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Abstract: There is a growing appreciation of the need and urgency to study and document mobility and energetics among extant hunter-gatherers. An increasing number of studies investigate the spatial and biophysical properties of hunter-gatherer movement, in order to gain a deeper understanding of such things as human energy expenditure and efficiency in foraging behaviour. So far, however, this research has not set out from representations of motion as expressed by the communities themselves. Such representations, as manifested in language for example, may provide significant clues to strategies of mobility. Here we conduct a first spatial investigation into indigenous hunter-gatherer representations of motion as they unfold in the landscape during foraging trips on foot. Specifically, we record using Global Positioning System (GPS) and explore in a Geographical Information System (GIS) the real-world instantiations of a set of cross-linguistically unusual motion verbs in the language spoken by the Jahai, a group of subsistence foragers in the Malay Peninsula. We analyse these verbs using a digital elevation model and show that their usage and meanings are directly connected to features and properties of local topography, notably gradient. Such topographical encoding in motion verb meaning is unexpected by current semantic theory. We conclude that the verbs are highly motivated by the affordances and interactional properties of the terrain, and are relevant to both foraging strategies and energy expenditure on the move. Our results underscore the significance of intangible indigenous representations as an informative inroad into human spatial behaviour, and the potential of GIS in exploring them.

Keywords: hunter-gatherer mobility, motion verbs, Jahai, geographical information systems, topography, digital elevation model

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1. Introduction

1.1 Hunter-gatherer motion and mobility

Cultural anthropology has a long tradition of interest in hunter-gatherer mobility.[1] This has focused on 'ways of walking' and has provided rich descriptions of specific cultural practices, especially in the context of sociality, materiality and environment (see eg the contributions in Ingold & Vergunst 2008; Lye 1997). Anthropologists and archaeologists have also extensively modelled hunter-gatherer mobility, residential and foraging strategies in relation to the structure of resources (Grove 2009; Hamilton et al 2014; Kelly 1983, 2013; Venkataraman et al 2017).

Furthermore, the past decade has seen a growing interest in the spatial, biomechanical and thermodynamic aspects of hunter-gatherer mobility. Thanks to new, improved and increasingly transportable technologies of measurement and recording – such as Global Positioning Systems, digital video and portable respirometers – advanced investigations of movement and foraging patterns, locomotion techniques and energy expenditure can be conducted in the field among the small part of humanity which still pursues a hunter-gatherer existence (Kraft et al 2014; Pontzer et al 2012, 2015; Raichlen et al 2014). This body of research has contributed significantly to our understanding of hunter-gatherer activities, and it has opened up new areas of research by offering quantitative windows on authentic human behaviour in remote indigenous settings. One significant finding is that human foraging patterns take the form of Lévy walks, a random walk search strategy in short move steps combined with rare longer move steps, as evidenced by spatial analysis of Hadza foraging trips (Raichlen et al 2014). Spatial principles and technologies promise to offer further applications to this developing field, since spatial analysis of behaviour can take multiple forms, starting from an exploration of the geometry of individual or grouped Global Positioning System (GPS) trajectories to identify basic movement parameters such as speed and sinuosity, ranging to more complex analyses which also include contextual information about the environment in which such movement takes place (Laube 2014).

However, none of these approaches is fundamentally informed by language. That is, they do not typically take as their starting point the indigenous conceptualisations of motion as instantiated in linguistic categories. For example, the measurement of hunter-gatherer spatial behaviour has so far not systematically

1. In this paper we use the terms *hunter-gatherer* and *forager* interchangeably.

targeted the activities and experiences associated with mobility as expressed in indigenous lexicons. Such linguistic categories are likely to represent culturally salient phenomena, and they may be significant as both determinants and reflections of mobility-related behaviour. Exploring them systematically might help to refine our understanding of hunter-gatherer mobility and offer guidance as to promising categorial baselines for studying human motion and energetics.

Unfortunately, languages and cultures do not always wear such concepts on their sleeve. For example, among the diverse ways in which languages express motion, few have overt systems of linguistic categories (eg verbs) that are meaningfully measurable from the point of view of recent research on hunter-gatherer mobility. But for those that do have such categories, which are the candidate dimensions for semantic encoding? Should we expect forager languages to instantiate the different components of Lévy walking (random short moves vs meditated long moves) as distinct linguistic categories, for instance? Or do other dimensions take precedence, such as purpose of movement (eg residential vs foraging) or directionality (eg outbound vs inbound)? Indeed, is it at all justified to expect forager languages to have special ways of structuring the domain semantically, and behave differently from languages spoken by non-foragers?

The Jahai – rainforest subsistence foragers of the Malay Peninsula who speak an Austroasiatic language – offer an unusual opportunity to study forager motion terminology in great spatial detail. Their language has a set of basic motion verbs, explored below, which encode movement in relation to features of the terrain, showing that actual topography and landscape can be primary semantic dimensions in motion representation. While this feature might seem unremarkable at first, it is cross-linguistically rather uncommon and challenges current theory about motion semantics, as explained below.

1.2 Motion in language

Motion expression in language has received a great deal of theoretical and descriptive attention, especially following Talmy's (1985, 1991, 2000) influential typology of lexicalisation patterns in the domain (see also Malt et al 2008, 2014). A key question is which aspects of meaning a language typically encodes in its basic motion verbs. Thus, the meaning of motion can be conflated with any of a number of distinct semantic components in such verbs, such as the Path of motion (*he entered the cave*), the Manner of motion (*he ran into the cave*), or the inherent properties of the moving entity, the Figure of motion (*it rained into the cave*). Languages have been shown to vary systematically as to their dominant

strategy of semantic encoding in basic motion verbs: Romance languages like Spanish generally encode Path whereas Germanic languages like English prefer Manner; indigenous languages of western North America, like Atsugewi and Navajo, regularly encode the Figure.

One semantic component that is poorly attested among motion verb encoding strategies of the world's languages is that of Ground; that is, the entity or surface in relation to which the motion takes place. Talmy himself notes this dearth of Ground-encoding systems and ascribes it to lexical economy: any such system would require an enormous verbal lexicon, considering the multitude of potential grounds to be encoded (Talmy 2000:60–62). English examples like *ford*, *dive* and *deplane* hint at how such Ground-encoding might surface in languages, but these are rare and articulate rather specialised and infrequent motion events. Importantly, they do not form systematic sets of distinctions or oppositions structuring basic types of motion events. Japanese comes closer, with a subset of basic motion verbs conflating Path with geometrical information about the Ground, eg *wataru* 'to cross a flat barrier (eg a street)' vs *koeru* 'to cross a vertical barrier (eg a wall)' vs *nukeru* 'to cross a constricted area (eg through a tunnel)' (Muehleisen & Imai 1997). Conflation of Path and Ground components is also present in the Papuan language Yélî Dnye (Levinson 2006). The following section outlines how Jahai verbs adhere to a similar pattern.

1.3 Jahai motion verbs

The Jahai are approximately 1000 subsistence foragers in the mountain rainforests of northernmost Peninsular Malaysia and adjacent parts of Isthmian Thailand. Their language is a member of the Aslian branch of the Austroasiatic language family (Burenhult 2005). Jahai society is traditionally highly mobile, bands of 15–50 individuals moving camp every few weeks. The Jahai area covers a landlocked region of about 3500km^2 centred on the upper reaches of the Perak, Pergau and Pattani river systems. The mountains of the Titiwangsa Range dominate its topography, with relief ranging between about 100 and 1800m above sea level. The entire area is characterised by narrow, steep-sided valleys and is drained by swift-flowing streams. Much of the area is still covered by primary Dipterocarp rainforest.

The Jahai language has a set of about a dozen verbs that express deliberate and prototypically non-vehicular locomotion in relation to landscape features. These features correspond to entities of terrain for which there are Jahai terms, typically in the form of nouns. Such entities are either hydrological (water features such as 'stream', 'rivulet') or topographical (landforms such as 'ridge',

'hill slope'). Each motion verb associates with a particular type of terrain feature and also expresses the directionality of movement in relation to the feature (up, down, along, across, around) (parts of the system are introduced in Burenhult 2008; Levinson & Burenhult 2009). Table 1 breaks down the glossing and meaning components of the members of the class.

Table 1 Landscape motion verbs in Jahai

Verb	Motion	Path	Ground
rkruk	to move	along	large stream – *tɔm bɨʔ* (mother-water)
cɨk		across	
liwɔr		around	obstacle along stream, waterfall – *lataʔ*
piris		across	(direction of) water – *tɔm*
dɛy		across	river flat – *hlydɨy*
dɛy[2]		up	source rivulet – *tɔm wɔŋ* (child-water)
hɛ̄c		down	
tigil		across	hill slope – *tbiŋ*
jɔh		up	
gɛs		down	
gəw		along	crest of ridge – *cbaʔ*

In componential terms, each verb systematically conflates the general component of Motion with the components of Path (in the form of a vector) and Ground (corresponding to a geographical feature). The Path vectors can be broadly divided into lengthwise vs crosswise vectors, typically forming natural pairs or sets of distinctions on one and the same geographical feature, eg 'move-along-large-stream' vs 'move-across-large-stream', 'move-up-hillside' and 'move-down-hillside' vs 'move-across-hillside'. Consequently, vectors systematically repeat across geographical features, as in 'move-along-large-stream' and 'move-along-crest', which represent two parallel types of horizontal motion. One verb denotes circumambulating motion around obstacles along a stream, such as waterfalls.

2. The verb *dɛy* seemingly has two meanings: 'to move across a river flat' and 'to move up along a source rivulet'. However, prototypically both categories of movement share a notion of motion away from a stream, as when making shortcuts across flat tongues of land formed by river bends, or turning off from a larger stream to cross over to an adjacent watershed (typically up along small tributaries). Only examples of the former reading are included in this study.

Significantly, the verbs are monolexemic, ie they are distinct and formally unrelated one-word forms and do not for example involve a recurrent basic motion verb 'go' or 'move' combined with directionals like 'up' or 'across'. They represent psychologically salient vocabulary, known and commonly used by all members of the community; they are not limited to specialist genres or other restricted registers. They thus qualify as basic terms (in the sense of Berlin & Kay 1969) on a par with English motion vocabulary like *walk*, *run*, *jump* and *roll*. Jahai has a number of additional motion verbs encoding other components (including several Manner-encoding verbs) and the landscape motion verbs addressed here only represent approximately one-fifth of the total motion verb vocabulary. However, the landscape verbs in focus here form a particularly well-defined and systematic subset of distinctions. They are ubiquitous in Jahai motion expression and denote activities of high cultural salience.

1.4 This study

Although the basic semantic dimensions of the Jahai motion verbs are rather well understood (Section 1.3; Burenhult 2008), their manifestation as types of movement in actual landscape has so far not been systematically explored. What is the relationship between the verbs and actual topography? Do real-world instances of the motion verbs map clearly onto identifiable topographical features or properties, and can we confirm or deduce anything about their semantics by recording and exploring how they unfold in the landscape? And can topographically contextualised linguistic distinctions help us gain a deeper understanding of locomotional strategies more broadly, among the Jahai and beyond?

To answer these questions we set out to investigate instantiations of Jahai motion verbs in a Geographical Information System (GIS). Data collection involved field-based creation of a GPS record of such verb categories as they emerge in elicitation from Jahai language consultants while travelling on foot with foraging parties (explained in detail in section 2). We then performed a number of analyses using GIS, exploring the verbs in a Digital Elevation Model (detailed in section 3). In section 4 we discuss the results and their implications.

Our approach departs from previous spatial analyses of hunter-gatherer motion in that it targets indigenous strategies of *representation* of motion, and not just motion behaviour as such. In doing so, it adds in real-time a level of fine-grained indigenous 'annotation' or 'tagging' to the behavioural record. It

also goes beyond previous work on motion semantics in that it captures actual spatio-physical instantiations of the linguistic categories and explores their meaning in relation to the environment.

2. Data collection

Data collection involved in situ elicitation and GPS recording of lexicalised categories in the form of motion verbs from two male Jahai language consultants during actual movements on foot at the landscape scale. These walks were a series of short day trips by small foraging parties in Jahai territory in the upper reaches of the Perak river, Peninsular Malaysia, conducted intermittently during the course of several fieldtrips between 2012 and 2015. The purpose of the walks was usually combined foraging activities such as fishing with casting nets, blowpiping of arboreal game, smoking of rodent burrows and digging for tubers.

The consultants were instructed to continuously explain to the researcher which type of movement the party was currently engaged in, so movements were constantly monitored, discussed and recorded. Continual in situ verbalisation of motion types is of course untypical for Jahai conversation on the move, but the consultants quickly grasped the format and took the lead in what they regarded as an opportunity to teach the researcher about Jahai movement. Instructions and conversations were all in Jahai. Motion tracks corresponding to instances of verbs were GPS-recorded as line vectors in x, y, and z coordinates, and each recorded line was coded for verb category (10 altogether, only six of which were frequent and are analysed here). For this purpose a rugged handheld Getac PS535F computer was used, equipped with ArcPad mobile mapping software. Line vectors proved highly applicable to motion of the kind studied here and were employed straightforwardly to record verbs.

Most of the walks were round-trips, and the recorded tracks correspond to intentional and partly premeditated longer transit trajectories. Thus, they do not represent the more random small moves characteristic of foraging in a confined area typical of Lévy walking (Raichlen et al 2014). However, one of the motion verb categories is typically accompanied by a continuous foraging activity (fishing with casting nets while moving along larger streams). The recorded instantiations of motion verbs total 37.4km.

3. Methods, analyses and results

To explore the relationship between verb use and the landscape, we undertook a range of analyses using GIS, which allowed us to both qualitatively and quantitatively explore the relationship between language and landscape systematically. We first identified 16 separate walks of lengths between around 800 meters and 8km for analysis (Figure 1). For each walk verb usage was recorded with consultants along its entire length. To link this verb usage to the landscape, we used a 30m resolution Digital Elevation Model (DEM) downloaded from https://earthexplorer.usgs.gov/ and reprojected both the original GPS data and the DEM to a locally appropriate projection (Kertau 1968 Perak Revised Grid). We then extracted individual points at an interval of 15m along the length of each of the 16 walks, associating every point with one of the six verbs (v1–v6, see Table 2). The inset in Figure 1 shows the relative frequency of usage of each verb along all 16 walks, ranging from 5.7% for v5 to 36.6% for v6. Table 3 shows the proportions of verbs associated with each individual walk, together with the overall number of points sampled.

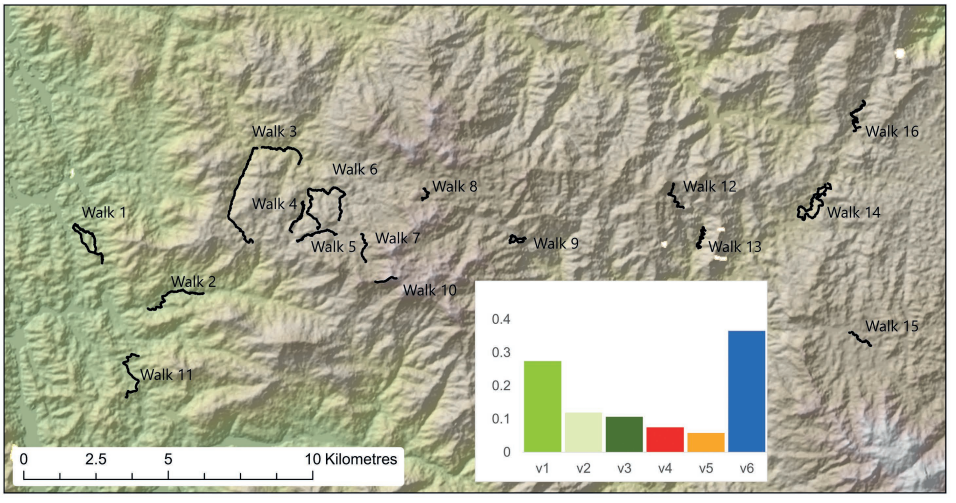

Figure 1 A map indicating the 16 analysed walks. The inset bar graph shows the relative frequency of usage of each verb. Underlying topography from 30m Digital Elevation Model derived from Shuttle Radar Topography Mission

Table 2 Jahai motion verbs included in the analysis

Verb	Code	Gloss
tigil	v1	move.across.hillslope
gɛs	v2	move.down.hillslope
jɔh	v3	move.up.hillslope
gəw	v4	move.along.ridge
dɛy	v5	move.across.riverflat
rkruk	v6	move.along.streambed

Table 3 Breakdown of proportion of verb use and number of unique points (n) sampled per walk. Walks chosen for detailed further analysis (Walk 1, Walk 6, Walk 10 and Walk 14) highlighted

Walk	Walk 1	Walk 2	Walk 3	Walk 4	Walk 5	Walk 6	Walk 7	Walk 8
v1	0.15	-	0.38	0.22	0.18	0.41	0.31	0.76
v2	0.15	-	0.02	0.09	0.15	0.12	0.26	-
v3	0.15	-	0.05	0.15	0.11	0.10	0.42	0.12
v4	0.31	-	0.02	0.18	-	0.07	-	-
v5	-	0.10	0.34	0.03	-	-	-	0.08
v6	0.24	0.90	0.20	0.33	0.56	0.31	-	0.03
n	388	241	546	250	209	431	99	59
Walk	**Walk 9**	**Walk 10**	**Walk 11**	**Walk 12**	**Walk 13**	**Walk 14**	**Walk 15**	**Walk 16**
v1	0.34	0.03	0.47	0.59	0.18	0.25	0.48	0.11
v2	0.14	-	0.24	0.38	0.15	0.21	-	0.07
v3	0.14	0.54	0.10	0.04	0.11	0.10	-	0.05
v4	0.06	0.44	0.19	-	-	-	-	-
v5	-	-	-	-	-	-	-	-
v6	0.31	-	-	-	0.56	0.43	0.52	0.77
n	126	78	215	111	209	412	102	336

To explore the relationship between topography and verb usage, we chose to calculate gradient (the magnitude of the steepest slope following the fall line at a location) and associate this with verb usage. In GIS gradient is calculated by comparing heights in a moving window, and is a standard operation. Since v1–v3 are associated with moving up, down and across hill slopes, v4 is associated with movement along a ridge, and v5 and v6 are related to movement along rivers and river flats, we hypothesised that v1–v3 might therefore be associated with steeper gradients than v4–v6. Figure 2 shows box plots for gradient

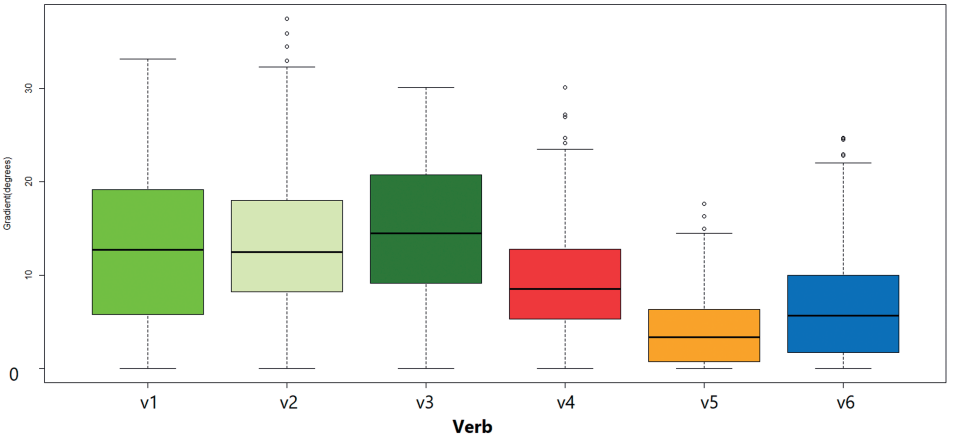

Figure 2 Box plots for gradient for each verb

for each verb, illustrating that this appears to be the case. We then grouped gradients we hypothesised to be associated with slopes (v1–v3) and flatter areas (v4–v6) and tested for statistically significant difference between the gradient distributions associated with the two groups. Slopes had an average gradient of 13.37°±7.88° while flatter areas had an average gradient of 6.88°±5.95°. These differences in distribution were statistically significant (Kruskal-Wallis test, $p < 0.01$). Having established that there appeared to be a general difference in verb usage globally, we selected four exemplar walks for further analysis. Our aim here was to explore verb usage qualitatively (by comparing use of individual verbs to topography) and quantitatively (by statistically analysing differences in verb usage as a function of topography).

Figure 3 shows the four walks we selected: Walks 1, 6, 10 and 14. These illustrate movement through different environments. Walk 1 first follows a ridge (v4), moving down (v2) and across (v1) hillslopes before returning along a streambed (v6) and up (v3) and along a ridge crest (v4). Walk 3 shows a similar pattern, but spends more time traversing hillslopes (v1). Walk 10 is short and was selected because it shows differentiation between movement up a hillslope (v3) and along a ridge (v4). Finally, Walk 14 is dominated by movement along a streambed (v6) and up (v3), down (v2) and across hillslopes (v1). Qualitatively these individual walks show remarkable agreement with verb usage and movement capturing both the path of motion (eg up, down, across) and the substrate (eg streambed, hillslope or ridge).

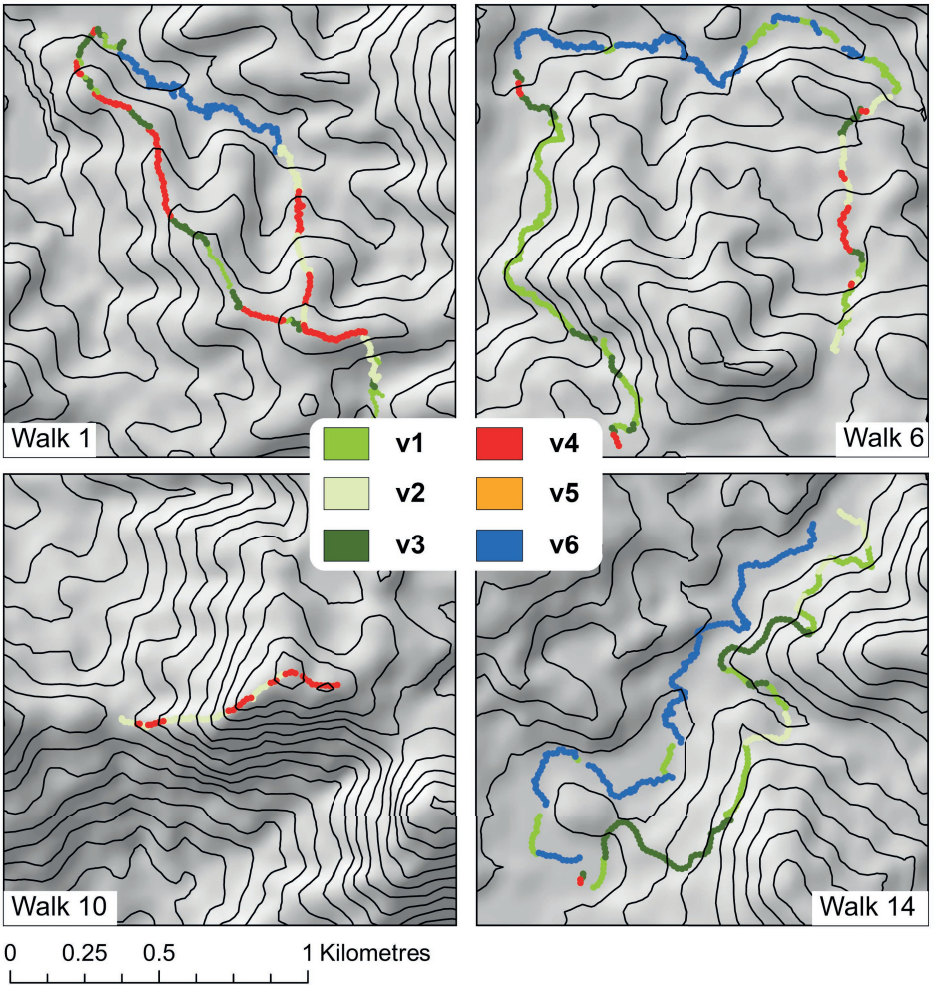

Figure 3 Maps showing Walks 1, 6, 10 and 14

In Table 4 we explore the gradients associated with verb usage in each walk, and statistically compare the resulting distributions. For each walk, we found that the distributions of gradient associated with verb usage differ (Kruskal-Wallis test, $p < 0.01$). We then carried out a post-hoc test to explore which verb usages were different in each case (Dunn 1964) (Kruskal-Wallis multiple comparison, p-values adjusted with the Benjamini-Hochberg method, $p < 0.01$) (Table 5). Remarkably, verbs moving across, down or up hillslopes (v1, v2, v3) are always associated with steeper gradients than those along stream

beds (v6) (Walks 1, 6, 14). Walk 10, which traverses a ridge shows a significant difference between verb usage for steeper ascents (v3) and flatter parts of the same ridge (v4). Similarly, though the ridge traversed in Walk 6 is less steep (7.09°±4.57°) than that in Walk 10 (13.03°±7.95°) verb usage between those referring to hillslopes (v1, v2, v3) and ridges (v4) is differentiable through gradient.

Table 4 Statistical comparison of gradient distributions associated with verbs in Walks 1, 6, 10 and 14

Walk	**v1**	**v2**	**v3**	**v4**	v5	**v6**
Walk 1 p<0.001	12.54±6.68 n=58	10.67±4.85 n=57	15.00±6.02 n=60	9.12± 4.34 n=120	-	7.12±4.72 n=93
Walk 6 p<0.001	14.52±7.24 n=176	12.19±6.59 n=53	11.64±5.41 n=41	7.09±4.57 n=29	-	8.25±5.30 n=132
Walk 10 p=0.003	16.97±0.00 n=2	-	20.02±8.61 n=42	13.03±7.95 n=34	-	-
Walk 14 p<0.001	13.34±9.40 n=103	14.56±6.77 n=88	14.90±8.06 n=41	0.00±0.00 n=2	-	4.76±5.57 n=178

Note: Each walk was tested for differences in distributions of gradient as a function of verb. All walks had significant (Kruskal-Wallis test, $p < 0.01$) differences in distribution (first column). Columns v1–v6 for each walk give mean gradient and standard deviation for verb usage along that walk and the number of sample points (n).

Table 5 Results of post-hoc test of differences in distribution in gradient for verb usage

Walk	**v1**	**v2**	**v3**	**v4**	**v5**	**v6**
Walk 1 p<0.001	12.54±6.68 n=58 (v4,v6)	10.67±4.85 n=57 (v3,v6)	15.00±6.02 n=60 (v4,v6)	9.12± 4.34 n=120 (v1,v3,v6)	-	7.12±4.72 n=93 (v1,v2,v3,v4)
Walk 6 p<0.001	14.52±7.24 n=176 (v4,v6)	12.19±6.59 n=53 (v4,v6)	11.64±5.41 n=41 (v4,v6)	7.09±4.57 n=29 (v1,v2,v3)	-	8.25±5.30 n=132 (v1,v2,v3)
Walk 10 p=0.003	16.97±0.00 n=2	-	20.02±8.61 n=42 (v4)	13.03±7.95 n=34 (v3)	-	-
Walk 14 p<0.001	13.34±9.40 n=103 (v6)	14.56±6.77 n=88 (v6)	14.90±8.06 n=41 (v6)	0.00±0.00 n=2	-	4.76±5.57 n=178 (v1,v2,v3)

Note: For each verb and walk, all verbs with significant differences in gradient are listed (Dunn [1964] Kruskal-Wallis multiple comparison, p-values adjusted with the Benjamini-Hochberg method, $p < 0.01$).

4. Discussion

A first conclusion to be drawn is that the semantics of the motion verbs are indeed topographically distinguishable, and decidedly so. The verbs whose meaning invokes hillslopes (v1–v3) associate clearly with steep gradients as revealed by the elevation model. The verbs whose meaning invokes ridges, river flats and streambeds (v4–v6) do not. Furthermore, the individual verbs express paths in relation to identifiable features or properties of the terrain: v1 across gradients; v2 and v3 down and up gradients, respectively; v4 along ridges; and v5 and v6 along the bottom of valleys. Here the results provide firm support to the idea that the Jahai verbs conflate semantically the components of Path and Ground (in the sense of Talmy 2000), and that they belong to a cross-linguistically unusual and hitherto largely undocumented class of basic motion verbs encoding Grounds in the form of features of the terrain. This adds Jahai to a small but growing number of languages that show that there are significant exceptions to Talmy's 2000 generalisation that Ground-encoding systems of basic motion verbs are non-viable.

The results also suggest that the verbs shadow the topography in a very direct and fine-grained way. Take another look at the walks illustrated in Figure 3 – even very short sections of topographically diverging movement trigger the use of a different verb, eg the switching between v3 and v4 in Walk 10, or between v5 and v6 in Walk 3 and 14. There is no indication in the data that the verbs can abstract away from immediate topography and represent, say, entire longer trajectories involving a dominant type of motion which happens to be interrupted occasionally by topographically diverging movements. Instead, each such divergence, however small and temporary, prompts a shift in verb usage. Again, this points to the fundamental role of terrain properties in the semantics of the verbs.

The well-contained set of motion verbs explored here provides a direct window into the distinctions that matter in the Jahai conceptualisation of mobility in landscape. The components of Path and Ground provide the systematic semantic scaffolding structuring the set, but a number of affordances and culturally entrenched pursuits also associate with the verbs and help to explain why they may have come about and are upheld. For example, the predominantly horizontal paths involved in *tigil* (v1), *gəw* (v4) and *rkruk* (v6) represent rather effortless and preferred types of movement, whereas vertical *gɛs* (v2) and *jɔh* (v3) are more strenuous (this may partly explain the relative frequency of verbs, illustrated in Figure 1; see also Alexander 2002). Furthermore, two verbs denote motion favourable to particular foraging activities, suggesting that Jahai

motion verbs do not make a distinction between travelling and searching types of movement (see section 1.1): *gəw* (v4) movement along a ridge offers optimal conditions for blowpipe hunting of arboreal game, since canopy within shooting range is found here both overhead and horizontally on both sides of the ridge; *rkruk* (v6) movement along a streambed presents a continuous opportunity to catch fish and other riverine and riparian resources. The verbs are overt 'tags' on environmental events of communicational relevance to the Jahai, and an understanding of them thus offers the analyst a shortcut into a range of expressions of culture and behaviour.

A noteworthy property of the phenomena explored here is their transience. Language use is fleeting and, in the absence of writing, linguistic categories leave no physical trace. The Jahai motion events labelled by the verbs are equally short-lived and, unless they involve repeated movement along the same path over a long period of time, have little lasting physical effect on the environment that would be identifiable in, say, the archaeological record. Our study shows that – despite these ephemeral characteristics – such representational and behavioural phenomena can be successfully captured by GPS, and their spatial properties can be fruitfully explored and explained in a GIS, as well as lodged for future reference. This underscores the functionality and potential of GIS as an environment for documenting and understanding intangible cultural heritage in its spatial context.

To our knowledge, our study is the first to map real-world instantiations of linguistic categories expressing motion in indigenous settings. We thereby add a representational layer to the spatial research on human mobility and in effect 'transcribe' actual motion events into the language of the walkers. Our target of study is the motion verb system of a language spoken by a particular group of extant mobile foragers. We do not wish to suggest that their motion representations can be generalised and claimed relevant to other communities and cultures, past or present, nor indeed that foragers should be expected to engage in specific types of linguistic representation (cf Güldemann et al 2020; Majid & Kruspe 2018). We are also not in a position to say if it is the subsistence mode and its manifestations of mobility that are the chief driving force in the development and maintenance of the system, or if ecological or linguistic factors are more important. But the Jahai do provide us with an unusually lucid example of what motion conceptualisation in landscape can be like in a hunter-gatherer setting. Their system may serve to stimulate new questions as to how motion is performed and represented in highly mobile communities.

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