stapert & Johansen, 1999). It is unknown whether the percussion method is ancient in South Australia, where flint (chert) is readily available (Davidson, 1947) or was present in other parts of the continent such as Western Australia where similar stone exists (Glover & Groves, 1978). This is perhaps one example where the combination of linguistic stratigraphy and archaeological evidence, and specifically the lithic record, may help resolve the chronology and distribution of fire-making technologies in Australia. Many more specific examples of how the existence of words can shed light upon archaeological investigations are presented in the next section.

Another potential locus of information is in colexifications, i.e. meanings expressed by the same word forms, which often reflects a practical context (Evans, 1992a), but these must be handled with care. For instance, the fact that words for “fire” or “flame” tend to colexify more practical than symbolic meanings may indicate a greater secular prominence of fire. The lack of this does not mean that these elements are excluded from ritual practices but rather that we have not encountered colexification evidence of their prominence (Hallam, 1975, p. 44). Indeed, the importance of fire in a ceremony is well known and there is extensive literature on fire in myth and ritual (especially burial customs) in different parts of Australia (e.g. Hallam, 1975; Szyjewski, 2018). However, the archaeological literature on ritual and “burial fire” is scarce (e.g. Clark & Hope, 1985; Meehan, 1971; Owen & Pate, 2014) and is another area where linguistic and archaeological investigation may work together to better understand this important, albeit sensitive, aspect of Australian

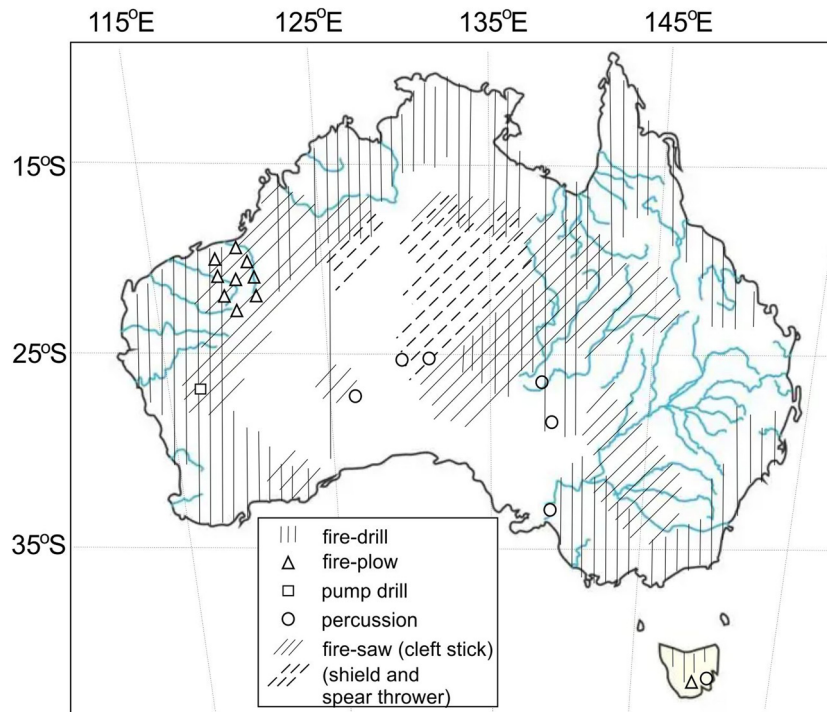


Figure 2: Distribution map of fire-making technologies (modified from Davidson, 1947, his Map 1).

indigenous culture. Indeed Meehan’s (1971) ethnographic records indicate possible regional differences in the custom of lighting fires in, on, or near burial sites, and hence highlighting the importance of noting any association of hearths or combustion material with any recorded burial sites. Similarly, framing archaeological identification of combustion features in accordance with typologies/functions recorded in lexicographic data has the potential to help recognise ritual or ceremonial fires in deposits.

Altogether, in our modest sample, words for fire (or flame) more often colexify concepts in the domain of material used to create fire, specifically relating to woody/plant resources, as well as immediate results (and perhaps primary function) of fire, i.e. heat and light. Interestingly, there is no colexification of fire with different types of combustion features (e.g. shallow pit, ground oven, etc.), as the latter are nominated each by their own specific words that clearly records the diversity of combustion features beyond the simple “hearth” (see below). However, this observation may also be related to our small dataset.

Finally, a third locus of information is in the ethnographic evidence/cultural knowledge contained in detailed definitions, examples, or additional lexicographic notes that illuminate specialised functions of fires (cooking, warmth, smoke), associated artefacts (firesticks), and derivative products (hot coals, cold ash), containing precious information to understand the archaeological record. Particularly meaningful examples relate to stipulations that a certain species is a good – or bad – combustible (Bindon & Peile, 1986), or has medicinal usages (e.g. Sadgrove & Jones, 2016; Sadgrove, Lyddiard, Collins, Greatrex, & Jones, 2016) (see also discussion on residues below). Following on, the lexicographic data we have started to gather provide insights into the specific practice of firewood collection (often deserving its own verb in the languages analysed) and preference vs avoidance of specific taxa. The Arrernte qualification of *Grevillea* wood as the typical undesirable firewood, *lyentye-lyentye*, directly echoes a possible pattern of avoidance in fuelwood collections that has been identified by anthracological analyses around particular Proteaceae wood (*Grevillea* and *Hakea*) in several areas of arid and semi-arid Australia (see discussions in Byrne 2022; Dotte-Sarout et al., 2015; Whitau et al., 2018b). On the contrary, mulga (*Acacia aneura*) and *Eucalyptus* species are often used as examples of good and abundant firewood in the dictionaries – and both are taxa that are most common in anthracological assemblages in Australian regions of interest for this study (Byrne et al., 2021; Carah, 2017; Smith, Vellen, & Pask, 1995; Whitau, 2018).

4.2 Language to Help Identify the Function of Hearths and Combustion Features Observed in Excavation

Fire is a multi-purpose phenomenon and combustion features, like many archaeological deposits, are often a palimpsest of many functions or activities including cooking, warmth, illumination, ceremony, ritualistic ordeals, clearing camps, signalling, driving game, and regenerating senescent vegetation (Bowman, 1998; Gould, 1971). Distinguishing between these uses requires careful study of the distribution, shapes and size ranges of combustion features and associated rocks, discrete lumps of sediment, bones, artefacts, and the various state and nature (taxa) of combustible material – from charcoal to ashes (see also Gowlett 2016; Whitau *et al.* 2018a; see also Morrison *et al.* 2022). Morrison *et al.* (2022) also acknowledge that hearths are often ambiguous features in archaeological contexts and promote the unique potential of earth ovens as being specific to food preparation, and hence able to provide more specific insights on aspects of past cooking and cultural practices. Language may also offer clues to help unpick some of this complexity.

As initially explored by Ward and Friesem (2021), lexical data can be used as a guide for different methods of site preparation and by extension what to look out for in archaeological excavation. In Martu, *pirti* means to clear the ground for fire. In Dalabon, *dubirrah* refers to a bush shovel used for removing dirt (e.g. in preparation for cooking a lot of meat) or removing coals from fire. In the region where Alyawarr is spoken, O’Connell, Latz, and Barnett (1983) makes a distinction between “hearths” and “roasting pits” with the former prepared on cleared, flat surfaces and the latter scooped out (40 cm wide × 30 cm) and used to cook *Ipomoea* sp. tubers. A hole dug for a roasting pit would be expected to manifest differently from a scraped surface and potentially have different floral or faunal remains, with different taphonomical histories and preservation states. These distinctions can potentially be identified through micromorphology analysis (e.g. Prossor *et al.*, 2022; Vannieuwenhuysse, O’Connor, & Balme, 2017), in association with archaeobotanical identification of micro and macro-remains (e.g. Whitau *et al.*, 2018a). For instance, micro-analytical techniques were used in the Levant to differentiate between internally fuelled baking ovens and externally fuelled pebble hearths, and also fuel-types; which for this study, reflected an “entanglement” of local and foreign cultural elements (Gur-Arieh *et al.*, 2014).

There is great strength in looking at things at the small scale, with O’Connell (1987) arguing that chipping debris, small bone fragments, and plant macrofossils can often be found in primary context. Careful examination of sediment samples by light microscopy or electron microscopy, can help reveal biological materials, charcoal, ash, or mineral grains with textural or compositional changes that might be due to heating (e.g. Mentzer, 2017; Prossor *et al.*, 2022; Ward & Friesem, 2020). The presence of bone fragments or carbonised plant and animal matter (e.g. phytoliths, dung) would seem more likely to result directly or indirectly from human activity than chance natural burning. Similarly, traces of organic residues, such as fats, oils, or resins, may arise from human activity (Lambrecht *et al.*, 2021; Ward & Friesem, 2020), and indeed the examples for some dictionary entries confirm that fire was used to treat wax and resins. Goddard’s (1992) Pitjantjatjara entry *ngiltjitjunanyi* “hold in warmth of fire,” indicates that this is something one does to soften resin, and Evans *et al.*’s (2004) entry *ngolngol-kinj* “melt” alludes to beewax and ironwood resin. Similarly, Binford (1984) and O’Connell (1987) refer to the making or using of spinifex resin adhesive in tool manufacture.

Beyond this diversity, it is important to note that the majority of contextual information recorded in the dictionaries relates to the use of fire for cooking. Previous Australian studies (e.g. Byrne, Dooley, Manne, Paterson, & Dotte-Sarout, 2020; Whitau *et al.*, 2018a) demonstrated how anthracological analyses can shed light on the possible uses of a combustion feature, based on taxonomic diversity and composition, in combination with other archaeological contextual information, and propose the identification of cooking fire in the form of earth-ovens. As pointed out earlier in this work, we believe that lexicographic data can add further insights into the probable function of different types of “hearths” recovered in archaeological sites. For instance, some languages, such as Yolngu Matha, differentiate between *larray’yun* “to cook on open fire,” *guyal’yun* “to cook or roast in stone oven,” or *muja* “to roast in ashes or hot sand” (Bowerman & Zorc, 2012). Some languages, especially Kaytetye, feature more words related to stages of cooking and here it is worth noting that this is where the linguists were women (e.g. Ross & Turpin, 2011). In Pintupi, for instance, three different synonyms

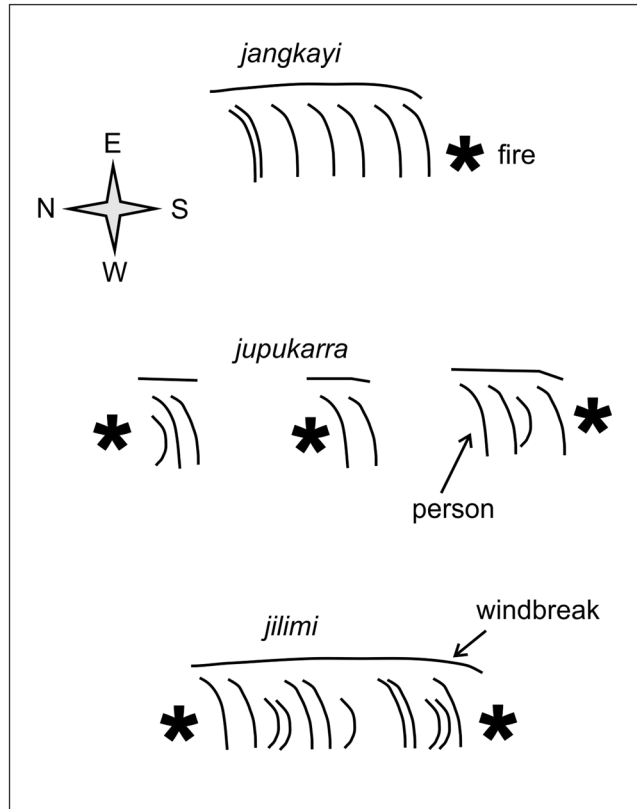


Figure 3: Spatial arrangement of traditional Warlpiri yunta (redrawn from Musharbash, 2013).

(*pinyiri*, *lurrngu*, and *kulku*) describe the precise moment when a fire is at the red coal stage at which cooking is done. In Arrernte, *alpmante* points to the hot earth and ashes beneath a fire used to cook in, similar to *kurlku* in Martu Wangka. Kaytetye has the verb *intelpinenke/intelpaylenke* to describe the action of letting a fire dying down so that there are hot coals, while Pintupi uses the verb *tuutjunu(rra)* to describe the precise act of raking coals over the animal cooked in a roasting pit. Additionally, in Kaytetye, the verb *ertntwerelh-aylenke* is reserved for the cooking of emu or bush turkey only – as being the only meat cooked with certain leaves and hot stones. These examples can support the identification of archaeological combustion features as ancient “cooking holes/roasting pits” from these regions, based on the morphology, presence of burned sand, or earth underlying charcoal or ash, and higher taxonomic diversity of charcoal remains explained by the very action of stopping the full combustion process for cooking purposes and possible re-use of the same feature. Such observations would be relevant for instance in the cases of features that were considered in anthracological analyses conducted at Puritjarra in Central Australia (Smith et al., 1995) or Karnatukul in the Western Desert (Byrne et al., 2021).

Outside of cooking, the second main reference to fire use in the dictionaries analysed was for warmth, with most languages using a specific verb to designate the action of warming up by the fire (or sun) – for instance, *ngantji* in Martu Wangka, *rahmû* in Dalabon, *ntywetyerreyel* in Alyawarr, or *tyampeme* in Arrernte. This is directly associated with campfires and night fires. The use of hearths for warmth at night-time, i.e. bed-time hearth, might be supported by the positioning of multiple hearths that are generally arranged in a line parallel to the long axis of the shelter, with sleepers lying between the hearths (O’Connell et al., 1983). In the Western Desert, *tawara ngura* comprise rows of hearths inside a continuous dug depression with a brush windbreak (Gould, 1971). In the Northern Territory, Warlpiri people similarly sleep in rows called *yunta*, (Figure 3) with camps comprised of a number of *yunta*, made up of windbreaks, sleeping hollows in the sand, and flanked by fires (Berndt, 1940; Musharbash, 2013). Identifying such spatial patterning requires expanding the scale of excavation beyond the standard 1 m × 1 m exposure and/or deploy such techniques

as near-surface geophysical mapping identifying ancient combustion features (i.e. Lowe et al., 2023 and references within; O'Connell, 1987). In this context, the support contributed by language data and cultural knowledge is both scientifically precious and practically affordable.

5 Conclusion and Future Research Themes

This article has proposed novel ways to enhance the archaeological investigation using linguistic lexicographic data, with the pilot study on combustion features serving as a proof-of-concept for this new approach. In the past, linguistic data have more often been used to augment or compare patterns of genetic and cultural/archaeological distribution and explore patterns of geographic dispersion of people (Ramallo et al., 2013; Sanchez-Mazas, Blench, Ross, Peiros, & Marie, 2008) and technology (e.g. Russell et al., 2014). Here we have showed that there is value in a more intrinsic and applied use of vocabulary for archaeological investigation, not only in terms of both identifying different aspects of domestic fire use and technology but also what this might mean in terms of cultural overlaps, mobility, and resource availability.

Our pilot study confirms that the importance of fire to Indigenous Australians is correlated with a wide vocabulary of fire-associated words that not only relate to landscape management but largely to domestic uses of fire, from different hearth types and fuel, to different purposes and products of fire. Understanding how First Nation Australians used, controlled, related to, and thought about fire provides a locally meaningful reading grid to interpret combustion features and conduct excavations on archaeological sites. In addition to alerting archaeologists to the diversity, potentially specialised or other-times multi-purposed activities associated with the so-called “hearths,” the semantic information contained in lexicographic datasets can actually direct the use of anthracological, stratigraphic, and spatial information to provide a finer interpretation of archaeological features more grounded in local indigenous perspectives.

The results from our pilot study show how linguistic data can help archaeologists understand the elements they are looking at, as well as search specifically for certain features and patterns during excavations. Some of this information is encoded in documented vocabulary, which can help us to recover them even when a language is no longer in use. In this way, semantic and lexicographic data have the potential to significantly enhance our understanding of excavation sites and past practices.

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