Underspecified Temporal Semantics in Pirahã:

Compositional Transparency and Semiotic Inference [1]

Daniel L. Everett

Bentley University

deverett@bentley.edu

"Perhaps it might be said rightly that there are three times: a time present of things past; a time present of things present; and a time present of things future. For these three co-exist somehow in the soul, for otherwise I could not see them. The time present of things past is memory; the time present of things present is direct experience; the time present of things future is expectation."

St Augustine ([1], Book 11, Chapter 20, Heading 26)

Abstract:

When the semantics is underspecified for some range of meaning, i.e. the grammar fails to display the full range of signs (words and syntax) required for semantic interpretation, compositionality across the relevant range is non-transparent. Pirahã tense is interesting because non-transparent temporal interpretations in Pirahã require more information than the syntax (or the pragmatics) provides. Moreover, not only are temporal interpretations in Pirahã underdetermined by Pirahã syntax, but this underdetermination provides yet more evidence against what one might label "naive compositionality" - the idea that meanings are provided Montague-style by mappings from syntax to semantics. Indeed, as we see, underspecified temporal semantics calls into question the very nature of compositionality itself. However, if we reinterpret compositionality as a subtype of inference in the Peircean sense, we are able not only to better understand some peculiarities in the relationship between Pirahã language and cognition but to also predict (as per Everett 2017 and Barham and Everett 2020) "degrees of fit" between morphosyntactic structures, meanings, and cultures across languages, leading to an informal typology of language types that includes languages without sentential recursion (e.g., but not limited to, Pirahã). Finally, Pirahã temporal semantics is also interesting because it forces an adjustment of Reichenbach's theory of tense, in line with Everett (1993), namely, that the "Reference" coordinate in his system is dispensable in some languages.

1. Introduction [2]

1.1. Summary of major points

      In what follows I review, revise, and move beyond the analysis of temporal semantics and grammar in Pirahã first developed in Everett (1993).[3] This revised analysis reaches several conclusions First, as argued by Everett (1993), the theory of tense developed in Reichenbach, if adopted at all, must allow for languages which lack what Reichenbach (see also Hornstein (1990)) called the "R(eference) point." Because Pirahã lacks perfect tenses and perfect interpretations, I argue that the R-point is unnecessary in Pirahã. Second, I argue that Pirahã's temporal structures require a theory of compositionality that, reminiscent of Partee (1995), Jazsczolt (2009; 2015), among others, fills in gaps of structures and meanings that are missing from the syntax, not merely via the pragmatics or implicatures, but by the general process of semiotic inference (see below). Although there are many theories of compositionality that address similar issues, I will argue that it is more parsimonious and accurate to treat compositionality as a subtype of inferential processes ranging at least over culture, grammar, and real-world knowledge. This better fits a particular approach to meaning, begun by Charles Sanders Peirce more than 150 years ago, influential across the natural sciences. I also argue that by treating compositionality as a subspecies of inference, we are better able understand a number of otherwise puzzling interpretations, including the recursive interpretations in Pirahã in the absence of recursive syntax, Pirahã tense, and interpretations in other languages. Finally, I argue that the inferential determination of Pirahã temporal semantics even though underdetermined by the syntax in the language allows better understanding of Everett's (2017) and Everett and Barham's (2020) conclusions that there are three types of language based on the tightness of fit between syntax and semantics.

If correct, this conclusion illustrates a possibility mentioned by Barbara Partee regarding syntactic underdetermination of quantification (based on a tripartite semantic structure for quantification found in several approaches):*"If we were to regard such a structure as a common semantic interpretation of the very different syntactic structures in question, we might find ourselves asserting that some languages are more compositional than others."* (Partee (1995, 541). Though Partee rejects this possibility, I argue here that it is necessary and natural).

1.2. Organization of paper

Section 2 of this paper provides a summary of Pirahã time words and temporal interpretations as discussed in Everett (1993), as well as motives for rejecting the universality of Reichenbach's full temporal theory (even as modified by Hornstein (1990)). Section 3 discusses getting from Pirahã temporal syntax to Pirahã temporal semantics. Section 4 discusses the implications of our findings for compositionality. Section 4 also discusses the possible fit, alluded to by Partee (1995, 541) above, between grammars and inference/compositionality, supporting Everett (2017) and Barham and Everett (2020). Section 5 summarizes the findings and discusses some additional implications.

2. Pirahã Temporal Signs and Interpretants

Although there is a rich system of verbal aspectual suffixation in Pirahã, there is no purely temporal morphology (Everett 1983, 1986, 1993). There is also a very limited number of time words. Thus Pirahã temporal semantics is underdetermined by lexico-syntactic sources. And yet Pirahãs are aware of past, present, and future, even though they do not mark them overtly in the language. This mismatch in Pirahã of the absence of overt marking of traditional

tenses with the presence of temporal interpretations corresponding in part to such tenses leads ultimately to a better understanding of the role of culture and real-world knowledge in linguistic interpretation[4]. Of course, the role of culture and other information in temporal interpretations is not unique to Pirahã (e.g. Jaszczolt 2009; Partee 1996, Everett (2012a,b; 2016), inter alia).

The facts of Pirahã temporal meanings remind us that the study of little-known languages can pay back the effort expended by discoveries of principles or better examples of principles than on better-known languages might reveal.[5],[6] From the perspective of Everett (2012, 2016) all temporal systems begin with real-world physical and cultural experiences (also cognitive, but this term, according to Everett (2016) is but a hyponym of culture - cf. Sapir 1921, 1931, inter alia).

One need not adopt a particular philosophical position on time and space to recognize that bodies require space and thoughts require time (cf. Prosser (2016)). Of course, we do not know this when we are born. We just live. Our interpretations of our proprioceptions and perceptions are constrained by the cultures from which we emerge, which shape our perspectives on the meaning and structure of time and space and the way in which these perspectives in turn affect our social expectations, knowledge structures, and values (Everett 2016). As we say in Portuguese when we want someone to arrive on time "Hora britânica, ouviu?" ('British time, you hear?') According to this Brazilian Portuguese saying, the British valuation and meaning of specific time interpretations guides one's behavior differently than those in Brazilian Portuguese. (Though the expression is ultimately intended to be humorous, it is frequently used to clarify beginning times of meetings.)

My proprioceptive awareness of my body's extension tells me something about the space I occupy. My eyes show differential distances. My awareness of time is in part formed by

external factors, such as the sun's rays' intensity changing based on the time of day and the time of year. Our hunger tells us it is time to eat. Our thirst that it is time to drink. At a party the host "realizes" it's time for guests to leave, though guests might not share this realization - vantage points are crucial. Events and our lives feel sequential, especially our thoughts as Peirce pointed out 153 years ago:

> *"To say, therefore, that thought cannot happen in an instant, but requires a time, is but another way of saying that every thought must be interpreted in another, or that all thought is in signs."* (Peirce (W2: 207ff, 1868)).

This sequentiality becomes a basis for time and the time-line metaphor (left to right = past to future) found in many languages, just as it can serve as a foundation for other time systems, such as the temporal semantics in Pirahã, wherein culture arguably plays a stronger role than the morphosyntax in time reference. Culture permeates our lives, as I have argued in many other places (e.g. Everett 2005, 2012, 2016), in ways that are often unspoken and even ineffable. One of the first to write about this with clarity and elegance was Edward T. Hall (1959, 1976, 1990).

In 1959, Hall published **The Silent Language**.

> *"It wasn't just that people 'talk' to each other without the use of words, but that there is an entire universe of behavior that is unexplored, unexamined, and very much taken for granted. It functions outside conscious awareness ... What is most difficult to accept is the*

fact that our own cultural patterns are literally unique and therefore not universal" (Hall [1959] 1973, vii).

Hall is not merely offering here the banal observation that there is an unconscious. He is talking about cultural tacit knowledge—a more articulated notion. The concept of tacit knowledge (Polanyi (1974, 1966)) is one that I have expanded into the wider idea of "dark matter of the mind," which I define as follows:

"*Dark matter of the mind is any knowledge-how or any knowledge-that that is unspoken in normal circumstances, usually unarticulated even to ourselves. It may be, but is not necessarily, ineffable. It emerges from acting, "languaging," and "culturing" as we learn conventions and knowledge organization, and adopt value properties and orderings. It is shared and it is personal. It comes via emicization, apperceptions, and memory, and thereby produces our sense of "self."* Everett (2016: p11)

The concept of dark matter includes our understanding of time, individually and culturally and, as the definition claims, is acquired gradually over time as we grow up in a particular culture.

For example, some cultures offer a distinct application of their concepts of time for their gods. From some gods' perspective, the past, present, and future present themselves to the deity simultaneously. For such a being there would be no past, present, or future - He or She created all times at once and sits outside of time, (e.g. Psalms 90:2 "Before the mountains were born or you brought forth the whole world, from everlasting to everlasting you are God"; or, from

Ephesians 1:4, "For he chose us in him, before the foundation of the world, to be holy and blameless in love before him").

Similarly Plato, a "deity" of the Western secular canon, according to Reichenbach, viewed time as a "moving image of eternity" where "eternity" is a "reality not controlled by time flow." (Reichenbach 1956, 5).

One topic that has long intrigued anthropological linguists is the relationship between humanity's various senses of time and how these cultural manifestations are represented in temporally-based philosophies, sciences, theologies, and grammars. How do human cultures effect the linguistic expression of time? In Peircean terms, the process of sensing, tracking, and eventually representing the movement of the phenomenological/phaneroscopic perception of time from a vague feeling (e.g. the warmth of sunlight on our face that we do not focus on consciously) to a recognition of temporal stages of the daytime (say, morning and noon), to words, morphology, and reasoning about time is the result of his three phaneroscopic (phenomenological) characteristics. Peirce labels these three components of experience "firstness," "secondness," and "thirdness." The thirdness in particular is culturally and linguistically constrained and is the focus of this paper.

2. A Review of Pirahã Time

2.1. Absolute Tenses

In Everett (1983, 1986, 1993, 2005) it is claimed that Pirahã lacks any dedicated morphosyntactic markers for past, future, or present. However, as presented in Everett (1986, 288ff), Pirahã has a rich set of aspectual suffixes to mark such notions as duration of action, realization of action, internal division of action, continuation of action, beginning of action or state, actions within and outside of the control of the speaker (which overlaps with

the notion of proximate vs. remote tense), iteration of action, and resultative aspect. There are also two separate positional classes with three suffixes, each to indicate the relative certainty of the speaker with regard to the action being asserted (complete certainty, relative certainty, uncertainty) and the speaker's source of evidence e.g. deduction, induction/observation/abduction, or hearsay, both of which systems can have temporal implications. These represent distinct semiotic subsystems and the signs they are composed of work in tandem with discourse, culture, and real-world knowledge to source temporal interpretations for Pirahã utterances.

2.1.1. Time words

There are no time words in Pirahã which unambiguously mark future or past times. In English, such time words and expressions include *yesterday* (moment of speech preceded by event**)** *tomorrow* (event follows moment of speech**),** *next year,* etc. The final interpretation of such time words and expressions as there are in Pirahã is crucially dependent on context. A partial list of Pirahã time words and expressions is given below.[7]

PAST/PRESENT

(1)   a.   **so   Ɂóá**   'already'

time   -used/already experienced (This is a diachronic formation, no

longer seen as productive in the language).

b.   **tíi   soɁóá   kaháp -i   -í**

I   already   go   -proximate   -action

'I'm going now.'

c. **tíi**   **soʔóá**   **kaháp -á**   **há**

I   already   go   -remote   -complete certainty

'I already left.

PAST

(2)   a.   **so**   **ʔógió** long time ago/from now'

time   big (Also, like the examples to follow, a diachronic formation

no longer productive in the language)

b.   **ʔaoói**   **soʔógió**   **koa - á**   **-i.**

foreigner   long ago   die   -remote   -action

'The foreigner died a long time ago.'

c.   **ʔaoói**   **soʔógió**   **ʔowá**   **-boí**   **-haí**

foreigner   long ago   purchase   -movement   -relative

certainty

baósai.

cloth

'The foreigner will buy/bought cloth some time from now.'

FUTURE/PAST

(3)   a.   **pii**   **ai**   **-so**

water   thin   -telic

'the water becomes thin (summer/dry season)

b. **ʔoogiái   hi   piiáiso   ʔab   -o   -óp**

Dan   3p   dry season   remain-stem vowel -go

a   -i.   baisí   hi   ai

remote   -relative certainty   Maici:river 3p   be

' ʔoogiái (Dan) will return in the summer (=low water time).'
OR
'Dan returned in the summer.'[8]

(4)   a.   **pii   bígaí   -so** 'when water is thickened' (winter/rainy season)

water thicken -telic

b.   **ʔoogiái   hi   piibigaiso   ʔabo -óp**

Dan   3p   rainy season   remain-go

-a   -i.   baisí,   hi ai.

remote   -relative certainty   Maici:river   3p be

'Dan will return in the rainy season.'

'Dan returned in the rainy season.'

(Separate clauses, with separate intonational breaks)

(5)   a.   **tíihí   káobí -so** 'Brazil nuts fallen' (used for latter part of

Brazil nut   fall   -telic   rainy season)

b. **ʔao**   **aáíbá -koí**   **tíihíkáobíso**.

foreigner   many   -intense   latter period of rainy season

'There are many foreigners (here) in Brazil nut season.'

(6)   a.   **ʔa ho ái** 'night'

at fire be

b.   **ʔoí**   **kabáo**   **ʔab i**   **í**   **-haí**   **ʔahoái**.

biosphere: remain stem vowel proximate   -rel.cert. night

jungle

'Don't go out at night.'

(7)   a.   **hoa**   **hoí**   **hi**   **-o** 'more than one day'

fire   couple at   -it

b.   **Hi**   **hoahoíhio**   **ʔab**   **iig**   **á.**

3p   couple of days   remain -cont.-rem.

'He is staying several days.'

Other examples of time words include words like:

(8)   **ʔahoa**   **koho -ai**   **-hio**   'early morning'

night   eat   -do   -in

(9)   **hi bigí bagá ʔais -o**   'sunrise/sunset'

3p ground/sky on top of do telic

(10)   **hiso ógi ái '**   noon' (lit: 'big sun time')

sun   big   do/be

(11)   **pi   ʔái** 'now' (lit: 'this water')

water -do/be

2.1.2. Sequential markers

      Sequential markers or ordering words are formed metaphorically in Pirahã (as in many other languages), including such words as:

(12)   a.   **ʔapaí** 'first' (literally: 'head')

            b**.**   **Gói**   **ʔapai ʔopí -ta**   **-á**   **-ti**

                  imp.pro   head go   -iterative   -remote   -directive

                  'You go first.' OR 'You go in front.'

(13). a.   **ti   ohi -ó** 'next' (at the butt)

             butt   side   -locative

        b.   **Kóhoi ʔapaí kao   -p   -á. Poioí hi tioh   -ó   kao**

             Kóhoi head, emerge-vertically-remote. Poioí he butt-at emerge

             -p   -á   -há.

-vertically   -remote   -complete certainty.

'Kóhoi was born first, then Poioi.'

(14)   a.   **gaaba** 'then/next'

            b.   **Kóhoi ʔapaí kaopá. Poioí hi tiohó   kaopáhá.**

                  'Kohoi was born first, then Poioi.'

            c.   **Ti   koho -ái -kab -á -ob -áo.   Gaaba ti gí kobai -sog**

                  1p   eat -do -end -remote -turn   -telic. Next I you see -des.

                  -abagaí.

                  -frustrated initiation

                  'When I finish eating, then I (almost) want to see you.'

Each of the temporal expressions above can be made precise only via specific

contextual inferences. Note, though, that in context each of these expressions is ultimately

interpreted by simply interpreting the moment of speech as prior to the future event,

following the event, or simultaneous present with the event.[9]

2.1.3. Other temporal representations

  2.1.3.1. Temporal Clauses

In Everett (1983/1986), I analyzed a particular suffix, **-ao/-so** (vowel-initial following

consonants, s-initial otherwise) as indicating telic aspect.

(15) **kab   -á   -o   -b   -áo   soxóá**.

finish -remote -away -down   -telic   already

'I just finished.' OR 'I am about to finish.'

The **-áo** is not a temporal connective/subordinator but rather it indicates 'boundary of an action'. Moreover, it can be omitted from what one might consider to be similar to syntactically subordinate clauses in other languages, as in (16) and (17):[10]

(16)   a.   **kohóai -xiigá.**   **Tíi gí ʔahoái -soog -abagaí**

           eat   -continuative   I you talk   -want -frustrated initiation

           '(You) are eating. I want to talk to you.'

           (Free translation: "When you finish eating, I want to talk to you.")

      b.   **kohóai**   **-kabá -o**   **-b**   **-áo.**

           eat   -finish -stem vowel   -down -telic.

           Ti   **gí**   **ʔahoái -soog**   **-abagaí**

           I   you   talk   -want -frustrated initiation

           '(You) are about finished eating/you just finished eating. I want to talk to you.'

           (Free translation = 'When you are done eating I want to talk to you.'

(17)   a.   **Pii**   **boí**   **-so.**   **ti**   **kahápií**   **-hiaba**.

           rain   move -telic.   I   go   -negative

           'Rain has completed. I won't go.'

           (This is because when the ground is wet, the snakes come out of their holes.)

        b.   **Pii**   **-boí**   **-iigá.**   **ti**   **kahápií**   **-hiaba**.

           rain   -move down   continuative. 1   go   -negative

           'It is raining. I won't go.'

If the suffix **–sai** 'old information' is used in these examples instead of **–so/-ao** the result is different:

(18)   a.   **pii   -boí   -sai.   Ti kahápií   -hiaba**.

                   rain   -move down -old information.   I go   -negative

                   'It rains (topic of discussion). I won't go.'

This can also be interpreted as a conditional (e.g. 'If it rains, I won't go'), but need not be. This arises just in case the conversation is about raining and one adds information about their plans. But there is no evidence for subordination apart from the English translation.

   2.1.3.2. Additional examples

Past readings:

(19)   **ti   kahi ob -áo   -b   -iig   -á**

     1   arrow see -telic   -down/perfective-continuative-remote

        'I was looking at the arrow.'

(20)   **xi   hiab   -ab   -óxóí -hix**

     animal negative-remain   -interrogative   -interrogative

        'Did the meat run out?'

(21)   **ti   xi   koho -áo   -p –iig   -á**

1	animal	eat -telic	-up -continuative	-remote

'I was eating meat.'

Future readings

(22) **hi   koab -ai   -p   -a**

3   die   -atelic -imperfective -remote

'He will die.'

(23) **ʔipóihií   ʔab -óp -ai -so.   ʔaaxái**

woman   return -go -be   -telic proper name

ʔipóihií.   tíi   ʔahá -p   -í   -t   -aó.

woman   1   go   -vert/imp. -prox. -iter. -telic.

Free translation: "When the woman returns, the wife of ʔaaxái, I will leave again." (lit: "The woman returned. I am gone again.")

Present Reading

(24) **kahaibó   bogíaga   -hoag   -á**

arrow point   warp   come/turn   -remote

-há   -taío

-compl. cert.   resultative

"Therefore, the arrow head does not warp."

(25)   **Kó,   Kohoibííihiai,   ti   gí   ʔahoa -ai   -sóog   -abagaí**

vocative, proper name   1p   2p   speak -be   -desiderative -frust:init

"Hey,   Kohoibííihiai, I want to talk to you.

Now that we have a basic concept of absolute tense expressions in Pirahã let's consider more complex cases, beginning with English complex sentences and proceeding to ask why perfect tenses are *not* found in Pirahã, beginning with a brief introduction to Reichenbach's theory.

3. Reichenbach's Temporal Theory[11]

There are clearly logical and real-world constraints on tense, so that, for example, we cannot have someone in the past being affected by events in the future:

(26)   *John ate when he will get his meal.

Tense is constrained partially by logic and the real world. But if the properties of tense grammar and interpretation in natural languages were all logically necessary, then there would be no language-specific variation in the tense system and thus little need for crosslinguistic studies in this area. For purposes of discussion, Reichenbach's (1947) system will be used, though I propose a nontrivial modification of that system (cf. Everett 1993).

Reichenbach (1947, 288ff) argues that tense relies on three distinct temporal points: the *event time,* **E,** the *speech time,* **S,** and the *reference time,* **R.** These are all illustrated in the English perfect tenses:

(27)   John will have finished when Bill arrives.

    S_1___E_1,___R_1 S_2___E_2,R_2 (where R_1__E_2)

In (27), the event of *John's* finishing precedes that of *Bill's* arriving, and both are subsequent to the moment of speech. So, in both the main clause and the adjunct clause of (27) the Moment of Speech (S) precedes the Events (E): S___E. The perfect tense reading comes from the R points. In the matrix clause the event of finishing precedes the event of Bill arriving. To achieve this result we say that both R points follow the moment of speech, but that the R point of the matrix clause precedes the E point of Bill's arrival, as illustrated.

Future tense in Reichenbach's system is also simply expressed: the moment of speech, S, precedes the event, E and R.

Future tense using Reichenbach's system: S___E,R

The representation above indicates that S(peech time) precedes E(vent time), i.e. that the event is future with regard to my speaking.

For past perfect tenses, the event of the main clause follows the moment of speech, but it will precede the reference point, **R,** the time of Bill's arrival in (30), which is the **E** of the adjunct clause (Bill's arrival). **R** is also seen in past perfects:

(27)   John had finished when Bill arrived.

    E_1___R_1___S_1 E_2, R_2___S_2 ($R_1 = E_2$)

The matrix tense structure of (30) is: E _ R _ S; the adjunct tense structure is E,R _ S.

That is, in the adjunct clause the Event (Bill's arrival) and the Reference point are simultaneous, both preceding the Moment of Speech. The main clause Event, John's finishing, takes place prior to the Reference point (the Event of the adjunct clause) which is itself prior to the Moment of Speech. Thus, the event of the matrix clause, *finished*, is not situated directly in relation to S but in relation to a point of reference fixed by the adjunct clause.

The crucial point is that the adjunct clause's temporal structure, in particular its **E** point, serves as the anchor for the **R** point of the matrix clause. Obviously, then, Reichenbach's reference point is important for talk about tense in English. Reichenbach goes so far as to claim that all tenses have R-points and he suggests that basic tenses may all be accounted for straightforwardly based on relations between **E, S,** and **R:**

(28)   a.   S, R, E   present tense

        b.   E, R ___ S   past tense

        c.   S___ R, E   future tense

        d.   E ___ S, R   present perfect

        e.   E ___ R ___ S   past perfect

        f.   S ___ E ___ R   future perfect

Note crucially, however, that **R** is not a logical necessity, even within Reichenbach's theory. For example, there are some tenses that we can talk about without it, as shown with Pirahã below. So, while it is clearly important to the interpretation of perfect tenses, it is not necessary for the interpretation of the simple past, present, or future tenses. In these tenses, **R** is always simultaneous with **E**, the event time and is therefore redundant (at least for simple clauses). On the other hand, **E** and **S** *do* seem necessary if we are to interpret the world around us

temporally. Without them an event cannot be situated along any temporal dimension. Indeed, it is difficult to conceive of talk about time without a concept of event (**E**) or a way to indicate whether that event precedes or follows a deictic anchor, **S**, at least pragmatically or contextually. If this is correct, then **E** and **S** are *epistemologically prior* to **R.** They make talk about tense possible in the first place, whereas **R** "merely" enables us to draw finer distinctions and to mark relations between these.

A further argument for conceding epistemic priority to the Event point over the Reference point comes from work by Davidson (1967) on action sentences, as further developed by Higginbotham (1985) and Leder (1991). Both Leder and Higginbotham argue at length that E(vent) is a crucial component of all verbal (and even nominal) structures, independent of tense. Leder further argues that this independently needed notion of Event is indeed the same notion of Event that Reichenbach-influenced tense specialists refer to. Assuming something along the lines of the Leder and Higginbotham approaches, then this provides further support for the contention that E and S are the primary building blocks of temporal interpretation, while R is secondary.

Of course, many proposals on tense have arisen since Reichenbach (1947), both within philosophical logic (e.g. Montague 1974) and linguistics (for an important survey of facts about tense in English and discourse-based interpretations, see Declerck (1991)). Within Generativism, Hornstein (1990) was one of the earlier proposals. Hornstein accepts most of Reichenbach's original ideas but, further develops Reichenbach's model by extending the model to account for a wider range of intrasential relations between tense in matrix and embedded clauses. I will not provide a complete introduction to Hornstein's model here, referring the reader to Hornstein (1990). I will however discuss those of his elaborations which are necessary in order to understand some relevant implications of Pirahã.

Consider how Reichenbach's theory might handle the famous Double Access Reading cases such (30) and (31) below. To analyze these examples in Reichenbach's tense theory Hornstein (1990) argued that Sequence of Tense (SOT) structures, such as Double Access Readings, require an additional syntactic component in Reichenbach's model, the Rule for Temporal Connectives (RTC). The latter is stated in (32) (from Hornstein 1990):

(29) Rule for Temporal Connectives (RTC)**:** Write the Basic Tense Structure (BTS) (the linear arrangement of **E**, **S**, and **R**) of the adjunct temporal clause (TNS_2) under the BTS of of the matrix clause, TNS_1). Associate the **S** points. Associate the **R** points by moving $\mathbf{R_2}$ to $\mathbf{R_1}$, placing **E** accordingly.

(30)   a. John heard that Mary is pregnant.
              b. John heard that Mary was pregnant.

(31)   a. John said that Harry will leave.
              b. John said that Harry would leave.

These are referred to as Double Access Readings (DAR) because the tense of the adjunct clause is checked against both the time of the main clause and the moment of the entire utterance (cf. Giorgi 2010). Under a particular reading, the a and b examples in (30) and (31) are temporally synonymous. They differ in that in the (a) examples, both matrix and subordinate **S** points are anchored to the actual moment of utterance. In the (b) examples, however, the **S** point of the subordinate clause is anchored to the **E** point of the (immediately) dominating clause, as in (32), representing example (30) above:[8]

(32)   [John heard that   [Mary was pregnant.]]

TNS_1 (E_1, R_1 ___ S_1) TNS_2 (E_2,R_2, ___ S_2)

(33)   SOT rule: TNS_1 (E_1, R_1 ___ S_1)

|

TNS_2 (E_2, R_2, ___ S_2)[12]

Another example of the utility of Reichenbach's system includes its ability to account for ungrammatical temporal modification. In (34) for example, the problem is that the Basic Tense Structure of the example is simple past, or **E,R _ S**. But the modifying expression, *at this very moment*, requires that **R** and **S** be simultaneous, since it requires a present tense meaning. This produces a grammatical/logical violation and the sentence is ruled out:

(34)   *John left at this very moment.[13]

Example (12) illustrates another problem:

(35)   *John left tomorrow.

The tense structure of *John left* is a simple past: **E,R S.** However, *tomorrow* requires that **R** follow **S.** This produces another violation and (35) sentence is therefore also ruled out.

Now consider what happens when a matrix structure is a simple future and the adjunct clause tense is present (subscripts indicate relevant clause):

(36) John will arrive when you eat pickles. TNS_1 $(S_1\_\_\_R_1, E_1)$ TNS2, (S_2, R_2, E_2).

The tenses of each clause must be aligned via the RTC:

RTC -->

$S\_\_\_R_1,$ $\qquad$ E_1

$\qquad\qquad\qquad$ |

$S_2,$ $\quad$ $R_2,$ $\qquad$ E_2
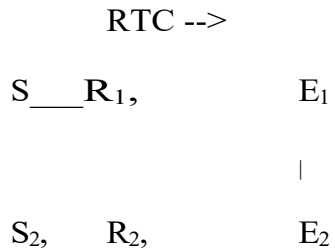
This eating pickles is linked to John's arrival, producing the grammatical (simultaneous future events) reading.

As noted, however, the **R**-point is not always needed, in even English. For example, one could say that the **R** point is unnecessary in past tense. Mary's pregnancy is unrelated to John's hearing when both matrix and subordinate tenses are past. Their only relationship is arguably that each occurs prior to the moment of speech. As we see below, for Pirahã the **R** point never seems necessary.

To conclude this summary, the tense points **E**, **S**, and, occasionally, **R,** as well as *syntactic* conditions on the ways in which these maybe ordered and related intrasentially are crucial to an understanding of English tense.

Reichenbach's system would similarly operate in Pirahã, in sentences like (37):

(37) **ti gáí -sai.** $\qquad$ **asi** $\quad$ **ti soʔóá ʔáab** $\qquad$ **-óp** $\quad$ **-á** $\quad$ **-p** $\quad$ **-á.**

1 say -old information assim 1 $\qquad$ alreadyturn $\quad$ -go $\quad$ -up $\quad$ -remote

kapiiga $\qquad$ **-kakaí-sai** $\qquad\qquad$ **ʔoogiái hi** $\quad$ **ʔigí - o**

paper $\qquad$ -mark -old information $\qquad$ Dan $\quad$ 3 $\qquad$ with $\quad$ -loc

"I just arrived. I want to study with/teach Dan."

E___S. S___E.

These sentences can be understood as time or causally-related clauses or, depending on speaker intentions, unrelated events as stated. Nothing connects them morphosyntactically.

There are thus two reasons why a simple application of either Reichenbach's basic system or Hornstein's (1990) modifications do not work here. First, Pirahã sentences are never embedded (Everett 2005, 2009a, 2012a, 2012b, 2017) and so the temporal interpretation of one clause is bound by the discourse and cultural context rather than morphosyntactic connections to another clause. Normally, the rightmost sentence in (37), "I want to study with Dan," would be interpreted as following the speaker's arrival noted in the first sentence. But it might also be the inverse, e.g. someone wanting to study with Dan (me) to earn money because they just arrived, the sentence having no implied temporal relationship to when Dan is studying (could have been four days ago, might be tomorrow). Thus due to the lack of sentential recursion in Pirahã, SOT constraints do not exist in Pirahã[14].

We have seen that Reichenbach suggests that tense can be understood in terms of the three points, **E, S,** and **R,** but that **E,** *event time,* and **S,** *speech time* are epistemologically prior to **R** in talk about tense. As Pirahã and many other languages illustrate, however, temporal systems vary significantly. The discussed variation predicts that tense systems crosslinguistically could vary with regard to **R** (or its equivalent) but likely never in regard to **E** or **S.** The crucial role for **R** arises not in the

basic tenses (where Hornstein (1990, 112) admits that **R** has '... no interpretive reflex'), but in complex tense relations, some forms of temporal modification, and **SOT** structures. In section 4, we see that this grammatical, "naive compositionality" (e.g. in Montagovian semantics) solution falls short and that generally to interpret tense structures in languages, we must use additional information from culture and the real world.

The stronger point is that while Pirahã manifests interpretations for past, present, and future tenses, though it lacks direct syntactic markers for them, it nevertheless lacks *interpretations* corresponding to perfect tenses, SOT structures, Double Access Readings, complex tense structures, or multiple temporal modification structures, due to the combination of its missing **R**-point and the absence of sentential recursion.

3.3.   Conclusion to Section Three

To summarize, Pirahã lacks any affixes for tense and otherwise has a very restrictive set of temporal nouns, adverbs, and adjectives. However, as presented in Everett (1986, 288ff), Pirahã also has a rich aspectual system including suffixes to mark such notions as duration of action, realization of action, internal division of action, continuation of action, beginning of action or state, actions within and outside of the control of the speaker (which overlaps with the notion of proximate vs. remote tense), iteration of action, and resultative aspect. There are also two separate positional classes with three suffixes each to indicate the relative certainty of the speaker with regard to the action being asserted (complete certainty, relative certainty, uncertainty) and the speaker's source of evidence (deduction, observation, hearsay).[15]

4. Peircean Semeiotics and Compositionality

4.1. Compositionality

The modern idea of Compositionality traces back, as many ideas about language do, to Frege (1892) and Peirce (a body of work on language dating back to before 1865). Although Peirce predates Frege in his writings about the formal nature of human language, most current researchers rightly see Frege (1892) as another foundational work. The so-called "Frege's Principle" states that, as Dowty (2007, p3) puts it:

(38) "*Frege's Principle* (So-called): 'The meaning of a sentence is a function of the meanings of the words in it and they way that they are combined syntactically."[16]

Although Frege's principle is not without opposition (see Gayral, et. al. 2006, among many others), one thing is clear to most linguists - the grammatical structure and lexical items in a specific linguistic unit are not irrelevant to its meaning. Just how relevant they are will depend on the degree of "compositional transparency" (Dowty (2007, 8) involved. Languages and constructions, I argue (Everett 2017, in progress) can be more or less transparent and this variation falls into one of at least three types of languages, which I label G_1, G_2, and G_3 languages; see section 4.3. below. Consider two English examples:

(39) Ol' John kicked the bucket.
(40) Sally kissed Mary.

Example (40) is compositionally transparent, while example (39) is not - idioms are idioms because their literal meaning is not what they actually mean or, as Peirce would put it, they have "grown" as symbols.

All languages likely allow grammatical utterances to vary according to whether they are more or less compositionally transparent. And as we have seen in the examples above, Pirahã temporal interpretations are not compositionally transparent.

Yet some linguists and philosophers believe that compositional transparency is universal, with occasional exceptions, all of which can be fixed by plugging the syntax into the pragmatics and downloading conversational implicatures and the like. I refer to this position as "naive compositionality" (Montague (1974) being perhaps the best example). The problem with naive compositionality, however, as currently practiced, is that it makes two erroneous assumptions - that all we need for literal semantics is in the syntax and that compositionality takes place at the sentence level, leading to the unfortunate fact that most syntactic theories are largely sentence-bound. There are many non-naive views of compositionality, of course. Jaszczolt (2009) and (2014) are two such examples. But although Szabó (2000), Jacobson (2014), Dowty(2007), Pelletier (1994), Kamp (2019), Fodor and Lepore (2002), Lepore and Stone (2015) and Peirce (1909), inter alia, offer more nuanced views of compositionality, they are by and large still sentence-bound and omit any theoretical role for culture[17]. Thus study of compositional transparency variation across constructions and across languages is vital for improving our theories of human language. In this regard, Pirahã joins all other languages of the world in forcing us to go beyond naive compositionality and pragmatics in order to model understanding of temporal intensions and extensions. As we see below (and see also Everett 2005, Everett 2012, Everett 2016, Everett 2017) Pirahã allows for less compositional transparency between the

syntax and the semantics than some other languages. I am going to argue that what unites all languages is not identical compositional transparency but what I will call "semiotic inference" (using signs to infer other signs, linguistic or otherwise; see section 5.2.).

4.2. Compositionality challenges

A modern statement of Frege's Principal is found in Szabo (2000):

(41)   *"Principle of Compositionality:* the meaning of a complex expression is determined by meanings of its constituents and by its structure.*"* (Szabó 2000, 3)

But this bare statement on its surface does not offer a solution for Pirahã temporal interpretation. The question remains as to how we achieve temporal interpretations for time words, affixes, and discourses in Pirahã without either precision time words or tense morphosyntax, if not by naive compositionality along the lines of (41)

In light of (44) let's reconsider examples like the following from Pirahã:

(42)   a.   **kohóai-xiigá.   Tíi gí ʔahoái -soog -abagaí**

eat   -continuative   I you talk   -want -frustrated initiation

"(You) are eating. I want to talk to you."

(Free translation: "When you finish eating, I want to talk to you.")

The interpretation of this example depends on seeing someone eating or quoting someone. The interpretation also depends on the cultural understanding of **-abagaí** which can also be an illocutionary force marker, i.e. this is an indirect speech act (literally it is "I almost begin to want to talk to you." making it not quite a direct statement). So we only know the temporal meaning of this example, like the English examples in (55)-(65) below by a combination of real-world knowledge and experience, with cultural values on how best to express ideas.

Thus again we see that in spite of the fact that lack of tense morphemes and precise temporal lexical items, the speakers of Pirahã are nevertheless able to come up with precise temporal understandings, modulo culture (see below)[18]. To accomplish this, they must *infer* from the context, the discourse, the words, expressions, gestures and so on what time frame is implicated in the meaning of individual utterances.
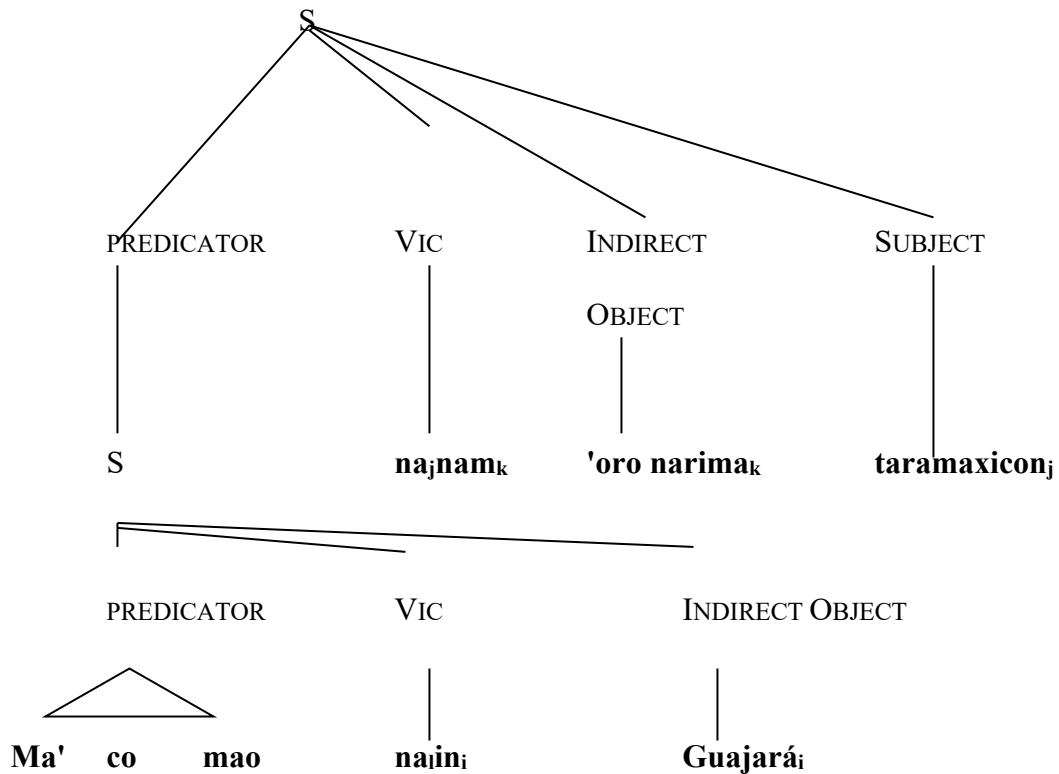
Peirce argued that all reasoning takes place via semiotics - using one sign to interpret another. For Peirce, however, signs, including entire propositions, need not be "expressed" linguistically. An interpreation can take words, gestures, immediate context, cultural values, and so on into account, not being exclusively bound by the linguistically expressed elements (see also Jaszczolt (2009, 2014), inter alia, for similar findings).[19] We have seen that Piraha uses inferences from a variety of sources to come up with temporal interpretations, for example. This use of linguistic and non-linguistic signs to infer meanings for utterances is what I refer to as "semiotic inference" (which is one way to classify the work of Floyd (2016) and Rodríguez (2014; 2019), for example.) Semiotics is crucial here because linguistic forms and divisions (phonemics, semantics, morphosyntax, pragmatics, semantics and so on) are all subdivisions of semiotics.

Yet another excellent example of the failure of naive compositionality in temporal interpretations is found in Wari' *Intentional State Constructions* (ISCs; Everett (2009b)). These are used to expressed a variety of concepts, including temporality. Consider, for example, the use of these constructions to express quotatives and future tense (Everett and Kern 1997 analyze these examples in the context of the wider Wari' grammar). The embedded sentence carries stress only on the last syllable of the sentence, i.e. the embedded sentence/predicate is stressed like a word; the embedded sentence is otherwise a non-idiomatic, fully productive sentence:

Quotative

(43) **Ma'**   **co**   **mao**   **na**   **-in$_i$**   **Guajará$_i$**

that:prox:hearer   m/f:rp/p   go:sg   3s:rp/p -3n   Guajará

                                                       (Brazilian city)

(44) **na$_j$**   **-nam$_k$** **'oro**   **narima$_k$'**   **taramaxicon$_j$**.

3s:rp/p -3pf   collective   woman   chief

'"Who went to Guajará?" (said) the chief to the women.'

        In what follows, I use the node 'predicator' as a neutral term for lumping together verbs and the semantic nucleus of ISCs (these nodes are labeled NUCLEUS in Role and Reference Grammar. Also, the grammatical relations (subject, object, indirect object) in the tree diagrams below are informal labels. Everett (2009b) restates them in RRG terminology (VIC stands for "verbal inflectional clitic" the normally second-position clitic, which agrees with the subject and the indirect object; see Everett and Kern (1997, 5ff) and Everett (2009b) for more details on the language and this construction in particular).

(45)

```
                              S
          ┌──────────┬──────────┬────────────────┐
      PREDICATOR    VIC      INDIRECT         SUBJECT
          │          │       OBJECT             │
          │          │          │               │
          │          │          │               │
          S       na_jnam_k  'oro narima_k   taramaxicon_j
      ┌───┴────────┬──────────────────┐
  PREDICATOR      VIC          INDIRECT OBJECT
      △            │                  │
   Ma'  co  mao  na_iin_i          Guajará_i
```

In (45) we see an (asymmetrically) embedded sentence, **Ma' co mao** 'who go', in the predicator position of the larger clause **nanam 'oro narima** taramaxicon which is followed by the agreement-tense clitic complex, **nain**, where **na** agrees with an understood masculine subject (not part of the structure) and **in** agrees with **Guajará.** The literal meaning of this most embedded clause is 'Who went to Guajará', where Guajará is the indirect object of the verb **mao**. This is in turn embedded in a larger structure (lacking a verb), 'he-to-them (fem) Chief women'. It means literally 'Who went to Guajará (said) Chief to women'. Though a verb of saying is necessary to the English translation, it is not necessary in the Wari' clause (more on this below). These intentional state constructions are also used to express future tense (even though Wari'

also has future tense morphemes that such constructions are gradually replacing; Everett & Kern (1997)).

Example (46) shows a temporal ISC construction, used to communicate future tense (see the next section) though it has the form of a quotative (Everett and Kern (1997, 55ff) and Everett (2009b)).

(46)   **Cao' xi'   carawa   nana   hwijima'.**

            eat   1pincl:rf   animal   3p:rp/p   children

            'The children will eat food.' (lit: '"We will eat food," the children (say).')

(47)
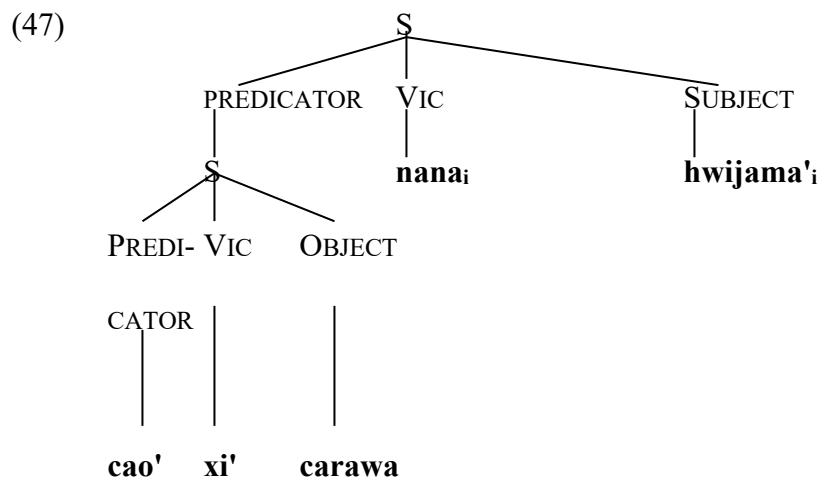
In such examples, the meaning is not compositionally transparent, but is computed based on the speakers' knowledge of Intentional State Constructions. One could of course force the interpretation of (47) to be compositionally transparent by adding a stipulation to Wari' grammar, e.g. "A sentence under the NUC/Predicator position is interpreted as a predicate and no other predicate is allowed." This stipulation allows the speaker to "compose" the meaning from the

syntax in Wari'. But although this works mechanically, it begs the questions of (i) how this language-specific stipulation is learned and (ii) how such stipulations fit into other aspects of temporal interpretation, as in English and Pirahã, etc.That is, in a theory of linguistics in which inference, rather than a series of language-specific components is implicated, such stipulations are unnecessary. Continued exposure to such examples leads to "habits of inference" (Hartshorne and Weiss (1932)) in which nothing further need be stated. The unifying answer is inference - speakers learn and interpret ISCs by induction (going from parts of utterances to the entire utterance) and deduction (having learned a grammar they apply deductive principles to determine that ISCs have a stipulation attached that tells them how to parse the utterance top-down). And the child learning the language begins its learning via inferential principle of Peircean abduction (see section 5) and tests its guesses by induction (to build a theory of the language) and deduction (to use that theory to interpret individual utterances).[20]

Now let us turn back to Pirahã. Just as temporal interpretations are not computationally transparent, neither are recursive interpretations. This is interesting because it reinforces the point that sentence interpretations need not be exclusively computed from the linguistic structure of single sentences. In other words, Pirahãs use inference to learn the unique principles of their grammar and inference to parse and interpret the meanings of their discourse, sentence, word, and other signs. If inference is indeed crucial to the learning of individual languages, beyond the lexicon - e.g. constructions, stipulations, idioms, etc., then all speakers of all languages must use inference to construct their grammars, modulo innate parts. But, again, compositionality is nothing more than the use of linguistic/semiotic knowledge in the inference of meanings, appropriate contexts of usage, grammaticality, and so on. Especially in light of Peirce's (1868) arguments against intuition and introspection as "capacities of man" (see footnote 26 below).

Inference is also important in understanding the relationship between *structures* relating syntax and semantics. Take the inference of meaning from combined sentences in discourse, for example (Peirce (1909); Kamp (2019); Grimes (1976); Givon (2020); Longacre (1976; 1996), and so on. Independent sentences can be interpreted semantically by a formally non-sentence-based compositionality (see especially Peirce (1909) for the original theory that is isomorphic to modern-day Discourse Representation Theory).

To take one example, Sauerland (2018) argues that Pirahã sentences manifest recursion, based on the fact that recursive interpretations are possible for some sequences of linguistic units and his apparent assumption of naive compositionality. His conclusion is that the linguistic units must form a single recursive unit in order to account for the recursive semantics. But this does not follow. Taking his examples (very poorly transcribed, so my own corrections are included) we can see why the point does not follow, owing to lack of compositional transparency.

(48) Spoken by speaker 1 (Toe):[21]

    ce kahápe ogéhiai igeuo

    I go star up

    (This should be: **Ti kahápií Ɂogihíai Ɂigí - o**)[22]

    (I go star alongside-locative)

     "I have been to the stars."

(49) Spoken by speaker 2:

    Toi he gái-sai ce kahápe ogéhiai igeuo

    Toe say first-person-singular have-been stars

(This should be: Tooí hi gái-sai Ti kahápií Ɂogihíai Ɂigí – o)

(proper name he spoke. I go star alongside-locative)

a. co-ordinate interpretation: "Toe talked, and I have been to the stars."

b. subordinate interpretation: "Toe said 'I have been to the stars'. "

Sauerland hypothesizes that there are two interpretations of the sequence of words in (48) and (49): the co-ordinate interpretation in (48) and the subordinate interpretation in (49b). Sauerland further hypothesized that the subordinate interpretation requires syntactic recursion in order to be interpretable as such, where as the co-ordinate interpretation does not require syntactic recursion.[23]

He constructed 10 items like (48) and (49), and a further 10 control items like (50) and (51) where speaker 2 misreports what speaker 1 says:

(50) Spoken by speaker 1 (Toe):

ce kahápe kahe'ai igeuo

I go moon alongside

(This should be: **Ti kahápií kahaiɁaííí Ɂigí – o**)

(I go moon alongside-locative)

"I have been to the moon."

(51) Spoken by speaker 2:

Toi hi gái-sai ce kahápehai heesé igeuo

Toi said "I have been to the sun."

(This should be: **Tooí hi gái-sai Ti kahápihaí hisí Ɂigí – o**)

(Tooí he spoke. I will go sun alongside-locative)

a. co-ordinate interpretation: "Toe talked, and I have been to the sun."

b. subordinate interpretation: "Toe said 'I have been to the sun'. "

Critically, both interpretations of (51) are false. Sauerland then had 16 Pirahã speakers take part in his survey. In this survey, participants were asked to decide whether each of the 20 items were correctly understood by Speaker 2 (specifically, they were asked "Did Speaker B hear well?"). Participants were trained on both versions of one item: they were told that they should say "no" to the control item and they should say "yes" to the target item (like (2)). They were then tested on the remaining 18 items (9 target, 9 control). Sauerland reported above chance behavior on the target items, and concluded that Pirahã contains true syntactic embedding.

There are several problems with (the reader is referred to Everett and Gibson (2019) for more details, which also criticize the design and interpretations of Sauerland's experiments). Most importantly, once again, Sauerland confuses a potential embedded *interpretation* with a need for *syntactic embedding* to obtain that interpretation. In particular, there is no reason to assume that interpreting (54) as "Toe said 'I have been to the stars' " requires any syntactic recursion. As many others have noted in the discussion of recursion, sets of non-embedded syntactic materials can easily give rise to an embedded semantic interpretation, especially if such an interpretation is contextually supported. For example, Hollebrandse (2018) makes exactly this point about English examples like (52), as I do as well in Everett (2010):

(52) Malcolm is guilty. The jury knows that. The judge knows that. (example is from

Hollebrandse, p. 37)

An available interpretation of (52) is that the judge knows that the jury knows that Malcolm is guilty, in spite of the fact that there is no syntactic embedding in this example. And in English, given a context in which someone has just said "I have been to the stars", if a second speaker says "Someone said something. I have been to the stars", most listeners will agree that the meaning of this in the context is that Speaker 1 said that he has been to the stars, even though there was no syntactic embedding in the original statement.

Indeed, this alternative possibility to Sauerland's assumed reading is testable and so Everett and Gibson (2019) report on Gibson's testing of the alternative. Gibson ran the relevant control experiment in English, with 20 participants from Amazon's Mechanical Turk, using the written versions of all 10 of Sauerland's items (as presented in the appendix in his paper), and using the very instructions that Sauerland provided to the Pirahãs ("Did Speaker B hear well?"). Example target and control items are given in (53) and (54).

(53) Example target item:

John: "I have been to the stars."

Bill: John said something. I have been to the stars.

(54) Example control item:

John: "I have been to the moon."

Bill: John said something. I have been to the sun.

Note that there is no syntactic embedding in the written form of what Bill says in each discourse: there is no quotation or embedded sentence. The embedded meaning would have to be inferred because it is not present in the presented syntax.[24] Sauerland's experiments are based on the now-falsified view of naive compositionality.

So where do these interpretations come from? Where do any meaning interpretations come from? Jaszczolt (2009) and Everett (2016) argue that interpretations are pieced together using whatever information is available to the speaker. Notice that if we were to step outside the confines of naive compositionality, we could refer to any piecing together of information (from solving crimes to baking cakes from recipes) as what they are - *inference*. In fact, we might say that the main function of the cerebral cortex (see Rolls 2016; Kortylewski; et. al. 2021; Baroni 2019; Bienenstock, et. al. 1996; inter alia) is to "compose meaning" via inference. As visual compositionality pieces together the visual components of the environment along with learned visual recognition patterns, so linguistic compositionality uses the clues of the linguistic elements to piece together partial meanings but is simply a subtype of Peircean inference (deduction, retro-/abduction, and induction)[25]. As Peirce says:

"*The elements of every concept enter into logical thought at the gate of perception [via signs, DLE] and make their exit the gate of purposive action [interpretation of signs]; and whatever cannot show its passport these gates is to be arrested as unauthorized by reason.*" (Peirce (1903)).

Peirce says that all knowledge, including all linguistic knowledge, is the result of inference. He attacks the idea that there is any special power used for making linguistic judgements, other than inference, rejecting Cartesian intuition and introspection, and was the first American social scientist to demand that research be quantitative and not merely qualitative,

emphasizing replicability and mathematical precision.[26] It is no surprise, therefore, that in recent years several works, e.g. Russell (2012), have argued that statistical inference is crucially implicated in speakers' interpretations of utterance (cf. Lepore and Stone (2013)).

To better illustrate the role of inference relative to naive compositionality, consider the following examples from English:[27] In these examples the grammaticality (or felicity, depending on one's theory) of each example varies depending on real-world and cultural knowledge.

(55)   a. John reported that Mary has COVID-19/is happy.

b. Yesterday, John reported that Mary has COVID-19/?is happy.

*c. Almost a hundred years ago, scientists concluded that the ivory-billed woodpecker is pregnant/happy/flying. (modification of example from Barbara Partee, p.c.)

d. Almost a hundred years ago, scientists concluded that the ivory-billed woodpecker is extinct. (example from Barbara Partee, p.c.)

(56)   a. John claimed that Mary is pregnant.

b. Yesterday, John claimed that Mary is pregnant.

(57)   ?a. Twelve months ago, John claimed/reported that Mary has COVID-19.

*b. Twelve months ago, John claimed/reported that Mary is pregnant.

(58)   a. Twelve months ago, John reported that the elephant is pregnant.

*b. Thirty six months ago, John reported that the elephant is pregnant.

(59)   *a. Two years ago, John reported that his neighbor Tricia is happy.

?b. Two years ago, John reported that the Virgin Mary is happy.

?c. Today, John reported that his neighbor Mary is happy.

d. Two thousand years ago, John reported that the Virgin Mary is happy.

e. Zookeepers who examined Ellie the elephant in the Cincinnati zoo five months ago announced/published that she is pregnant. (example from Barbara Partee, p.c.)

(60)   *a. One thousand years ago, John reported that Bill is his friend.

b. One thousand years ago, John reported that Muhammed is God's prophet.

c. Two thousand years ago, John reported that Jesus is alive.

*d. Two thousand years ago, John reported that Bill is alive.

e. The ancient Egyptians believed that the earth is flat.(example from Barbara Partee, p.c.)

People interpret and evaluate the grammaticality of the sentences above inferentially, via cultural and real-world knowledge, in conjunction with their knowledge of the words and structures of their languages. All of the judgements in (55)-(60) (whether we call the judgements "pragmatics," "semantics," "syntax," or whatever is irrelevant) rely on inferential reasoning. Thus in (60c), Jesus, as an eternal being to some religions, can be alive after a thousand years, while Bill cannot be in a physical sense (though for some he is eternal in heaven). Each of the contrasts in (55)-(60) depend on inference in which the linguistic information is just one part of the final felicity/grammaticality of the example. One might of course argue that compositionality plays its role then submits the result to pragmatics to determine if the constructed meaning fits the context. But there are a couple of problems with this suggestion. First, we must ask why this division is desirable or whether it only arises in order to artificially distinguish compositionality from the general inferential abilities independently known to be possessed by humans (indeed, all animals). Again, cooking by a recipe or solving crimes seem to be abilities that require a power and process of inference identical in operation to the construction of sentence meanings.

The idea that there are only inferences in understanding our native tongues, not some other special capacity (intuition) of the mind, obviously means that no speaker is able to make intuitive judgments about what is grammatical or not, because intuition doesn't exist. We only judge whether something is grammatical or not just as we only judge what something means in the first place - via inference, using one or more of the three "-ductions" - induction, abduction, or deduction. If I ask you if the following sentences are OK, what is the process by which you answer me?

(61) John is three years old and is CEO of a major company.

(62) John are the nicest guy I know.

(63) Talking about Mary, he is a smart woman.

(64) Who do you wonder whether saw John?

(65) Who do you wonder whether John saw?

According to Peirce there is only one answer for any form of reasoning, inference. You (child or adult) know the answer to these questions because you *infer* that it is ungrammatical or grammatical and why based on its comparison to other sentences, using known signs to infer properties of unknown signs (as we have seen, Peirce demonstrates the vacuity of notions like "intuition" and "introspection," replacing them with inference.

But for Peirce the forms of inference are dependent on his theory of signs, his semeiotic. Simply put, Peirce's semeiotic system differs from all others in its stricty triadicity. A sign must have three components (not merely the Saussurian dyadic form+meaning). These are the Object, Interpretant, and Representamen (the form of the sign). So "apple" has the phonemic form

"apple" that varies by dialect and it has as object the red, sweet fruit that we make cider with. But the form and the object can only come together as a sign of some type if they have an interpretant - if they can be interpreted by other signs in the language. In "apple of my eye" the interpretant of apple will be different than in "apple in my eye" and so on. Semiotic inference uses knowledge of linguistic signs and their arrangement (the arrangement is also a sign) and other forms of knowledge in an inferential process built on cultural learning and semiotic principles, such as "closeness in function --> closeness in syntax" (also known as iconicity).

4.3. Compositional transparency and linguistic typology

This leads us to a proposal in Everett (2017) and Barham and Everett (2021), in which it is argued that there is more than one bauplan behind the organization of the individual languages of the world. These language types (which are not exhaustive)are classified according to the relative degree of compositional transparency, i.e. how tight the fit is between the syntax and the semantics. I propose three broad organizational structures and argue that we find examples of all three in the world's currently spoken languages. Only one of these organizational plans might support the compositionality that Szabó (2000) and others assume, however. For the other two types, compositionality is less directly connected to the syntax. The broad language types that I defend here are: a linear order grammar, G_1, (subject-verb-object in (69)) that conveys meaning (Figure 1). G_2 languages, which have hierarchical structures but no recursion (Figure 2), and G_3 languages, which have recursion, as well as all of what G_1 and G_2 languages have (Figure 3) (Everett 2017: Chapter 9). In this hierarchy of grammars, there is no need for a protolanguage in language evolution; a G_1 language is sufficient to convey nuanced, abstract meaning. G_1 languages may evolved first, with recursion a late and unnecessary expectation for early

languages (Karlsson 2009; Everett 2017; 2012a). G1–G3 coexist today with G1 and G2 languages found in some societies without graphic traditions (Everett 2005; Gil 2009; Pullum 2020).[28]

The empirical differences in these three grammars are illustrated diagrammatically using sentences (66)-(68), in Figure 1a–c:

(66) John came in the room. John sat. John slept. (Interpreted as "John came into the room, sat, and then slept.")

(67) John entered the room by the garden. John slept. (Interpreted recursively, as in ())

(68) John came in the room, sat, and slept.

The illustrations in Figure 1a–c conform to a G_1 grammar. In these diagrams, there are no category labels, e.g. "noun" or "verb", and no phrase labels, such as "verb phrase". The simplest grammatical structure would be a linear arrangement of words as a proposition/sentence. There are modern languages represented by G_1 grammars, for example, Pirahã (see also Futrell et al. 2016; Everett 2005; 2009a; Everett and Gibson 2019) but also Warlpiri,Wargamay, Hixkaryána, Kayardild, Gavião and Amele among others (Pullum 2020).

A G_2 grammar would allow the structure in Figure 2 which shows hierarchical nesting of sub-phrases. A G_3 grammar would allow structures such as that shown in Figure 3. Two sentences are contained in or "dominated by" the highest sentence making this a grammar without constraints on recursion. These different grammars can understood as a set of "templates" in the Role and Reference Grammar sense (Van Valin 2001), i.e. there are similar proposals in the literature.

Figure 1 a–c Three diagrams illustrating the linear sentence structures enabled by G1 languages

a

Sentence

John   came   into   the room.

b

Sentence

John   sat.

c

Sentence

John   slept.
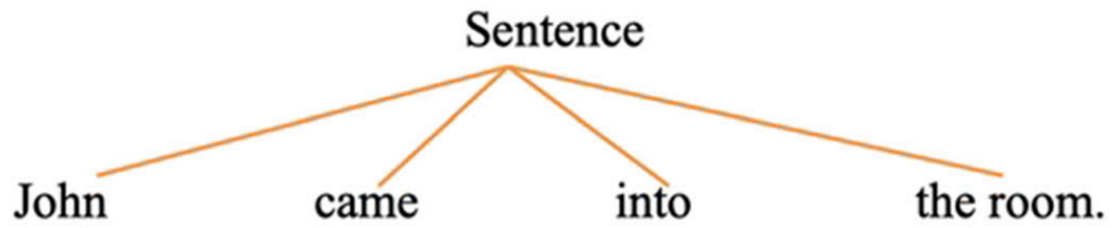
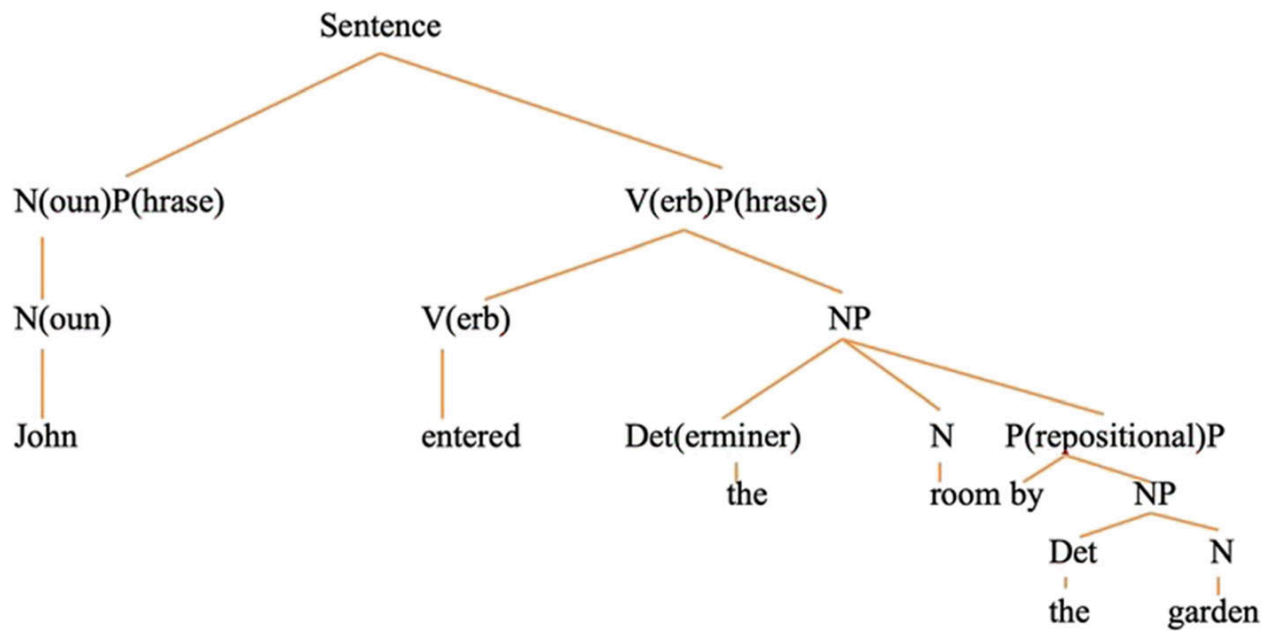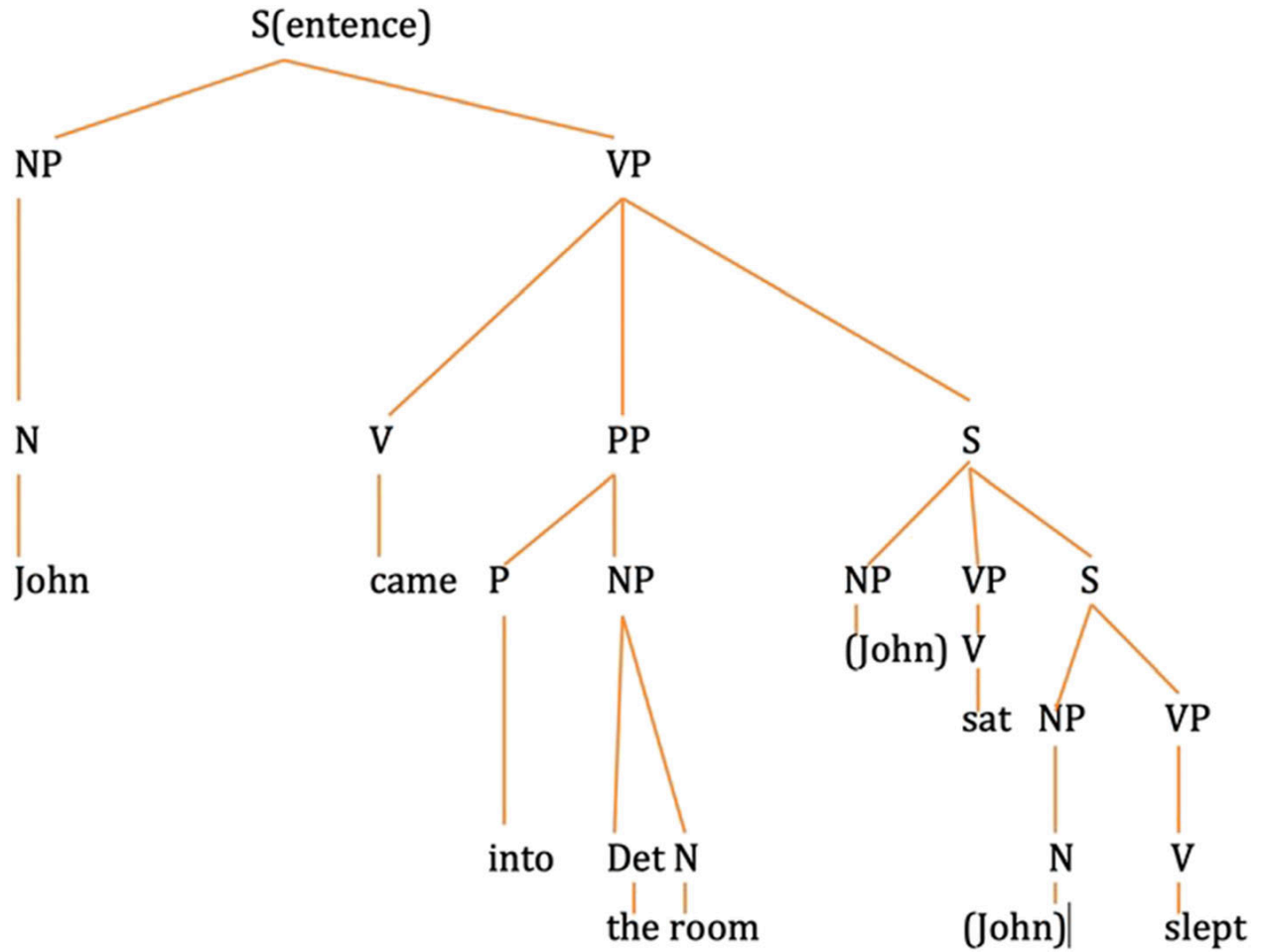Figure 2 An example of the hierarchical nesting of sub-phrases in a G2 language

Figure 3 Diagram of the embedded structure of a G3 language with recursion

These grammar types are hypothesized to reveal the differential degrees of compositional transparency found in languages of the world.

Thus temporality in Pirahã and other languages has much more to teach us about human cognition and the interpretation of language than merely a novel tense system. If there were space, we might further explore how this inference-based account of interpretation can account for a variety of other interesting facts about Pirahã such as the contrast between interpretation of numerical concepts vs. color concepts, the distinction in the language between the absence of quantifiers (of certain types) and generic terms, and so on (cf. Everett (in progress)).

5. Conclusion

5.1. Dark Matter and Culture

The Pirahãs, the Wari's, English speakers, and others know what times are relevant and important in their languages because of their knowledge of the external world, cultural values, the ways in which these values have been encoded into their languages, and the ways that they are learned and applied - all examples of inference. This correspondence between the world, culture, grammar, and meaning also supports the idea that we "get" meanings because of our species' advanced capacity for the general animal ability to infer from one sign (or datum) to another. This raises several additional questions. Setting those aside for now, if this widely accepted process is not wrong, compositionality is but a special form of inference that is applicable once inference has built up a sufficient knowledge of the language to enable the further, more specialized inference from form, culture, real-world knowledge, discourse context, sentence structure, lexical choice, etc. to meaning. Compositionality, a subdomain of inference, is conducted by the same means just in a distinct semiotic domain, i.e. linguistic form (for another semiotic domain, vision, cf. Kortylewski; et. al. 2021; Baroni 2019; Bienenstock, et. al. 1996).

Using culture and inference further answers the question of why any languages have tense marking in the first place and, if so what kinds. After all, if all languages could construct interpretations without tense as Pirahã does, why have tense morphemes or grammatical operations? Because cultures value (Everett 2016) more or less precision in temporal interpretations, precision that is underwritten by a wider array of terms, and constructions. Cultures create tense markings for the same reasons that they create color terms, numerals, and so on - what terms a language has and how it builds them into discourses, the lexicon, sentences, and so on is a matter of cultural values. No special linguistic ability or endowment will in general be necessary. Some cultures value one set of words, others value another.[29] From these terms inferential relations and interpretations are born.

On the other hand, the question of why people appear to have semantic interpretations for absolute tenses in every language known even without tense-marking doesn't seem to be a cultural problem but an issue of universal facts about animal cognition and the relationship of life to the world. Yet even here, we still must learn these tense inferentially.

Another crucial cultural component of time in Pirahã is what Everett (2005) calls the "Immediacy of Experience Principle." Stated informally with regard to time/tense/temporal interpretation, this simply means that as far as temporal semantics goes (see Everett (2005) for more details) Pirahãs do not talk about the distant past or the distant future ("distant" being loosely defined as beyond two generations). They may talk about what their children will be when they grow up, but this is uncommon. They may talk about a time when they had not seen outboard motors, but this is not a distant past and is easily inferrable from the fact that the motors are known to have postdated the arrival of the first missionaries. This is not to say that the Pirahãs have no idea that there will be a distant future or that there is/was a distant past. But they

do not as a rule talk about these. It is similar in this respect to taboos in many cultures (but not in Pirahã) against naming the dead. Or like raising your voice to children in Western culture. These are, as cultural values usually are, violable constraints (in the sense of Everett (2016)), but strong (highly-ranked) constraints nonetheless. This principle may very well have affected the development of the tense system in Pirahã or, vice-versa, may have come into the culture due to the language - as I point out in Everett (2016) the direction of causality in language-culture relations is not always transparent, largely because these two domains form a symbiosis.

5.2. The role of inference

Inference is in a sense the subject to which Peirce devoted his entire research career, across physics, chemistry, mathematics, logic, philosophy (especially pragmatism) and so on. In this sense Peirce is similar to Herbert Simon who dedicated most of his research life (Nobel-Prize-winning economic theory, management theory, cognitive science, computer science, and so on) to problem-solving (a form of inference). Peirce's is careful to emphasize throughout his body of work that there is only one way that humans know anything - inference. Inference for Peirce has three forms (prior to Peirce, only deduction and induction were understood/known):

(69) Deduction:

    1. Rule (major premise)

    2. Case (minor premise)

    3. Result (conclusion)

(70) Example of Deduction:

    All phrases are formed by Merge (major premise/rule)

John's brother's friend is a phrase (minor premise/case)

John's brother's friend is formed by Merge (conclusion/result)

(71) Induction:

1. Result

2. Case

3. Rule

(72) Example of Induction:

John's brother's friend is formed by Merge (result)

John's brother's friend is a phrase (case)

All phrases are formed by Merge (rule)

(73) Abduction:

1. Result

2. Rule

3. Case

(74) Example of Abduction:

John's brother's friend is formed by Merge (result)

All phrases are formed by Merge (rule/guess)

John's brother's friend is a phrase.

We negotiate our paths through life by inference. We either build generalizations (induction), we decompose general ideas into particulars (deduction), or we guess (abduction).[30] New knowledge, as Peirce argued at length, arises primarily via abduction, which he also referred to as "ampliative inference." We guess. Then we make inferences about that guessing

and a combination of induction and deduction will tell us whether our abduction is also on the right track.

Just as Peirce believed that all philosophy and reasoning should be firmly based in mathematical principles, Russell (2012) offers a quantificational theory of inference in certain domains of linguistic knowledge. The avoidance of such quantificational inference in modeling human interpretations of sentences, actions, events, and so on, is done at science's peril (cf. Lepore and Stone (2015)).

Compositionality, then, is that form of inference (any of Peirce's three forms of inference) in which prior knowledge of linguistic units is often necessary, though not sufficient. Prior knowledge is not always necessary because we can use inference to figure out utterances that have foreign words we do not know in them or even entire foreign sentences we have no previous knowledge of (especially in the appropriate contexts).

Of course, in computing the meaning of a sentence, priority will be given to the information contained in the sentences - the words contained and their arrangement. But this particular inferential operation can be overridden by context, by "coercion" (Pustejovsky (1995)) of word meanings, by the introduction of foreign words into the sentence, by implicatures (Grice 1991), and so on. As stated earlier, by way of simple illustration, this is similar to following a recipe, another inferential process. A recipe for biscuits may be followed carefully with the final biscuit the "compositional interpretation" of the recipe. But recipes, like linguistic meanings can be overriden. A given recipe can be altered to fit dietary restrictions, different altitude, extra spice, lack of ingredients, and so on. This is the same operation of inference as interpreting a sentence. The purpose of dwelling on this is to remind us that it is not necessarily the case that linguistic meaning is as special as we might have otherwise thought.

The above discussion is further support for the old claim by Bar-Hillel (1964, 174) that "... the idea of fully automatic high-quality translation (FAHQT) is just a dream which will not come true in the foreseeable future." This is not because we lack understanding of syntax, semantics, pragmatics, or culture, but because our understanding of how to link these types of knowledge (along with psychological states, dialectal variants, diachronic change in progress, i.e. variation, and the like) is presently not widely recognized as *the* problem in linguistics and the cognitive sciences more generally. This is Peirce's problem of *synechism* - understanding the links between all things, that all knowledge is part of a continuum in a non-trivial sense - and it is our job to figure out how the flow of knowledge works within the continuum - imposing secondness as needed to isolate individual portions of that continuum (see Everett in progress; among many others). Serious and interesting attempts to address this issue in a formal way do exist, however (beyond efforts like Russell (2012)). For example, the work by Gibbon and Griffiths (2017), Zaslavsky, Hu, and Levy (2020), Frank and Goodman (2012), all provide promising analyses and testings of the inference problem going beyond the standard considerations of compositionality found in mainstream linguistics). Everett (2016) discusses more such problems of compositionality and inference, as well as their philosophical, psychological, anthropological, computational, linguistic, and historical roots.

As we approach a quarter-century into the Second Millenium C.E. it is occasionally disheartening to see how little progress linguistics, for example, has made in solving the inference problem - the foundational problem of the field. But one finds optimism in the knowledge that attempts are becoming more numerous.

5.3. Back in Time

After this discursus on inference we come back to time in the world's languages and, in particular, in Piraha. The case of time in Piraha is, as a review of the papers of this volume will quickly show, not all that unusual. In every temporal system there are well-specified constraints on temporal interpretation and semantics provided by the morphosyntax. In English we have John *is* running vs. John *ran* where the mapping is close to one-to-one between temporal morphosyntax and semantics. But we also have expressions such as John *used to* run, in which the habitual aspect is indicated periphrastically/idiomatically. And then we have things like Sun shinin' I'm travelin', in which no tense is marked, though one can interpret this as a statement of habit or future intent, depending on the context. It is constructions like this that illustrate best perhaps the use of inference in English temporal semantics, what Peirce would call the "interpretant."

The point of this paper has been to focus on these latter types of constructions, inferentially interpreted constructions, and show that they are the most common type of temporal interpretation in languages like Piraha. This Peircean perspective of semantic interpretations as inferential takes compositionality to be a special case of inference, in which the syntax bears a heavier burden in the determination of the meaning of the linguistic unit. Temporal systems like Piraha's are thus of special interest to theories of understanding time in human language because in them general inference (cultural inference in particular) is the unmarked case, as opposed to the role of the special form of inference, compositionality, that seems to be the unmarked case in many, perhaps most, other languages.

References

Amaral, Luiz, Marcus Maia, Andrew Nevins,and Tom Roeper, eds. 2018. *Recursion across domains*. Cambridge: Cambridge University Press.

Barham, Larry and Daniel Everett. 2020. "Semiotics and the Origin of Language in the Lower Paleolithic," *Journal of Archaeological Method and Theory* (online).

Bar-Hillel, Yehoshua. 1964 [1960]. "A Demonstration of the Nonfeasibility of Fully Automatic High Quality Translation." in Y.Bar-Hillel: *Language and information*. Addison-Wesley, Reading, Mass. 1964. p.174-179.

Baroni, Marco. 2021. "Linguistic generalization and compositionality in modern artificial neural networks," *Philosophical Transactions B*, Royal Society Publishing.

Bienenstock, Elie, Stuart Geman, and David Potter. 1996. " Compositionality, MDL priors, and object recognition," *Proceedings of the Conference on Neural Information Processing*, pp. 838-844.

Bisang, Walter. 2013. "Chinese from a Typological Perspective." *Human Languages and Linguistic Typology*, *Papers from the Fourth International Conference on Sinology*. Taipei, Academia Sinica.

Comrie, Bernard. 1985: *Tense,* Cambridge University Press.

Davidson, Donald. 1967. "The logical form of action sentences", In: Nicholas Rescher (ed.) *The Logic of Decision and Action,* pp. 81-95, University of Pittsburgh Press.

Declerck, Renaat. 1991. *Tense in English.* Routledge, London.

Dowty, David. 2007. "Compositionality as an Empirical Problem," In: Chris Barker and Pauline I. Jacobson (eds.), *Direct Compositionality*, Oxford University Press, pp 14-23.

Everett, Daniel L. 1983. *A Lingua Pirahã e a Teoria da Sintaxe*, Sc.D. dissertation, Universidade Estadual de Campinas.

Everett, Daniel L. 1986. "Pirahã", In: Desmond Derbyshire & Geoffrey Pullum (eds.) *Handbook of Amazonian Languages* I, Mouton de Gruyter, Berlin, 200-325.

Everett, Daniel L. 1993. "Sapir, Reichenbach, and the Syntax of Tense in Pirahã," *Pragmatics & Cognition* 1:1, 89-124.

Everett, Daniel L. 2005. 'Cultural Constraints on Grammar and Cognition in Pirahã: Another Look at the Design Features of Human Language,' a CA article in *Current Anthropology* 76: 4, 621-64.

Everett, Daniel L. 2009a. 'Pirahã Culture and Grammar: A Reply to Some Criticisms.' *Language.* 85, 2: pp 405-442. 10.153/lan.0.0104.

Everett, Daniel L. 2009b. 'Wari' Intentional State Construction Predicates,' In: Robert Van Valin (ed.), *Investigations of the Syntax-Semantics-Pragmatics Interface*, John Benjamins Publishing Company, Amsterdam.

Everett, Daniel L. 2010. "You Drink. You Drive. You Go to Jail. Where's Recursion?" *Lingbuzz*. lingbuzz/001141

Everett, Daniel L. 2012a. *Language: The Cultural Tool*, Pantheon Books (Random House USA) and Profile (UK).

Everett, Daniel L. 2012b. 'What does Pirahã Have to Teach Us About Human Language and the Mind?' *WIREs Cogn Sci*. doi: 10.1002/wcs.1195.

Everett, Daniel L. 2016. *Dark Matter of the Mind: The Culturally Articulated Unconscious,* University of Chicago Press.

Everett, Daniel L. 2017. *How Language Began: The Story of Humanity's Greatest Invention,* Liveright Publishers.

Everett, Daniel L. 2019. "The American Aristotle," *Aeon Magazine***.**

Everett, Daniel L. 2020, "O Papel da Cultura na Língua e na Cognição," *50th Anniversary Edition of the Proceedings of ABRALIN* (Brazilian Linguistics Association), ABRALIN Press, São Paulo, Brazil).

Everett, Daniel L. In Progress. *Peircean Linguistics: A Chapter in the History of Empiricist Thought*, Oxford University Press.

Everett, Daniel L. and Edward Gibson. 2019. Review of *Recursion Across Domains. Language*, Volume 95, Number 4, December 2019, pp. 777-790

Everett, Daniel L. and Edward Gibson. 2020. "Semantics requires knowledge of meaning: A reply to Rodrigues" *Lingbuzz*. https://ling.auf.net/lingbuzz/005060

Everett, Daniel L. and Barbara Kern. 1997. *Wari': The Pacaas Novos Language of Western Brazil,* Routledge Descriptive Series, London.

Floyd, Simeon. 2016. "Modally Hybrid Grammar? Celestial Pointing for Time-of-Day Reference in Nheengatu," *Language*, 92, 1.

Fodor, Jerry A. and Ernest Lepore. 2002. *The Compositionality Papers*. Oxford University Press, Oxford.

Frank, Michael C. and Noah D. Goodman. 2012. "Predicting Pragmatic Reasoning in Language Games," Science, Volume 336, May 2021, 998.

Frege, Gottlob. 1892, "On Concept and Object", *Vierteljahrsschrift für wissenschaftliche Philosophie*, 16: 192–205, Peter Geach (trans.), 1952, *Translations from the Philosophical Writings of Gottlob Frege*, Oxford: Blackwell, pp. 42–55. Reprinted in Frege 1984: 182–194.

Frege, Gottlob. 1984, *Collected Papers on Mathematics, Logic, and Philosophy*, Brian McGuiness (ed.),
Oxford: Blackwell.

Gayral, Françoise, Daniel Kayser, François Lévy. 2006. "Challenging the Principle of Compositionality
in Interpreting Natural Language Texts," E. Machery, M. Werning, G. Schurz, eds. *The
Compositionality of Meaning and Content*, vol II,, ontos verlag, pp.83–105, 2005, applications to
Linguistics, Psychology, and Neuroscience.

Gibbon, Dafydd and Sascha Griffiths. 2017. "Multilinear Grammar: Ranks and Interpretations." Open
Linguistics, 3: 265-307.

Giorgi, Alessandra. 2010. *About the Speaker: Towards a Syntax of Indexicality*. Oxford Studies in
Theoretical Linguistics, Oxford University Press, Oxford.

Givon, Tom. 2020. *Coherence*. John Benjamins, Philadelphia, PA.

Grice, Paul. 1991. *Studies in the Way of Words*. Harvard University Press, Cambridge, MA.

Hall, Edward T. 1973 [1959]. *The Silent Language*. Anchor Books.

Hall, Edward T. 1976. *Beyond Culture*. Anchor Books.

Hall, Edward T. 1990. *The Hidden Dimension*. Anchor Books.

Hartshorn, Charles and Paul Weiss, eds. 1932. *Collected Papers of Charles Sanders Peirce*, Harvard
University Press, Cambridge, MA.

Higginbotham, James. 1985. 'On semantics', *Linguistic Inquiry* 16:4, 547-594.

Hornstein, Norbert. 1990. *As time goes by: tense and universal grammar,* MIT Press, Cambridge, MA.

Hollebrandse, Bart. 2018. "Indirect Recursion: The Importance of Second-Order Embedding and Its
Implications for Cross-Linguistic Research." In Amaral, et. al. 35-47

Jacobson, Pauline. 2014. *Compositional Semantics: An Introduction to the Syntax/Semantics Interface*.
Oxford Textbooks in Linguistics. Oxford University Press, Oxford.

Janssen, Theo M.V. 1997. "Compositionality," In: J. Van Benthem and Alice Ter Meulen, eds. *Handbook of Logic and Language*, MIT Press, Cambridge, MA.

Jaszczolt, K.M. 2009. *Representing Time: An Essay on Temporality as Modality*. Oxford University Press, Oxford.

Jaszczolt, K.M. 2005. *Default Semantics: Foundations of a Compositional Theory of Acts of Communication*. Oxford University Press. Oxford.

Kamp, Hans. 2019. "Tense and Aspect in Discourse Representation Theory," In: Robert Truswell (ed.), *The Oxford Handbook of Event Structure*, Oxford, UK.

Karlsson, F. (2009). Recursion and iteration. In H. van der Hulst (Ed.), *Recursion and Human Language* (pp.43–68). Berlin: Mouton de Gruyter.

Kortylewski, A J He, Q Liu, C Cosgrove, C Yang, and AL Yuille. 2021. "Compositional Generative Networks and Robustness to Perceptible Image Changes," *55th Annual Conference on Information Sciences and Systems* (CISS), pp1-8

Leder, Harry. 1991. *Tense and temporal order,* unpublished Ph.D. dissertation, Depart- ment of Linguistics, Massachusetts Institute of Technology, Cambridge, MA.

Le Guen, Olivier and Lorena Ildefonsa Pool Balam. 2012. "No Metaphorical Timeline in Gesture and Cognition Among Yucatec Mayans," *Frontiers in Psychology*.

Lepore, Ernie and Matthew Stone. 2015. *Imagination and Convention: Distinguishing Grammar and Inference in Language.* Oxford University Press, Oxford.

Longacre, Robert E. 1976. *An Anatomy of Speech Notions*. Peter de Ridder Publications in Tagmemics.

Longacre, Robert E. 1996. *The Grammar of Discourse*. Springer, New York.

Montague, Richard. 1974. "The proper treatment of quantification in ordinary English", In: Richmond Thomason (ed.) *Formal philosophy: selected papers of Richard Montague,* Yale University Press, New Haven, CT.

Partee, Barbara H. 1995. "Quantificational Structures and Compositionality," In: Emmon Bach, Eloise Jelinek, Angela Kratzer, and Barbara H. Partee, eds., *Quantification in Natural Languages,* Kluwer Academic Publishers, Dordrecht, pp541-601.

Peirce, Charles S. 1865. Harvard Lecture 1, (MS 94) (Writings of Charles S. Peirce 1, 162-175)

Peirce, Charles S. 1868. "Questions Concerning Certain Faculties Claimed for Man,"*Journal of Speculative Philosophy* 2, pp. 103-114.

Peirce, Charles Sanders (1903). "Harvard Lectures on Pragmatism, Lecture VII." (In: Hartshorne and Weiss 1932.

Peirce, Charles Sanders (1909). "Manuscript 514." Transcribed by Michel Balat with commentary by J. F. Sowa. http://www.jfsowa.com/peirce/ms514.htm (accessed 15 November 2009).

Pelletier, Francis Jeffry. 1994. "The Principle of Semantic Compositionality," *Topoi*, 13:11-24.

Pietarinen, Ahti. 2005. "The Compositionality of Concepts and Peirce's Pragmatic Logic," In: E. Machery, M. Werning and G. Schurtz, eds., *The Compositionality of Concepts and Meanings: Foundational Issues*. Ontos

Polanyi, Michael. 1974. *Personal Knowledge: Towards a Post-Critical Philosophy*, Universityof Chicago Press, Chicago.

Polanyi, Michael. [2009 (1966)]. *The Tacit Dimension*, University of Chicago Press, Chicago.

Prosser, Simon. 2016. *Experiencing Time*. Oxford University Press, Oxford.

Pullum, Geoffrey K. 2020. "Theorizing About the Syntax of Human Language: A Radical Alternative to Generative Formalisms," *Cadernos de Lingüística*, Abralin. Doi: 10.25189/2675-4916.2020.V1.N1.ID279.

Pustejovsky, James (1995). *The Generative Lexicon*. Cambridge, MA: The MIT Press.

Reichenbach, Hans. 1947. *Symbolic logic,* Macmillan, New York, NY.

Reichenbach, Hans. 1956. *The Direction of Time*. University of California Press, Berkeley, CA.

Rodríguez, Lydia. 2014. *Time in Language, Gesture, and Thought: A Case Study in Chol Mayan*. unpublished PhD dissertation, University of Virginia.

Rodríguez, Lydia. 2019. "Time is *not* a Line. Temporal Gestures in Chol Mayan," *Journal of Pragmatics*, pp1-17.

Rolls, Edmund T. 2016. *Cerebral Cortex: Principles of Operation*. Oxford University Press, Oxford.

Russell, Benjamin. 2012. *Probabilistic Reasoning and the Computation of Scalar Implicatures*, unpublished PhD dissertation, Brown University.

Sapir, Edward. 1921. *Language,* Harcourt, Brace, & Co, New York.

Sapir, Edward. 1931. 'Conceptual categories in primitive languages,' *Science,* 74:578.

Sauerland, Uli. 2018. False Speech Reports in Pirahã: A Comprehension Experiment. In: Amaral, et. al. 21-34.

Steedman, Mark. 1997. "Temporality," In: J. Van Benthem and Alice Ter Meulen, eds. *Handbook of Logic and Language*, MIT Press, Cambridge, MA.

Stjernfelt, Frederic. 2014. *Natural Propositions: The Actuality of Peirce's Doctrine of Dicisigns. Docent Press.*

Szabó, Zoltán Gendler. 2000. *Problems of Compositionality*. Routledge. New York.

Van Valin, Robert D. 2001. *An Introduction to Syntax*, Cambridge University Press, Cambridge, UK.

Whorf, Benjamin L. 1956a. "The relation of habitual thought and behavior to language', In: John B. Carroll (ed.) *Language, Thought, and Reality: Selected Writings of Benjamin Lee Whorf,* pp. 134-159. MIT Press, Cambridge, MA.

Whorf, Benjamin L. 1956b. "A Linguistic Consideration of Thinking in Primitive Communities", In: John B. Carroll (ed.), *Language, Thought, and Reality: Selected Writings of Benjamin Lee Whorf,* pp. 134,.159. MIT Press, Cambridge, MA.

Zaslavsky, Noga, Jennifer Hu, and Roger P. Levy. 2020. "A Rate-Distortion view of human pragmatic reasoning," arXiv:2005.06641v1 **[cs.CL]**

Xigábaí almost bitten by snake

Told by **Xahoápati** to Dan Everett ca.

2000

Xaí	**ti**	**ig**	**-a**	**-í**	**apaí.**
Thus.	1person	comit.	-sound	-proximate	first (literally 'head')

'*So I spoke at first.*'

Xigábaí	**gí**	**basí**	**ig**	**-a**	**-b**	**-o**
Xigábaí	2person	bed	comit.	do.	-down	-direct

-p	**-a**	**-p**	**-í**
-up	-vertical	-up	-proximate

'*Xigábaí was bringing your bed back up.*'

Xís	**ib**	**-á**	**-i**	**-ta**	**-a**	**-b**
animal		hit	-vertical	-proximate	-repetive	-down

-o	**-i**	**-haí**	**tigaiti.**	direct	-transition	-rel:cert	snake

'*He arrowed the snake a couple of times.*'

Xís	**a**	**-xáa**	**-há.**	animal	bite	-intelic	-comp:cert	'*The snake bit (at him).*'

Xaí	Toítoí	hi	xigí	-a	-xáa	-i
Thus		Toítoí	3person	comit.	-bit	-intelic	-proximat

-há.

comp:cert.

'Thus Toítoí with (him) it bit at (also).' Hi   agíai tigaiti -gíi   xibigaá.

3person   thus   snake -real   direct observation:be (bushmaster)

'Thus it was a real snake, a bushmaster, they saw.'

Tigaiti -gíi   xaí.   Xis   ib   -á   -i

snake -real   thus   animal hit   -vertical   -proximate

-ta   -b   -og   -aáti.

-repetitive   -down -desiderative -uncert/imperative

'It is a bushmaster. Shoot it!'

Hi   agía   xogi -áaga -ó

3person   thus   big   -be   -directional

xis   aihi   og   -a   -á   -a

animal that:one   want   -find -intense   -vertical

-b   -ó   -p   -a   -p   -á.   Xaí   tigaiti.

-down -direct -up   -remote   -up   -comp.cert   thus   snake. *'Thus the bulk*

of the people wanted to search carefully down on the ground. Thus (for that) snake.'

Ti   agía   xis   igí   -o

1person   thus   animal   comit. -directional

k   -á   -ab   -ó   -p   -á

object -intensely   -bite -direct -up   -vertical

-p   -á   -xaí.

-up   -vertical   -do

'(When I was) with the animal, (it) struck up (at me).'

Ti   ig   -áí   -sai.

1person   comit. sound -old:info

xi   ab   -áo   -p   -í   -saxáa

3person   bite   -telic   -up   -proximate   -frustrated:event

-g   -abaga   -á.

desiderative   frustrated:initiation -complete certainty

'I spoke (as I have been doing). It almost bit him, almost wanted to.'

Xiabáísi   k   -á   -ab   -o   -ó

human:being object -intensely   -bite   -direct -directional

-p   -a   -i   -hiab   -i

-up   -vertical   -proximate   -negative   -transition vowel

-só   -(a)i.   Xáihá.

-telic- -do   thus.

'*Thus, it (the bushmaster) didn't bite the human being (upwards and viciously).'*

Xi   go   -ó   -i   xa   -ó   -o

3person   -focus -locative   -proximate   bite   -direction   -direct

-p   -á   -a   -ha   -xaí.

-up   -intense   -vertical   -comp:cert   -do

'He was there (almost) bitten?' (It was there that he was almost bitten)

Xi   go   -ó   -i   xa   -ó   -o

3person   -focus -locative   -proximate   bite   -direction   -direct

-p   **-á.**

-up   -intense

'He was there (almost) bitten.

xoí   **hi**   **aí**   **-si**   **-xíga.** environment 3person is

       -old:info   -emphatic *'It was there in the jungle.'*

Xigábaí   **hi**   **aa**   **-b**   **-áo**   **-b**

Xigábaí   3person   bite   -down -telic   -perfective

-íi   **-sa**   **-xá**   **-abaí.**

-intentive   -old:info   -intensive   -frustrated completion

'(The snake) almost bit Xigábaí, as we have been saying.'

Xigábaí   **hi**   **áa**   **-b**   **-o**   **-ó**   **-p**

Xigábaí   3person   bite   -down   -direct -locative   -up

-ái   **-hiab**   **-sói**   **-xáihi.**

-do   -negative   -doubt   -declarative

'(The snake) barely didn't bite Xigábaí.' Quase medo.

(Port) 'Almost afraid.'

Notes

---

[1] I would like to think Kasia Jaszczolt for her invitation for me to participate in the workshop Understanding Human Time and to all the participants for their individual research and for the many who commented on what follows. The Zoom format had the advantages of keeping the workshop green and the discussions up close and personal.

[2] This chapter borrows and paraphrases frequently from Everett (1993).

[3] Pirahã is a language of the Brazilian Amazon, the only surviving member of the Mura language family (Loukotka 1968).

[4] Note that my claim is not that I am the first to notice the long-known fact that real-world knowledge influences semantic and pragmatic interpretations. Rather I use this observation to urge a different conception of the nature of this influence, as inference rather than as purely a linguistic principle.

[5] Pirahã is a "tenseless language" in the sense of Comrie (1985, 50ff): languages "...where time reference per se is not grammaticalized...", i.e. where there is time reference but it is not reflected morphosyntactically.

[6] The reader is urged to consult more cross-linguistic work on temporal semantics of less-studied languages, e.g. Dr. Lydia Rodriguez on temporal representation in the Mayan language Chol (Rodriguez (2019)), Simeon Floyd (2016) on Nheengatu (Brazilan creole language), and my own work (Everett and Kern 1995) on Wari'.

[7] More data is available from the MIT corpus of Pirahã texts: https://osf.io/kt2e8/

[8] From this point on, I will give on free translations and skip morpheme-by-morpheme glosses, unless these are crucial for a particular point about time.

[9] That is, as per Everett (1993), in a Reichenbachian system these can all be generated by orderings of the coordinates **E** 'event time' and **S** 'moment of speech.'

[10] As we see, a sentence may be semantically hypotactic to another without being syntactically subordinate.

[11] This section borrows heavily from Everett (1993), simply repeating some of what was given there and rewriting those portions where my opinion/analysis has changed.

[12] The SOT rule is provided here for completeness' sake in presenting Hornstein's (1990) adaptation of Reichenbach's system and is not crucial to the argumentation.

[13] For some speakers this example is fine. In that case "at this very moment" must be interpreted as non-literal.

[14] Paul Postal comments on this section (p.c.) that in Arc Pair Grammar it is possible to treat discourses as sentences, via "overlapping arcs." He says:

> *"Now, suppose we apply that view of anaphora to Pirahã's purported lack of embedding with one further assumption. Assume that so-called discourses are not different from sentences, just are one specific type of sentence. Think of coordination as involving neighboring arcs 1….n, each with the label 'Coordination', while discourses involve neighboring arcs 1…n with the label 'Discourse'. And then assume that Pirahã temporal sequences are just such discourse sentences... The point then is that under the assumptions above, the representation of the Pirahã examples do involve syntactic embedding. This is not an ad hoc assumption to achieve some result about the example, but is simply a consequence of (i) the treatment of anaphora as in Johnson and Postal (1980) plus (ii) the assumption the discourses are/can be single sentences."*

But of course the problem with doing away with discourse as Postal suggests in this case, is that discourse is a separate domain of which sentences are constituents and is marked by non-

sentential particles, coherence, topic-marking, and many other of the facts that have emerged in the vast discourse literature over the years. Moreover, the view that discourse is just a large sentence (not uncommon unfortunately) cannot account for the Pirahã facts or the myriad other aspects of discourse grammar, as many of the works referred to this paper are at pains to demonstrate.

[15]   However, superficially there may appear to be counterexamples to the claim that Pirahã lacks perfect tenses, represented in (i). Such examples might superficially look like perfect tense:

(i)   **Kaoáíbógí   ?ab   -o   -óp   -ai   -ta   -ha   -ó.**

jungle entity   remain-stem   -go   -atelic   -repeat-comp.cert.   -position

Gíxai   soxóá   koho -ái   -p   -á   -há

you   already   eat   atelic   -vert/imp   -remote   -compl. cert.

"The jungle entity completely returned. You already ate."

*"When you arrived I had eaten."

Example (i) does not express a perfect tenses. Nor is a perfect reading found in either the literal translation or in the most common usage of the Pirahãs. Very similar structures are found in other languages with similar aspectual markings and do not entail perfect tense readings (e.g. Chol, Lydia Rodriguez, p.c.).

And indeed in Everett (1993) I deny that this structure type has a perfect reading. On the other hand, I have not yet conducted experiments on such readings with native speakers. Therefore I cannot rule out the possibility that (i) might be used as the closest equivalent to a past perfect example for some speakers. Similar examples could exist for future and present perfects, though they are, like (i), translations of independent clauses without overt tense marking. I doubt

that this is the case, but, again, experimental work is needed. Of course, if these did receive

perfect tense translations, this would present a problem for my 1993 analysis that Pirahã lacks

the R reference point for temporal interpretations since this point is required for a perfect tense in

the Reichenbachian system. But they do not seem to have perfect tense interpretations.

[16] Once again, like most researchers of his era and the modern era, unlike Peirce, Frege's view of

language was sentence-bound. In Everett (in progress), I suggest that this is because of the

centrality of the proposition, often expressed by a single sentence in natural language, to much

philosophy of language and mind. But as Stjernfelt (2014) and others make clear, propositions

can be expressed perfectly clearly external to language.

[17] It might sound strange to say that Kamp's Discourse Representation Theory is sentence-bound.

In several ways it clearly is not sentence-bound. But it lacks any account of the standard features

of discourse that, say, Longacre (1983; 1976), Grimes (1976), inter alia). Thus it extends

sentence principles across sentence boundaries, but omits vital characteristics that distinguish

discourse and justify not treating those boundaries as insignificant. Discourse is not a mere set of

conjoined sentences.

[18] By the expression "modulo culture" I mean that cultures have different rankings of time values

and their relevance (see Everett 2017). Thus their understandings of what a "long" time or a

"distant" time will vary, among other aspects of the mapping between temporal ontology

(Steedman (1997)) and linguistic meaning.

[19] Consider in this regard the wind blowing the weather vane to the west when it is blowing in

from the east. The configuration/movement of the weather vane expresses the proposition "The

wind blows westward" nonlinguistically but fully semiotically (showing that linguistics is but a

subspecies of semiotics).

[20] This does not rule out a role for innate knowledge. This paper does not take on that larger issue. But innate knowledge is used inferentially like any other knowledge (for Peirce innate knowledge is phylogenetic learning while non-innate is ontogenetic learning, though he was relatively agnostic on the amount, if any, of the former in human cognition). On the other hand, I have argued elsewhere, e.g. Everett (2012; 2016) there is very little, if any, convincing evidence for nativist, rationalist beliefs on the acquisition of knowledge.

[21] Sauerland does not speak the language at all and hence does not represent the phonetics accurately, thus also unwittingly omitting much grammatical information from his transcriptions.

[22] The reason that I constantly make the effort to correct the "mere phonetics" of data collected by people without any speaking knowledge of Pirahã, as I have been asked on multiple occasions, is not to make these researchers look sloppy (though that is indeed an effect), but because as any field researcher knows, without careful phonetics, one is shooting blind in what he or she considers relevant or even perceptible in the syntax. All field workers understand that every statement on the grammar of a given language ultimately rests on a solid phonetic foundation or it is of little worth.

[23] It is worth mentioning that it is a category mistake to confuse embedding with recursion. One does not imply the other. Even if, for example, it could be shown that a language has embedding, this does not entail that it has recursion.

[24] Our English participants agreed with the target sentence on 99% of the trials, demonstrating that they obtained the embedded interpretation in spite of the lack of embedded syntax. Furthermore, they disagreed with the control (as desired) on 98% of the trials. All materials are available at osf.io/z86k2/.

[25] Clearly, as the works cited make clear, our inferential abilities are underwritten by the structures of our brains.

[26] Peirce (1868), argues at length that there is no such thing as intuition, a central part of the cognitive research of Descartes and many linguists (e.g. Chomsky). Defining intuition as a cognition unlinked to a previous cognition, Peirce concludes that no such cognitions exist and that all cognition is part of a chain of inference with other cognitions. He claims that the only evidence for intuition is that we think we have it. To this dubious claim he replies:

"A child has, as far as we know, all the perceptive powers of a man. Yet question him a little as to *how* he knows what he does. In many cases, he will tell you that he never learned his mother tongue; he always knew it, or he knew it as soon as he came to have sense. It appears, then, that he does not possess the faculty of distinguishing, by simple contemplation, between an intuition and a cognition determined by others [which would be an inference, DLE]."

[27] Different authors mark some of these examples as pragmatic infelicities or grammaticality violations (see Giorgi (2010) for example). It isn't clear that such distinctions are relevant if we recognize all interpretations as forms of inference.

[28] Perhaps a more workable definition of compositionality in light of the above discussion is that of Pietarinen's (2005, 525ff) "Pragmatic Principle of Compositionality (PPC)":

  (i)   "The meaning of a sentence is the meaning of all sentences that follow from that sentence either by inductive or deductive principles and permissions under all authorized circumstances (i.e., those arising out of mutual consent by [the interlocutors, DLE]." Pietarinen (2005, 525ff)

     But this would still be a subtype of inference. And it also fails to account for the greater amount of information found entirely outside of sentences, as per Jaszczolt (2009).

[29] For example, my subculture does not value golf. My male relatives considered golf a "sissy" sport and any man who played it was not quite a real man. So growing up in such a culture, I have no terms (and I never left those cultural confines in this respect) for golf. I do, however, know a lot of words about cattle and the raising of them, since this was a respectable male activity in my upbringing.

[30] Peircean abduction (and Peirce is the originator of the term) is not to be confused with more recent bastardization of the term to mean "inference to the best explanation," which needs a separate term.

[31] This appendix is included so that the interested reader can trace temporal interpretations through a text in Pirahã to better exemplify temporal readings in context.