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► **To cite this version:**

Cris Edmonds-Wathen. The grammar and conceptualisation of motion in Iwaidja. CERME 9 - Ninth Congress of the European Society for Research in Mathematics Education, Charles University in Prague, Faculty of Education; ERME, Feb 2015, Prague, Czech Republic. pp.1361-1367. hal-01287664

HAL Id: hal-01287664

<https://hal.science/hal-01287664>

Submitted on 14 Mar 2016

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The grammar and conceptualisation of motion in Iwaidja

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Different languages have different ways of using spatial language, grammatically and conceptually. This paper reports on aspects of the language of motion in Iwaidja, an indigenous Australian language. The way that Iwaidja groups and separates spatial concepts such as direction, height and movement in relation to another object are briefly described using examples from a route description task. The implications are discussed in terms of how understanding these grammatical features can help teachers of Indigenous students, as well as providing keys to cross-linguistic investigations of mathematical cognition.

Keywords: Spatial language, motion, grammatical structures, Indigenous, cognition.

INTRODUCTION

The language we use for mathematics, the mathematical register, can have words and grammatical structures that are specific or specialised for their purposes in the register, but it is built on or out of everyday language. The linguistic structures of individual languages affect how the languages can be used and developed for mathematical thinking. Grammatical structures can constrain what is possible but they can also offer opportunities. Improving mathematical learning outcomes for Indigenous language speaking students in Australia requires a better understanding by non-Indigenous teachers of how their students think and talk mathematically. Describing the variety of mathematical expression can also assist other teachers who are teaching in multilingual classrooms, as well as enrich researchers' appreciation of the scope of variations in mathematical conceptualisation in different languages.

This paper considers the expression of motion in Iwaidja, an indigenous Australian language spoken in Northwest Arnhem Land, Northern Territory, and how this expression might affect mathematical thinking. Spatial language is an area of everyday language with mathematical impact. This impact is direct in relation to those parts of mathematics that are overtly spatial, such as the description of position and movement in the early years that progresses into the languages of mapping and of coordinate systems. Spatial language is also used in areas of mathematics that at first thought may not be appreciated as spatial, such as the manipulation of numbers. In particular this can involve the use of spatial metaphors (Edmonds-Wathen, 2012).

Iwaidja is an Australian language spoken predominantly at Minjilang, a community of approximately 300 people on Croker Island, Northwest Arnhem Land in Australia's Northern Territory. There are also speakers in other nearby communities. Investigating mathematical features of Iwaidja provides insights into mathematical ways of thinking and speaking that are shared by speakers of nearby and related languages such as Mawng and Kunwinjku, as well as contributing to broader knowledge and understanding about the breadth of how languages can express mathematical concepts.

RESPONSES TO DIVERSITY IN MATHEMATICAL LANGUAGE

Some grammatical features of mathematical language have been described; one is that mathematical language tends to nominalise processes (Halliday, 2004). Barton (2009) notes that the English language copes particularly well with the nominalisation processes of mathematics compared with some other languages. Some languages are less conducive to nominalisation

than others because they begin with stronger roles for their verbs than other languages. Lunney Borden (2011) has described dynamic verb-based features of the Mi'kmaw language. She advocates the use of a verb based discourse pattern for teaching mathematics to Mi'kmaw children, for example focusing on the active properties of geometric objects, rather than identifying and naming their parts. It does not necessarily mean using the first language of the students, but of responding to some of the ways meaning is made in their languages. Lunney Borden talks about teaching Mi'kmaw children in English, but targeting her English in a manner that used more verbs to describe things and processes and fewer nouns.

In the Navajo language, shapes are also verbs: there is no circle, there is circling. Pinxten, van Dooren and Harvey (1983) describe the worldview of the Navajo as premised on the dynamic nature of the world. Inspired this description, and working with John Mason, Barton (2009) explored mathematical implications of treating shapes as verbs, as actions, calling it Action Geometry. For example, the static view of a circle is all the points that are equidistant from a centre point, forming a planar shape. In a dynamic view a circle is movement with a constant speed and with a constant rate or turn: "circling is actually a special case of spiralling" (p. 31). Barton stresses that Action Geometry is not an actual practice of the Navajo, but was invented by mathematicians.

Responses to diversity in spatial language thus can include teaching about and within the cultural worldview (Pinxten et al., 1987), developing new mathematics (Barton, 2009) and responding to discourse patterns to bridge to the Western mathematics (Lunney Borden, 2011). The example of Action Geometry shows how investigating linguistic diversity can enrich mathematics and stimulate mathematical innovation.

FRAMING PATH AND MANNER

Languages also differ in how they package meaningful components, in what they put together at a word level and what they put together at a sentence level. An example of this is Talmy's (1985) widely used distinction between verb-framed and satellite-framed languages. Verb framed languages present the path of motion on the verb, with manner as a subordinate addition, as in the Spanish *La botella entró en la cueva (flotando)* 'The bottle moved-in to the cave (floating)'. In satellite-framed languages such as English, the manner is contained in the main verb, as in *The bottle floated into the cave*, where the preposition *into* indicates the path (examples from Talmy, 1985, p. 69). As Talmy notes, while English also has the verb-framed pattern, it is not characteristic, and the verbs that can be used with it are almost all borrowings from Romance languages.

Possible cognitive effects of this distinction are most likely to involve the differences in these expressions in which parts are compulsory to make a full utterance and which are optional extras. Slobin (2006) found differences in the mental imagery of Spanish speakers from English speakers related to this distinction. Similarly, an investigation of language and event perception using eye movements found while the language used does not affect event perception, it does affect their memory of events (Papafragou, Hulbert, & Trueswell, 2008).

The ways in which different languages express motion events is relevant to mathematics education because of the importance of spatial language in mathematics, both directly and metaphorically. Mathematics educators may have a tendency to interpret the way that their own language uses spatial language for mathematics as necessarily linked to the mathematics. Jorgensen (2010) declares that "coming to learn mathematics is heavily associated with the use of prepositions" (p. 29). One example in English might be the phrase "Two goes into six three times". Note that "goes into" is being used in a metaphorical sense; it would be erroneous to say that two *enters* six. The extensive use of spatial prepositions, of course, is a feature of satellite-framed languages such as English. Jorgensen makes her statement in the context of comparing English and Pitjantjatjara, an indigenous Australian language with far fewer prepositions than English. However, it might be useful to ask what mathematical functions are performed by these prepositions, and then ask what other ways do other languages express those functions.

Furthermore, not all languages fit within one of Talmy's two groups. Some languages favour a serial verb construction, in which both path and manner can occur in verbs used sequentially, and these verbs can have equal status within an utterance (Slobin, 2006). Serial verb constructions have been noted in various languages such as Ewe, spoken in Ghana (Ameka &

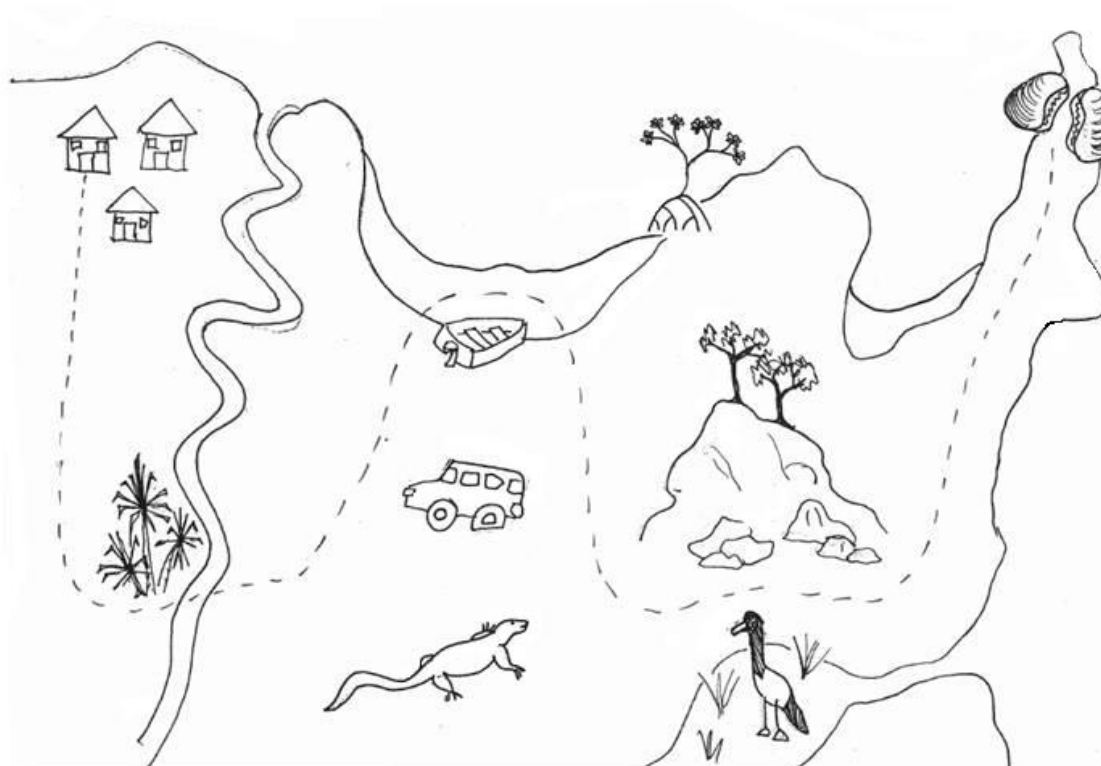


Figure 1: Example of a Director's map showing route

Essegbey, 2006) and Kilivila, spoken in Papua New Guinea (Senft, 2006). Serial verb construction is common in Iwaidja, and the actions themselves can be sequential or simultaneous (Pym, 1985). The remainder of this paper will present some examples of the language of motion in Iwaidja in terms that could enrich our thinking for mathematics education.

THE MAP TASK

This paper reports on some of the results from a Map task designed to elicit route descriptions. It was a barrier task for two participants, derived from the HCRC Map Task (Anderson et al., 1991). One participant, the Director, was given a map with a route marked on it. The other participant, the Matcher, had the same or similar map but without the route. The Director described the route to the Matcher and the Matcher drew the route on their map. I designed the maps to contain items that would be familiar to all participants. An example of a Director's map is shown in Figure 1. The maps differed from those used in the HCRC Map Task by having a coastline and other landscape features such as a creek and beaches. The items on the maps were shown as drawings rather than symbols, as some of the participants would not have been familiar with map conventions.

This task was conducted six times with adult Iwaidja language consultants, with three pairs of participants who each had a turn at directing. The sessions were videoed with an external microphone. The first pair used matching maps where the only difference was that one had a route marked and the other did not. The other two pairs were given different maps, so that some of the items on one map either did not appear on the other or were in different locations. The Director's map still had a route marked on it. The intention was that more complex language would be generated as the participants encountered the differences in their maps. Participants in the sessions where the maps differed were informed that the maps might be different. The task allowed participants to choose what types of spatial language they used to solve it.

The task elicited a rich variety of route descriptions using motion verbs. The current paper focuses on only a few features of Iwaidja that were used in the task – the serial verb construction, the directional distinction and a set of specific motion verbs to describe ways of passing. These features are of interest because of the ways in which they combine or separate mathematically meaningful components as compared to more well-known languages such as English. Other features such as the use of verbs to describe circling,

as in Mi'kmaq, are described in Edmonds-Wathen (2013).

Like some North American languages such as Navajo and Mi'kmaq, Iwaidja is a verb-rich language. Many aspects of life are described as processes rather than things. Kin relations, for example, may be expressed using inflected verbs, so that one says “she sisters me” or “he uncles you” (Evans & Birch, 2007). Verbs often take coverbs or adverbs, many adjectives inflect for number, and it is not always immediately clear whether words are verbs, adjectives or adverbs. Iwaidja is a ‘head-marking’ language, in which affixes, both prefixes and suffixes, provide information including subject, object, direction and tense with regard to a stem.

In general, spatial verbs consist of a stem with a prefix indicating either the subject (in the case of intransitive verbs) or both subject and object (in the case of transitive verbs). Past tense is indicated by suffixes. Future tense is indicated via a separate prefix. In addition, there is an optional prefix indicating directionality, either AWAY from a deictic centre or TOWARDS it (glossed TO). Without this prefix the directionality can be considered neutral. These directions are with respect to the deictic location, which may or may not be the speaker’s location. This prefix sometimes combines with subject and object prefixes as well as the future tense prefix to form a single morpheme (Pym & Larrimore, 1979). Examples include *jan-ara*, glossed AWAY.I.FUT-go, ‘I will go’, and *nyan-ara*, glossed TO.I.FUT-go, ‘I will come’. An example of a prefix which combines subject and object is *r-*, glossed he.to.it, which means ‘he (third person singular masculine subject) acts upon it (third person singular object)’.

Examples in Iwaidja are shown in four lines. The first line shows the sentence or phrase in the standard orthography. The second line shows each word. The Iwaidja words have hyphens separating morphemes (meaningful word parts). The third line shows an aligned morpheme by morpheme English gloss. Where the Iwaidja word is translated by more than one English word, but these cannot be separated morphemically in the original, the English words are separated by a period. For example, *artirran* ‘he came back’ can be separated into *art-* ‘towards; he/she/it’, *irra* ‘come back’ and *-n*, which marks the past tense. The third person singular pronoun and the towards direction marker cannot be separated in the morpheme *art-*, nor can the ‘come’ and ‘back’ in *irra*. Hence, *art-irra-n*

is glossed ‘TO.he-come.back-PST’. The final line shows a free English translation of the sentence or phrase. Translations and transcriptions were done with the assistance of a fluent native speaker.

The predominant approach of the six participants was to use specific verbs of motion. Example (1) illustrates many typical characteristics of Iwaidja motion description.

(1) *Artirran ararlarrngbung abulakuny awaran. Yabulakuny wardad ba ajbud. Yartirran yarnukbun jumung murrhala ari. Yartirran yarnukbun wuka jumung narrhardi bani. Yartirran barakbarda yariman ba alan ba yawaran, barakbarda jumung birtbani, arrarnarn lda arrayi.*

<i>art-irra-n</i>		<i>a-rarlarrngbu-ng</i>	
TO.he-come.back-PST		TO.he.to.it-turn-PST	
<i>a-bulaku-ny</i>		<i>aw-ara-n</i>	
TO.he-come.down-PST		TO.he-come-PST	
<i>ya-bulaku-ny</i>		<i>wardad ba ajbud</i>	
AWAY.he-come.down-PST		one the beach	
<i>yart-irra-n</i>		<i>y-arnukbun</i>	
AWAY.he-come.back-PST		AWAY.he-turn.off	
<i>jumung</i>			
REL			
<i>murrhala ari</i>		<i>yart-irra-n</i>	
pandanus it.stands		AWAY.he-come.back-PST	
<i>y-arnukbun</i>			
AWAY.he-turn.off			
<i>wuka</i>	<i>jumung</i>	<i>narrhardi</i>	<i>bani</i>
LOC	REL	goose	it.sits
<i>yart-irra-n</i>			
AWAY.he-come.back-PST			
<i>barakbarda</i>		<i>yari-ma-n</i>	
that.one		AWAY.he.to.it-take-PST	
<i>ba alan</i>	<i>ba</i>	<i>yaw-ara-n</i>	
the track	the	AWAY.he-come-PST	
<i>barakbarda</i>	<i>jumung</i>	<i>birt-bani</i>	

that.one	REL	they-sit
<i>arrarnarn</i>	<i>lda</i>	<i>arrayi</i>
milky.oyster	and	black.lip.oyster

‘He came back, he turned, he came down, he came. He went down to one beach. He turned back to where the pandanus tree is. He turned back to where the goose was sitting. He went back there and he took that road, he went along where that thing is, milky oysters and black lip oysters.’

This example includes several uses of the TOWARDS and AWAY prefixes. The basic movement verb *ara* which means ‘go’ or ‘come’ depending on the context is seen in the past third person singular forms *awaran* ‘he came’ and *yawaran* ‘he went’. We also see the verb *irra* which means ‘go back’ or ‘come back’ depending on the direction, in the forms *artirran* ‘he came back’ and *yartirran* ‘he went back’. *Irra* thus refers to a change of direction. The example also contains both TOWARDS and AWAY forms of *wulaku* ‘go down’, in *abulakuny* ‘he came down’ and *yabulakuny* ‘he went down’. Hence the use of the directional contrast enriches the semantic scope of the verbs to which it is applied.

We can also see the serial verb construction which is frequent in Iwaidja. The first sentence consists only of four verbs, all taking the TOWARDS prefix: *Artirran ararlarrngbung abulakuny awaran* ‘He came back, he turned, he came down, he came.’ A colloquial English translation might be something along the lines of ‘he turned and came straight back down’. The use of a series of verbs in this context does not necessarily represent a series of actions that follow each other. Rather, the protagonist’s single, if complex, act of turning, returning and descending are conceptually packaged together despite each being expressed as independent verbs which could each stand as a sentence themselves in Iwaidja.

In any language, you would expect the language of motion to involve the use of verbs. However, in ‘verb-framed’ languages, according to Talmy’s (1985) classification, manner of motion is expressed outside the verb, for example as an adverb. In ‘satellite-framed’ languages the path is expressed outside the verb, for example with a prepositional phrase, as in English. The serial verb construction of Iwaidja frequently

combines both manner and path in a series of verbs, as was seen in example (1).

Iwaidja encodes specific spatial information into distinct, although related verbs. The range of verbs elicited to refer to passing objects on the map is a good example of this. The most general of these is *marraywung* ‘pass.’ It is a transitive verb, requiring the specification of what is passed, but does not provide any more detailed information about how the object is passed. Its use is shown in example (2).

(2) *Rimarraywung yawarang mangawala ajbud jumung kabala ari.*

<i>ri-marraywung</i>		<i>yaw-ara-ng</i>
he.to.it.pass		away.he-go-NPST
<i>mangawala</i>	<i>ajbud</i>	<i>jumung</i>
fast	beach	REL
<i>kabala</i>	<i>ari</i>	
boat	it.stand	

‘He goes past them and runs along the beach where boat is.’

There are also verbs derived from *marraywung* for passing in front, behind or to the side of objects. Their use depends upon those objects having an intrinsic front, back or side. The verbs are *marlmarraywung* ‘pass behind’ (example 3), *wudbarraywung* ‘pass in front’ (example 4), and *ngunyunmarraywung* ‘pass beside’ (example 5).

(3) *Artirran ararnukbung rimarlmarraywung wuka jumung mudika wulurr.*

<i>art-irra-n</i>		<i>ar-arnukbu-ng</i>
TO.he-come.back-PST		TO.he-turn.off-PST
<i>ri-marlmarraywung</i>		<i>wuka</i>
he.to.it-pass.behind		LOC
<i>jumung</i>	<i>mudika</i>	<i>wulurr</i>
REL	car	back

‘He came back, turned off and passed behind the back of the car.’

(4) *Kirrimul warrkarrk aju riwudbarraywung.*

<i>kirrimul</i>	<i>warrkarrk</i>	<i>aju</i>
like	goanna it.lies	he.to.it-pass.

ri-wudbarraywung
in.front

‘He passes in front of where the goanna is.’

(5) Kabanangyunmarraywun baraka dinghy.

<i>kabana-ngunyunmarraywu-n</i>	<i>baraka</i>
you.to.it.FUT-pass.beside-NPST	DEM

dinghy
dinghy

‘You will pass beside the dinghy.’

Ngunyunmarraywung ‘pass beside’ contains the body part stem *ngunyununi* ‘waist’ which also occurs in words such as *mangunyununi* ‘beside’ and *angunyunulunmin* ‘side by side’. The derivational origins of *marlmarraywung* ‘pass behind’ and *wudbarraywung* ‘pass in front’ are not so transparent.

In addition to the adverb *mangunyununi* ‘beside’, Iwaidja has *warrwak* ‘behind’ (an adverb) and *wurdaka* ‘in front’ (a verb). *Warrwak* and *wurdaka* are common words and were used by the Iwaidja speakers frequently in activities involving description of static location (Edmonds-Wathen, 2014). The examples here of the various verbs of passing indicate more than just choices in the expression of ‘beside’, ‘behind’ and ‘in front’. Rather, there are differences in their expression depending on whether one is talking about static location or about motion. Similarly, Iwaidja has adverbs *yurrngud* ‘on top, above’ and *wurrrwud* ‘below’, which are often used to describe static locations. However, the verbs *bulaku* ‘go down, descend’ and the opposite *wurti* ‘go up, ascend’ are used to describe motion up or down.

DISCUSSION AND CONCLUSIONS

Most Australian Indigenous language speaking children are taught mathematics in English by English-speaking teachers. Their mathematics learning is assessed in English. When English speaking teachers talk and think about how to teach the language of mathematics, they tend to package concepts such as spatial concepts in the way that English packages

them. They are likely to think of a concept of “down-ness” which applies in the same way to being down and going down, as this is how the English grammar of “down-ness” works. However, it is far from certain that speakers of languages such as Iwaidja link the location of *wurrrwud* ‘below’ with the motion of *bulaku* ‘go down, descend’. Similarly, an English speaker may conflate the “behind-ness” and “in front-ness” conceptualised in the verbs *marlmarraywung* ‘pass behind’ and *wudbarraywung* ‘pass in front’, with that in *warrwak* ‘behind’ and *wurdaka* ‘in front’ to a greater extent than an Iwaidja speaker. Kriol, a creole language with an English lexicon spoken by over 4000 Indigenous Australian people, and learnt by many Indigenous children as their first language, also expresses path in basic motion verbs. Examples include *guwap* ‘go up, ascend’ and *gudan* ‘go down, descend’.

Educationally, a possible response to this would be for teachers of Indigenous language speaking students to try to use the discourse patterns of their students in teaching the language of location and motion in English (Lunney Borden, 2011). While the spatial prepositions may be emphasised in describing static location, when describing motion the path should not be separated or emphasised: rather than “down, down, go down”, the whole verb phrase “go down, go down, go down” could be repeated.

Grammatical structures provide clues to how speakers of different languages structure their understanding of events and to what they are likely to pay attention. Finding out about these grammatical structures can help mathematics education researchers to design investigations cognitive differences between speakers of different languages. The cognitive effects of using a serial verb construction as in Iwaidja could be investigated to add to comparisons between path- and satellite-framed languages. These types of structures are relevant when considering the design of mathematics questions in different languages. Questions that focus attention to one part of the information in one language and to another part of the information in another language may promote different problem solving strategies.

Finally, investigations such as that reported in this paper, into the grammar of basic mathematical concepts, can also provide us with the opportunity to look more deeply into our assumptions about these concepts. This in turn may inspire mathematicians to

think creatively beyond the grammatical constraints of their own languages.

ACKNOWLEDGEMENT

This research was supported by a grant from the Australian Institute of Aboriginal and Torres Strait Islanders Studies and an Australian Postgraduate Award scholarship at RMIT University, Melbourne. The author wishes to acknowledge the assistance of Bruce Birch in collecting and analysing the data, and of Joy Malwag Williams in translating the data.

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