SPACE-MACHINE

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This paper is about representation of knowledge, in particular of how a system of representation, by virtue of being a visual system, must obligatorily transform time into space; time, in this view, becomes fodder for, what we call, the "Space-machine". The system of representation that we deal with is the visual-manual system of sign languages. Such a system, owing to its differing modalities (visual-manual), has a higher degree of spatial encodings in its representation than a system of spoken/ hearing language with aural-spoken modalities. In contrast to spoken languages, sign languages treat spatial and temporal relations at par, precisely because the representational system is visual; this visual requirement, we claim, is the trigger for the "Space-machine". The Space-machine, in this view, is thus an abstract linguistic component of sign languages which makes production of time expressions in sign languages possible and perceivable. If visual-spatial thinking is at the root of all conceptualisation, then a proper characterisation of the "Space-machine" provides an insight into the process of learning (through) languages.

Keywords: Sign language, Space, Time, Tenses, Prepositions

INTRODUCTION

All conceptual domains are organised in terms space or in space-like fashion (Pütz & Dirven, 1996). The primacy of space is well supported by non-linguistic cognition like vision, touch and action. In this paper we take up the case of one such 'essential faculty' (Jackendoff, 1983) namely, vision, that is at the heart of processing linguistic information. The system that depends for both generation and parsing on vision, is the system of sign languages. Visible signs act as the cue for perception and generation of sign languages; understanding, conceptualising, and thinking proceeds via visual stimuli.

This crucial requirement of visual cues for processing, we claim, necessitates the positing of a linguistic device in sign languages that transforms abstract expressions into forms that are visible. For this paper, we take up the use of time expressions in Indo-Pakistani Sign Language (IPSL) to demonstrate the possibility of a device that necessarily converts abstract time expression into concrete spatial expression; for obvious reasons, therefore, we call this device "Space-machine".

We demonstrate the indispensability of the "Space-machine" for sign languages from three related perspectives. First, we present the descriptive facts of the IPSL, where we show that time expressions are always depicted in spatial terms, more often than in spoken languages. Next, we justify positing a Space-machine in production of sign languages, proving evidence from the use of adpositions in spoken languages and IPSL. Finally, we discuss the implication of the proposal for deaf education and education in general by examining the possibility of use of sign languages enhancing non-linguistic cognitive processes.

TIME IN SPACE

In this section, we discuss the descriptive facts related to the use of time expressions in IPSL in terms of spatial terms. However, in order to contextualise the issue of use of spatial metaphors for time expressions, we begin the discussion with such uses in languages in general.

Representation of time and space in language

Time is best represented in spoken language through the grammatical category of tense. In fact, modern linguistic theories treat tense as the 'head' or the most important part of a sentence, why this should be so, is little understood and even less discussed. The obligatory presence of tense in every sentence is an indication that a sentence cannot be what it is without tense. Tense in fact is the mode of anchorage of the sentence in the referential world, in other words, a sentence 'takes birth' in the real world only by anchoring through tense. This referential pegging is the reason why tense is considered to be the 'head' of a sentence. The structure of a sentence in modern syntactic theories is thus depicted as follows where the Verb Phrase (VP) denotes the event:

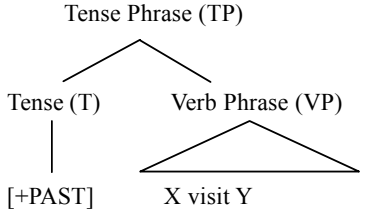

Figure 1: The syntactic Tree-Diagram of the sentence *X visited Y*

In comparison to the obligatoriness of temporal information in terms of tense marking, the expression of spatial shapes and relations is optional in spoken languages in general. As a result of this difference, the linguistic manifestations of the two vary; spatial information is best represented through spatial prepositions (Landau & Jackendoff, 1993).

Thus language – at least the variety that is spoken – treats time and space unequally, making the former obligatory and the latter optional. As the discussion in the next section will make it clear, this difference is to do with the less abstract or more concrete character of space in comparison to time, thus making it essential to *represent* the latter whereas the former is left to be configured not through language but through general cognitive devices, most importantly through the visual cognitive system.

In the backdrop of this inequality, the fact that space is conceived as three-dimensional but time as one dimensional or linear, predicts that space will lend itself more easily to the visual system than time. In this connection, various authors claim that temporal language is metaphorically based on spatial language (Clark, 1973), which accounts for the observation that many relational temporal prepositions in English, such as *before*, *after*, *ahead*, *behind*, etc., are historically derived from *front* and *back*.

This may indicate the operation of a Space-machine like device even in case of spoken languages. However, it is easy to show that in spoken languages, there are many temporal expressions that are independent of spatial terms. For example, the words for yesterday, today and tomorrow in many languages are not spatial in any sense:

(1)	g❷to kal	aj	por♦u	[Bangla]
	Past time	today	tomorrow	
	ŋəraŋ	ŋəsi	həyeŋ	[Meiteilon]
	yesterday	today	tomorrow	

Furthermore, different expressions of time like period, moment, etc., are devoid of any spatial connotations; here shown for Bangla:

♦❷moy 'time'	kal 'time, period'	kh❷n 'time'	b❷rtoman 'present'	bhobi♦♦❷t 'future'
b➔la 'period'	muhurto 'moment'	l❷gno 'moment'	d❷n➘o 'moment'	otit 'past'

Table 1: Different expressions of time in Bangla

The pervasive linearity of time is manifested by the fact that any event that is not simultaneous or overlapping with another event, takes place either *before* or *after* the other event, the multi-dimensionality of space, in contrast, displays different options of ordering entities. However, descriptions of spatial relationships are necessarily linear; thus, linguistic representations imposes sequentiality on spatial settings. Furthermore, it is possible to move around freely in space, but not in time; the absence of simultaneity and perceptual inaccessibility makes it impossible to point to temporal instances using gestures, Time is thus represented in temporal order in spoken language through the use of tense. Grammatically marking tense (and aspect) also helps set up sequences of events, as shown below where E1 is prior to E2 prior to E3:

(2) Event 1: X visit**ed** Y

Event 2: X **is** visit**ing** Y

Event 3: X **will** visit Y

Representation of space and time in sign languages

The last section points to the inevitability of difference in behaviour and representation of temporal and spatial expressions in spoken languages. Notably, we have seen that although space is multidimensional, its description is linear, not all temporal expressions are spatial, and inaccessibility of time makes tense as a marker of time obligatory in spoken languages.

The situation in case of signed languages is quite different. Due to the obligatory presence of the "Space-machine", we claim that signed languages convert all time expressions into spatial expressions with the result that expressions as in (1) and Table 1, are interpreted spatially. Furthermore, due to the essential visual nature of the language, the all absorbing space-machine turns any temporal information into space, with the result that tense is not grammatically marked in IPSL. Finally, since signed languages are not constrained by the linear-temporal nature of spoken languages, the true multidimensionality of space is retained in these languages. However, before we demonstrate these properties of signed languages, we will first elaborate how space is organised in signed languages in general and in IPSL in particular.

Space in sign languages

Sign languages create representations in the space in front of the signer; due to the importance of vision, signed languages take advantage of spatial representations. Pronouns and some types of verbs can be produced at specific locations in space or directed towards specific areas of space to produce distinctive meanings. Signs of this type can also be directed toward things that are physically present, including the signer, the addressee, other participants, and other entities. The linguistic uniqueness of multiple semantic distinctions of sign localisation is beyond doubt.

Space for sign languages is viewed from the signer's perspective – in particular, the space in front of them or a certain well-defined part of it. Note that this space is also shared by

the addressee, in other words, it has to be the same well-defined, boundaried space in front of the addressee as well. Furthermore, the space in front of the signer is divided in particular zones. This is shown in Figure 2, where the channel between the two interlocutors is the potential space for signing or the active signing space with the possible locations of 1st and 2nd person pronoun locations in its extremities, whereas the space to the right and left of the signer are possible location for 3rd person pronominals:

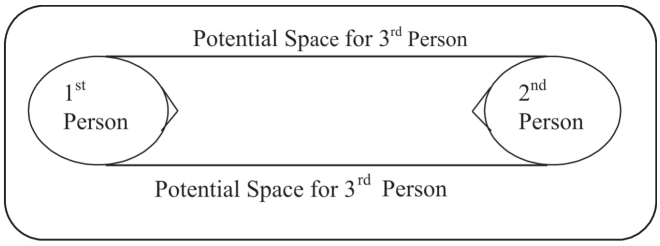

Figure 2: The complete signing space

Locations of persons in space can be considered as creating "holes" which are not filled till the discourse fragment is finished. Both the signer and the addressee must remember these holes for the conversation or narration to proceed meaningfully. Since further references made to these loci are like the use of pronominals in spoken language, "indexing" these loci are considered to be pronominals in sign languages.

However, the signers sign in a limited space. The distribution of the loci that mark different 'zones' of the signer's body also derive, what is called, the signing space. If we view space in terms of three-dimensional axes, the signing space is constituted of the positive sides of X-axis, Y-axis and Z-axis with '0' being the base. Thus the signing space is constituted of the front, top and right of the signing hand side of the signer from the centre of the signer's body. The axis that extends on both sides of the body in parallel to outstretched hands, which we will call the Z-axis on the basis of Hidam (2010), is shown in a topographic view as follows:

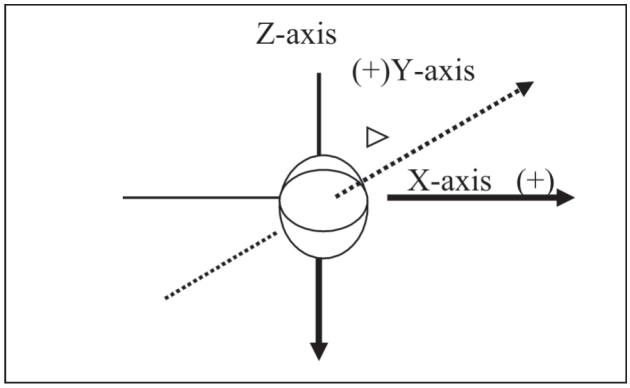

Figure 3: Topographic view showing all the three axes

Anatomically, however, the hands cannot be used for signing in the back or stretched beyond a certain limit – far back in time (-X) or far from here (+Z) or after a long time (+X) etc. In order to encode degree of time or distance, the Y-axis is brought into play. The Y-axis thus coordinates with the X-axis and Z-axis in order to convey intensity or degree. For depicting temporal expressions of various shades, both the vertical path (Y-axis) and the distance from the body (X-axis) are meaningful places of articulations. Thus for depicting a time far ahead in future, the signing hand moves forward in the X-axis *as well as* vertically higher in the Y-axis.

Time in sign languages

Having thus looked at the organisation and representation of space in signed languages, let us now come back to the representation of time in signed languages and specifically examine ways in which it differs from representation of time in spoken languages. We mentioned earlier that the presence of an all absorbing "Space-machine" in signed languages ensures that (i) there is no tense marking (unlike in Figure 1 above), (ii) there is no non-spatial time expressions (unlike in 1) and in Table 1 above), and (iii) the true multidimensionality of space is possible. We are now in position to demonstrate these. The first point can be made by showing the sign for the sentence *I will come tomorrow* in IPSL is as follows:

I COME TOMORROW

Figure 4: IPSL sign for *I will come tomorrow*

It is clear from Figure 4 that the verb is neither marked for Tense nor a separate modal auxiliary like the English will is used and the sign for the adverb TOMORROW is enough to indicate future eventuality. The second point can be made by considering the following lexemes in IPSL:

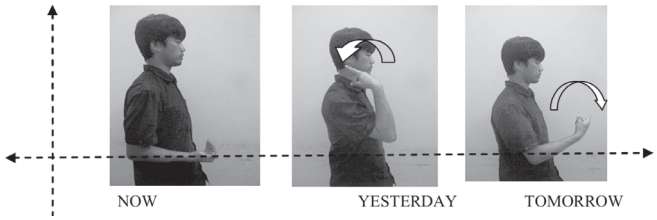

Figure 5: Time expressions in IPSL

Figure 5 clearly shows that the time expressions in IPSL are spatially expressed in terms of sign representations along the X-axis, behind the signer's body for YESTERDAY and in front of the signer's body for TOMORROW. Note crucially that *behind* and *in front of* are typical adpositions that indicate

spatial locations. The use of space in line with the discussion in the previous section is clearly seen in degree of time expressions in IPSL:

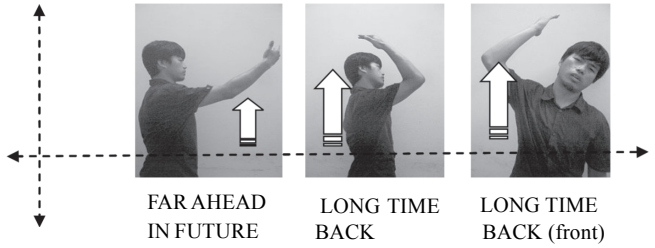

Figure 6: Degree of time expressions in IPSL

The Y-axis, shown as the dotted line in, is clearly made use of in combination with the X-axis here when degree expressions are involved. Thus, for showing a time far ahead in future, the signing hand travels in both +X (in front of the signer's body) and +Y (higher) directions. Similarly, for the degree expression a long time back, the signing hand travels higher and back.

Finally, the third point about the true nature of multidimensionality of space, is already shown in the above examples. We noted earlier that spoken language is constrained by *description* of space in linear terms, although space itself is multidimensional. Here, if we look closely at the third snapshot in Figure 6, non-manual marking of intensity on the face of the signer occurs simultaneous to the sign. Furthermore, the signs for YESTERDAY and TOMORROW in Figure 5 and Figure 4 show that the number '1' is incorporated into the sign to mean one day earlier or one day later, respectively. Not only does this make the entire sign spatial but it also overlaps with non-manual marking or with other signs.

Justifying the Space-Machine

Given the discussion in the previous section, although the conversion of time expressions to spatial terms in IPSL is beyond doubt, we will provide some further evidence from the use of adpositions in IPSL and spoken languages in this section to lend further support for the existence of the "Space-machine".

Use of Adpostions (Ps) in IPSL and Spoken Languages

Prepositions in IPSL do not exist as separate lexemes. Thus, there is no difference in signing (a, b) due to their functional similarities:

(3) a. put a flower in the vase

b. A flower in the vase

To elaborate further, the relation between the flower and the vase cannot be expressed without reference to how the flower came to be in the vase, thus even in the case of the noun phrase (b), the motion verb *put* is signed. We thus claim that prepositions, the crucial linguistic manifestations of space in language, are not needed in signed languages since space or location is already an obligatory part of the signs themselves.

In the domain of spoken languages, apart from prepositions, space is often located through locative morphemes. This is shown in the following for Meiteilon:

(4)	aa-**da**	si-**da**	a-*dom*-**da**	a-*som*-**da**
	there-LOC	here-LOC	there-towards-LOC	there-towards-LOC
	'over there'	'over here'	'towards that side'	'towards that side'

Similarly for Bangla, the locative marker *-e* is employed to mark a space stem *–khan-* in a space deixis:

(5)	e-khan-**e**	o-khan-**e**
	this-space-loc	that-space-loc
	'here'	'there'

However, in time deixis, the locative cannot appear:

(6) *E-khon-e

this-time-loc

Thus, spoken language being a non-visual system of representation, cannot and need not, have the time expression pass through a possible "Space-machine". Time, though one-dimensional in spoken languages, passes through the "Space-machine" in signed languages and becomes three-dimensional or spatial. Since vision can access only space, the requirement that representations be visual triggers the "Space-machine" in this system of representation. This is represented diagrammatically as follows:

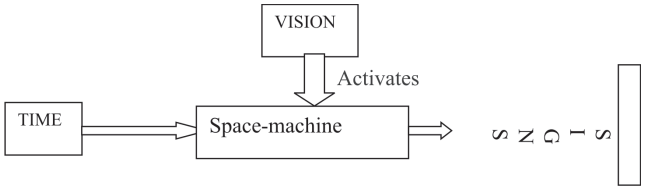

Figure 7: The operation of the Space-Machine

Space as the Key to Conceptualisation

In this final section, we discuss possible implications of proposing "space-machine" as a device that is integral to the generation and parsing of sign language representations. Given the discussion in the Introduction section, it is indeed the case that "space is at the heart of all conceptualization" (Pütz & Dirven, 1996) and that "abstract domains are consistently conceptualized in terms of spatial image schemata" (Kreitzer, 1997). An understanding of spatial categorisation, therefore, would provide the key to human conceptual categorisation in

general. Furthermore, if space provides a direct access to conceptualisation, sign language as a visual-spatial system can provide valuable evidence towards this.

There is another side to this. If it is shown that processing a visual-spatial system such as that of sign languages can lead to increased general non-linguistic spatial cognition, then adopting such a system for general educational purposes is likely to result in improved spatial cognition and therefore conceptualisation. Emmorey, Kosslyn, and Bellugi (1993) in fact examined the relation between processing ASL (American Sign Language) and the use of visual mental imagery, among other things. Specifically, they examined the ability of deaf and hearing subjects to mentally rotate images and hypothesised that mental rotation may play a crucial role in sign language processing because of the changes in spatial perspective occurring during referential shifts in narrative and the shifts in visual perspective occurring between signer and addressee.

The result of the experiment with regard to mental rotation is represented graphically as follows:

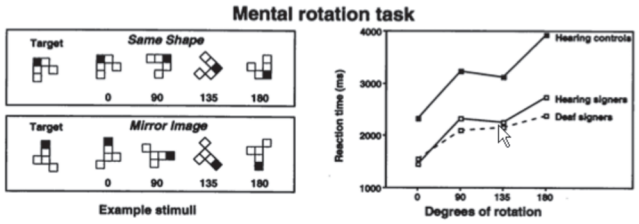

Figure 8: Illustration of mental rotation task by Emmorey *et. al*. (1993)

The results support the hypothesis that use of sign languages can enhance mental rotation skills as both deaf and hearing signers had faster reaction times compared to non-signers at all degrees of rotation.

Enhancement of such non-linguistic cognitive skills has implication not only for education of deaf students but also for hearing students. Thus adopting sign languages as a parallel medium of instruction or at least as a subject in schools will not only encourage mainstreaming of deaf students in regular schools, but also benefit the larger majority of the so-called non-disabled students. Results from available studies show that adopting inclusive programmes targeted mainly towards children with disability benefited majority of non-disabled pupils (Bhattacharya, 2010).

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