Invention and Community in the Emergence of Language: Insights from New Sign Languages

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The interplay of biological and cultural evolution

We seek insights into our prehistory by analyzing two new sign languages

- Nicaraguan Sign Language (***NSL***): developed in just 25 years within a community of deaf Nicaraguans
- Al-Sayyid Bedouin Sign Language (***ABSL***): developed in 70 years in a community of deaf and hearing Bedouin

Our focus:

- Understanding the tradeoff between innate capabilities and social influences in the emergence of NSL and ABSL
- to ground an understanding of how these modern social influences may differ from those available to early humans at the dawn of language

A Brief History of Nicaraguan Sign Language (NSL)

Before the 1980s:

- Deaf Nicaraguans had little contact with each other
- Children developed home sign within their families, but these varied widely
- No sign language emerged.

In the 1980s:

- A vocational school for the deaf opened in 1981 in Managua.
- Instruction was conducted in Spanish, with minimal success.
- The children began to develop a new, gestural system for communicating with each other – in part by consolidating the different home signs each had developed. The gestures soon expanded to form a rudimentary sign language

As the years passed, the early collection of gestures developed into an expressive sign language, Nicaraguan Sign Language (NSL)

While NSL is the first language for today's deaf children in Nicaragua, it is not quite a native language, since they start learning NSL when they enter school at age 6 or younger.

A Brief History of Al-Sayyid Bedouin Sign Language (ABSL)

The Al-Sayyid Bedouin group, in the Negev region of Israel, are descendants of a man who arrived 200 years ago from Egypt and his wife, a local woman.

The group, now in its seventh generation, contains about 3,500 members, residing in a single community with frequent consanguineous marriages

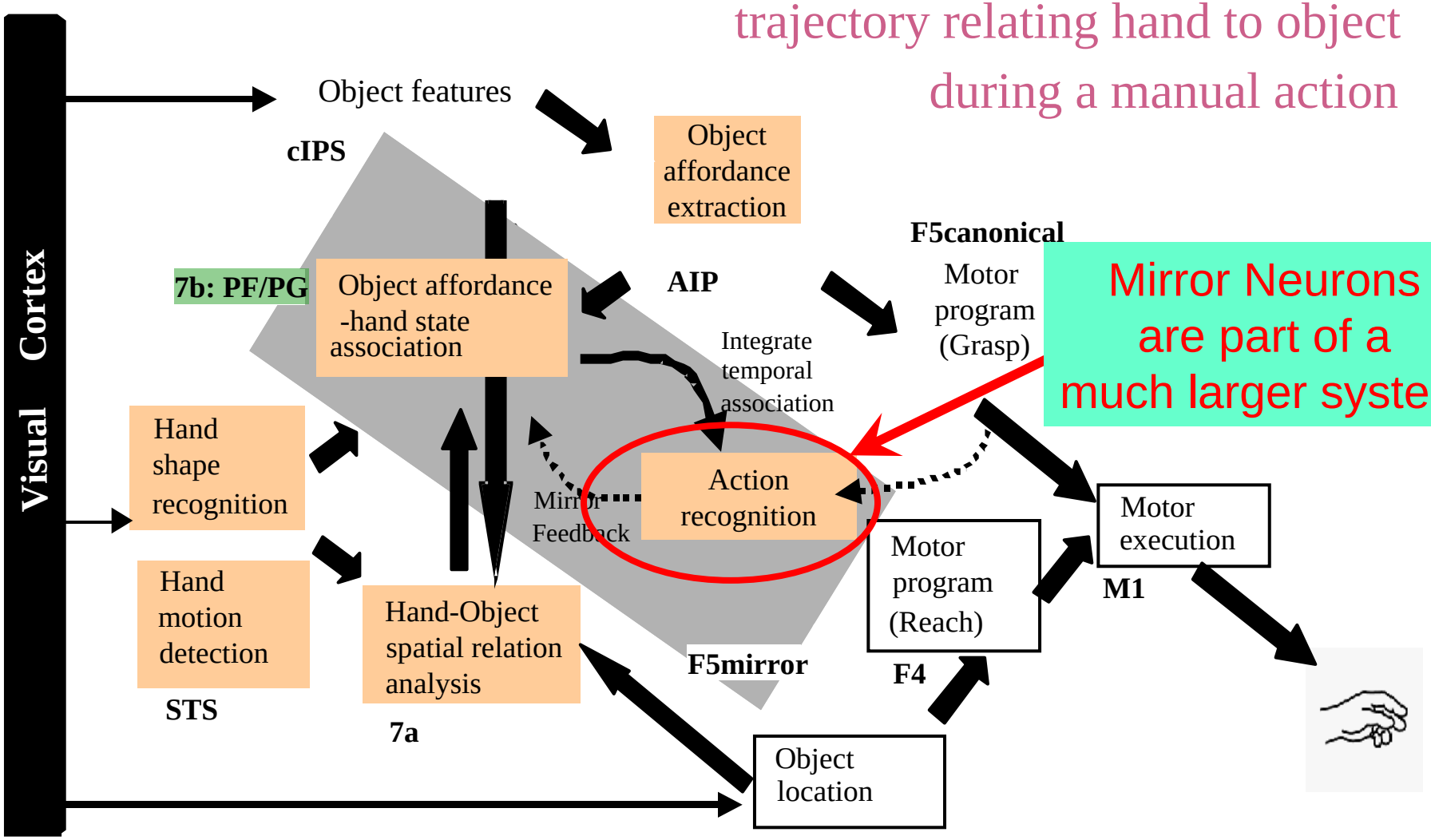
- There are now about 125 congenitally deaf individuals distributed throughout the community, all descended from two of the founders' five sons
- All deaf individuals show profound neurosensory hearing loss and are of normal intelligence.

Unlike the deaf in Nicaragua, the deaf members of the Al-Sayyid Bedouin community are fully integrated into its social structure

- Not only the deaf members of the community but also many of its hearing members communicate by means of the sign language
- ABSL is a second language of the village with each deaf infant born into an environment with adult models of the language available to them

MNS Model of the Mirror System (Oztop & Arbib 2002)

Key idea: Learning to recognize the trajectory relating hand to object during a manual action

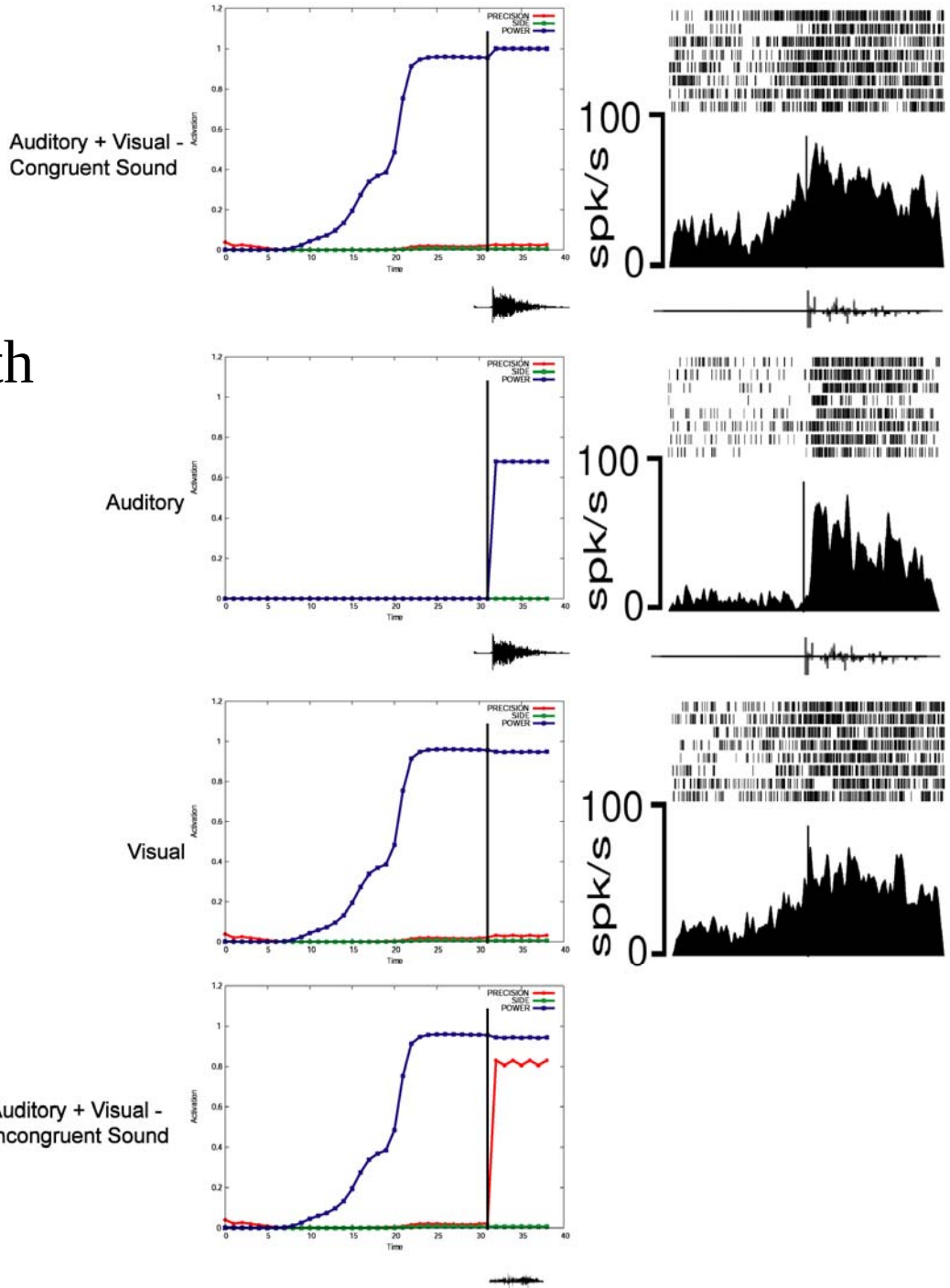


Audible Grasps

Model addition required:

Audio input connected to output layer - modified with Hebbian learning

Pair each grasp type with different patterns in audio input



Hidden Grasps

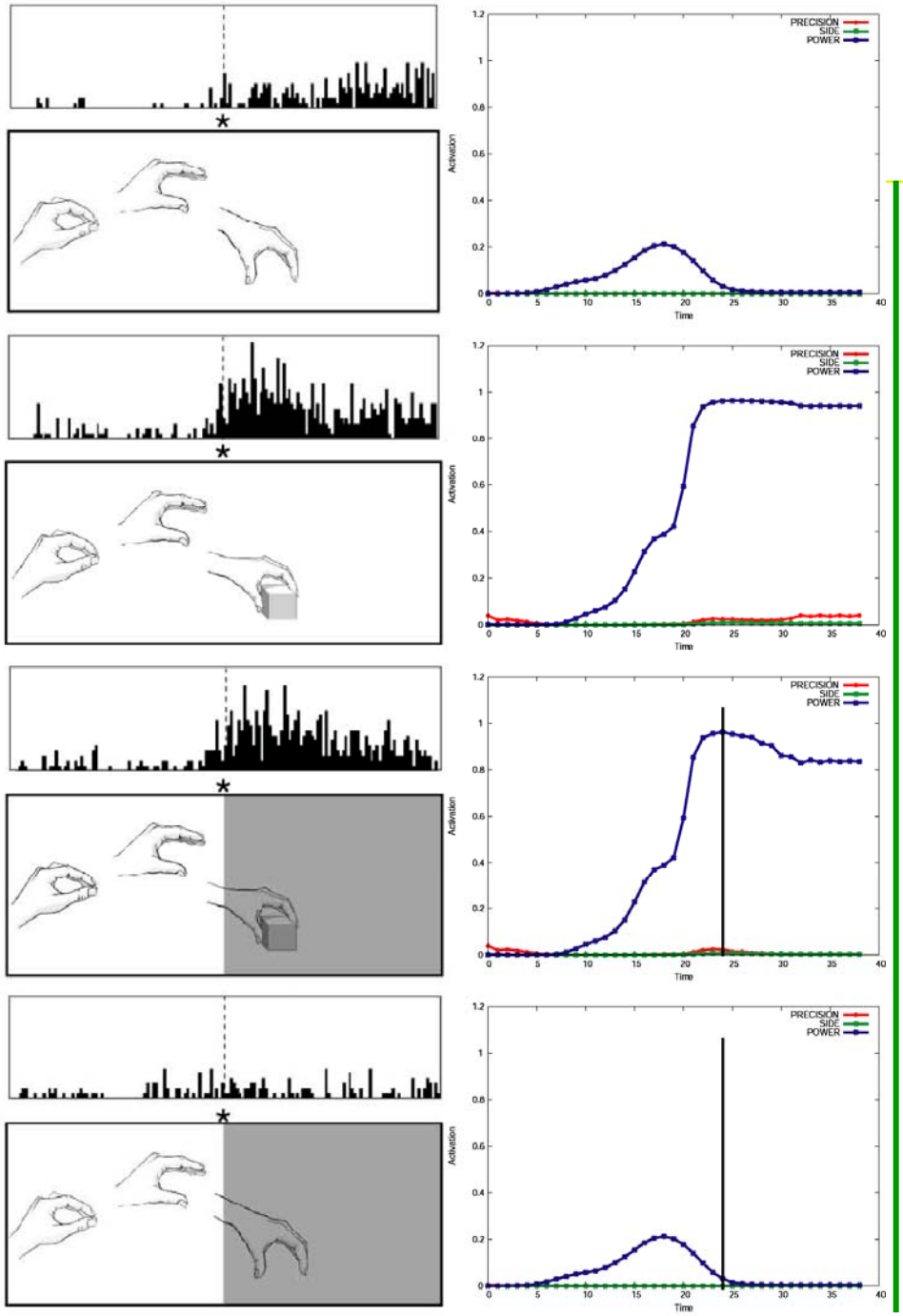
Model additions required:

Working memory

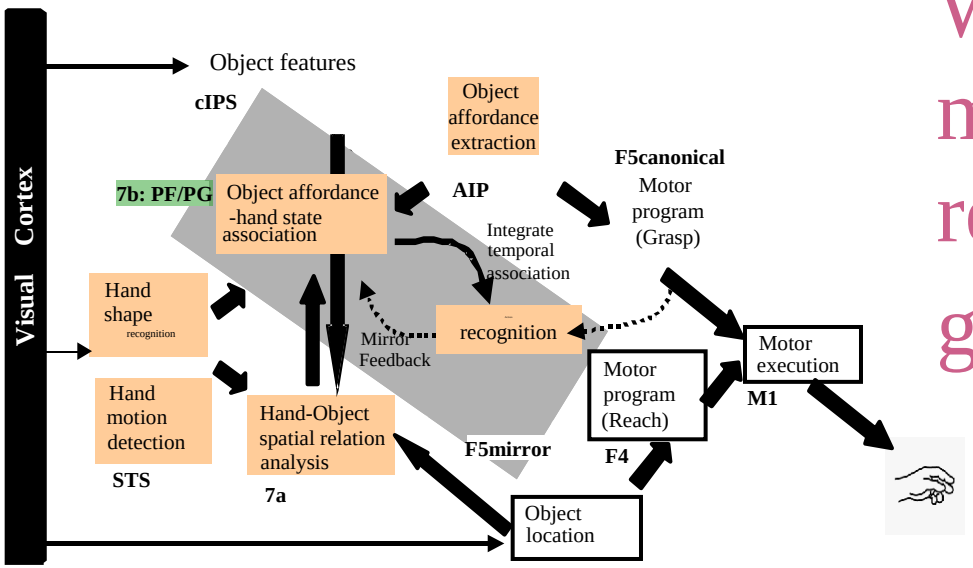
- object and hand information

Dynamic remapping

- update working memory representation of hand location



Beyond the Mirror System



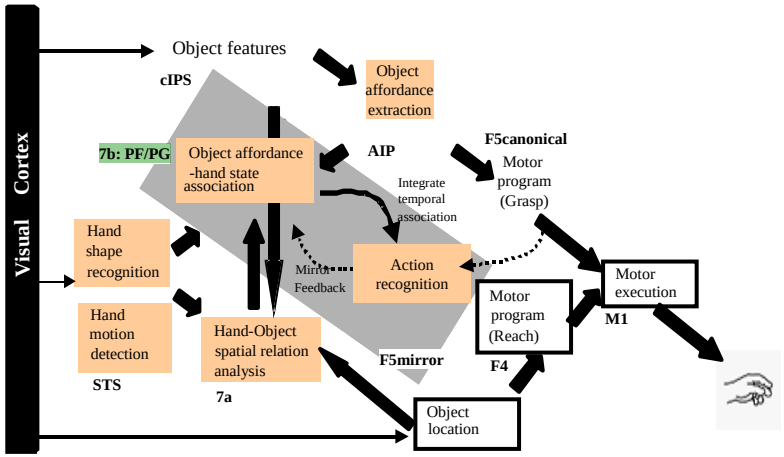
Want to go beyond manual action to recognition of actions generally

But perceiving the "minimal scene" Action(Agent, Object) involves more than even a generalized mirror system:

- inferotemporal cortex (IT) holds the ***identity of the object***
- regions of STS (?) hold the ***identity of the agent***

and thus poses a ***generalized binding problem***

The Two-Fold Challenge



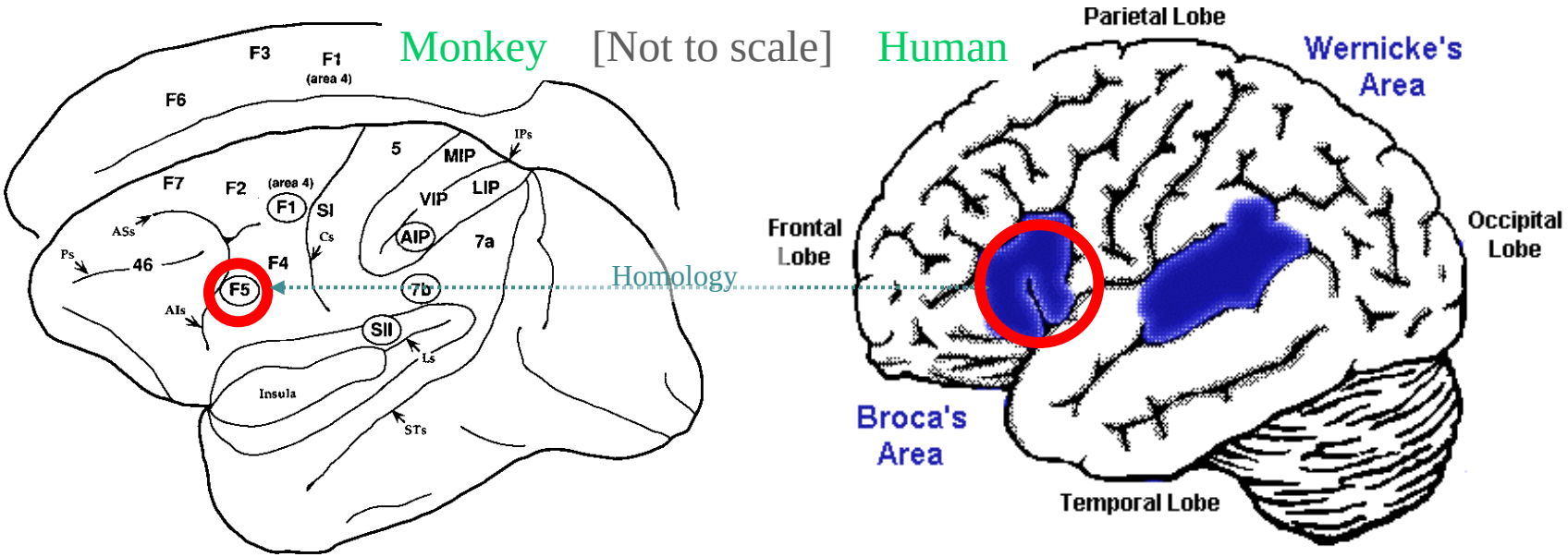
- The Attention Problem: How did the viewer's brain come to attend to (say) the object as "anchor" and then attend to the hand as well, to provide the MNS input – with another system recognizing the "owner" of the hand?
- The Language Problem: The monkey can perceive the scene and act upon it. What is special about the human brain that lets us *also* "talk" about it – adding "semantics" and "phonology" to "cognition"?

The Mirror System Hypothesis (MSH)

Arbib & Rizzolatti, 2007; Rizzolatti & Arbib, 2008

A gestural origins theory of language with a neurological twist

- Hypothesis: the brain mechanisms that support language evolved "atop" a ***mirror system for grasping*** – a brain system active both when the subject is grasping and when the subject observes another grasping – which is similar in the brains of monkeys, apes and humans.



Simple and Complex Imitation in MSH

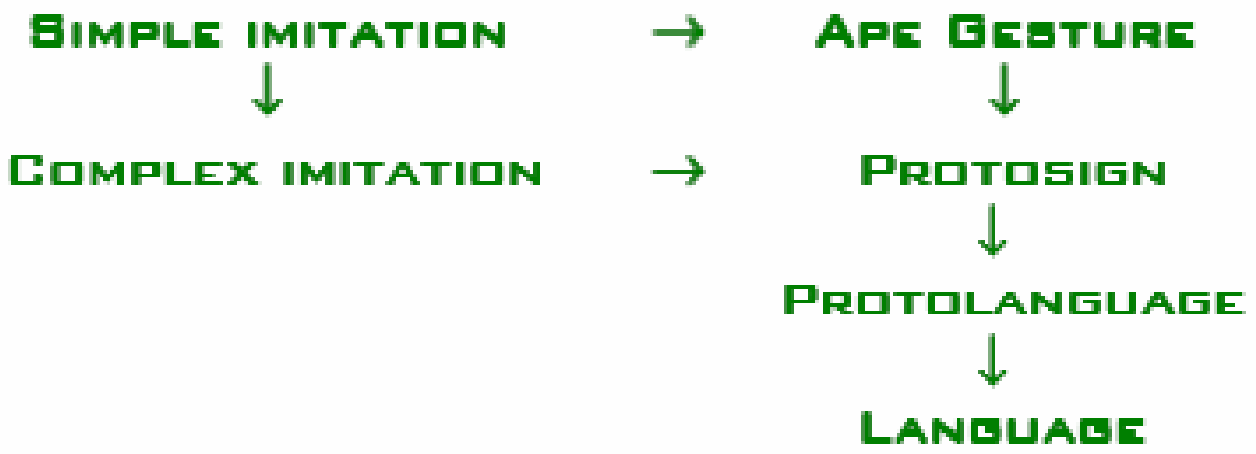
The mirror system evolved in human ancestors as part of successively larger, more competent systems:

- An enlarged system to support ***simple imitation***, the ability to acquire some novel actions by extensive observation and repetition, but only on a limited basis (the common ancestor of humans and apes)
- ***Complex imitation*** evolved in the human line since the divergence from the great apes, with imitation based on the ability to observe a novel performance and see, to a first approximation, its key subgoals and the actions which appear to achieve them

The ability to imitate praxic skills conferred selective advantage for those who can learn from the successful goal achievements of others.

What about communication?

Imitation: From Praxis to Communication



- The vocal repertoire of nonhuman primates is relatively fixed
- But simple imitation allows apes (and, presumably, the common ancestor of apes and humans) to acquire a small but open repertoire of communicative manual gestures
  - ontogenetic ritualization + social learning

MSH: Complex Imitation as A Key to Language

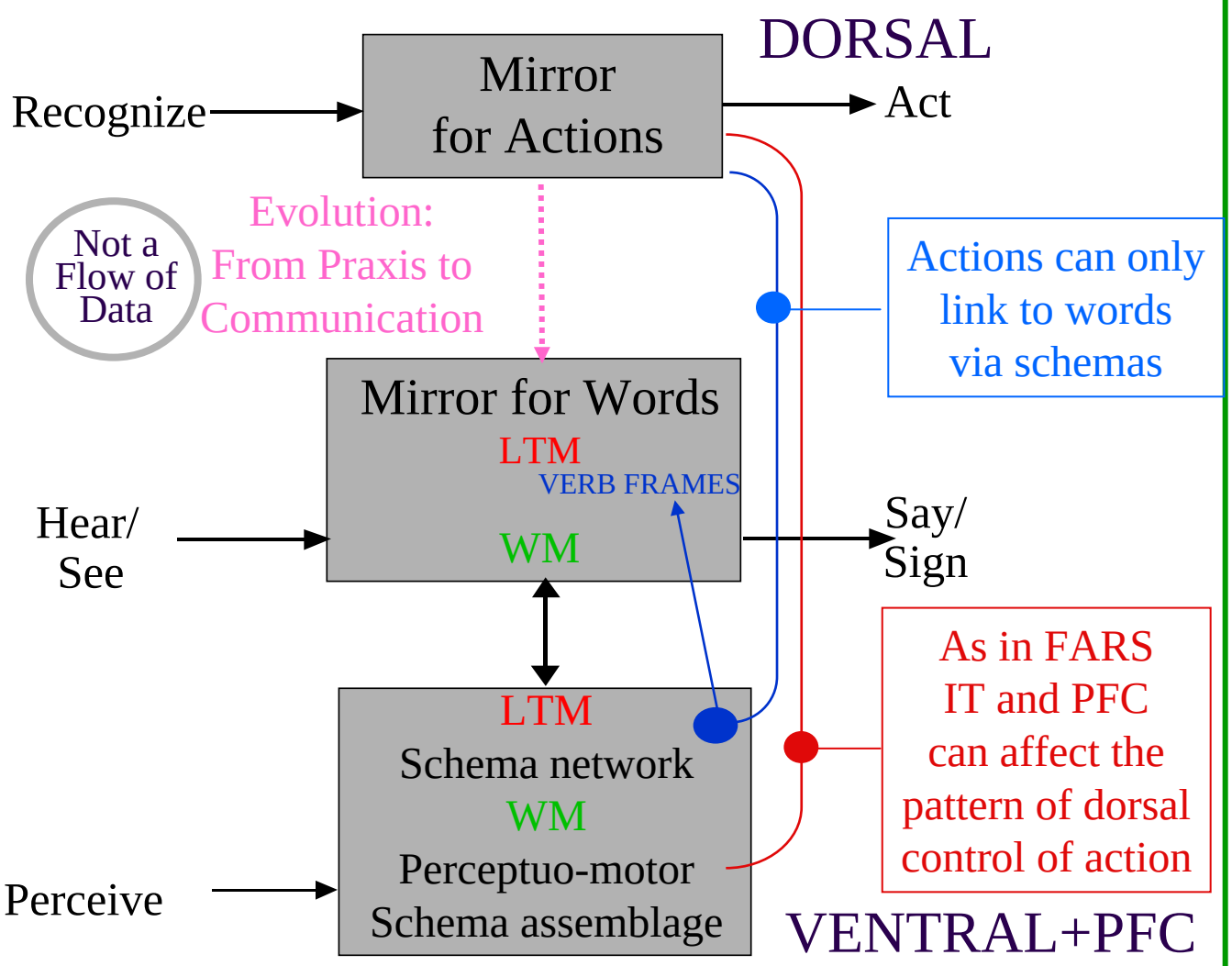
Once complex imitation was established, further evolution yielded novel brain mechanisms which allowed protohuman groups

1) to freely create pantomimes to achieve an open-ended semantics in their communication; and thereafter (using novel brain mechanisms, Corina et al. 1992, Marshall et al. 2004)
2) to move from pantomimes which, while expressive, may require much time to produce yet still be ambiguous
3) to protosign – a system of conventionalized gestures which were easier both to produce and interpret
4) and, adding protospeech, to protolanguage.
5) The transition from protolanguage to language was then a matter of cultural rather than biological evolution. (Controversial)

The Signifier versus the Signified

Mirror System Hypothesis:

- a mirror system for phonological expression ("words") evolved atop the mirror system for grasping to serve communication integrating hand, face and voice



Two Ways to Characterize a Language

Autonomous Syntax/Generative Grammar

- autonomous syntactic rules put words together in very general ways and without regard for the meaning of the result

Construction Grammar

- a more or less language-specific set of constructions which combine *form* (how to aggregate words) with *meaning* (how the meaning of the words constrains the meaning of the whole)

The latter seems more hospitable to accounts (historical linguistics/cultural evolution) of how languages emerge and change over time.

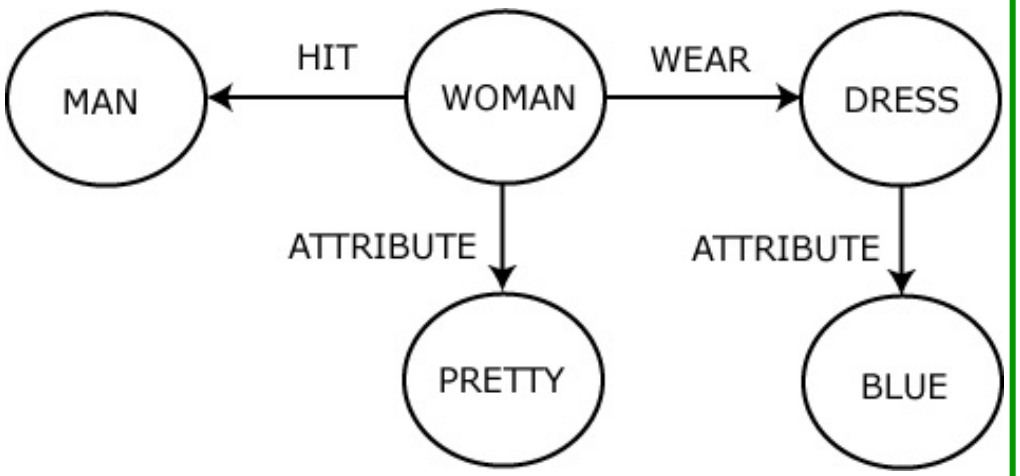
Template Construction Grammar (TCG)

Work in Progress (with JinYong Lee):

Define ***Template Construction Grammar (TCG)*** as a variant of CG that bridges from

- SemRep – a non-linguistic graphical representation of *some* of the agents, objects, actions – and their relations and attributes, to
- Scene descriptions in English (or Korean)
  - First extension will be to question answering
- Using Competition & Cooperation based on our earlier work on schema theory

Discourse Focus Drives SemRep



- Relative clause construction if what the woman is wearing is pertinent

"The woman who is wearing a blue dress is hitting a man"

vs.

- Idiosyncratic "PERSON in COLOR" construction

"The woman in blue is hitting a man

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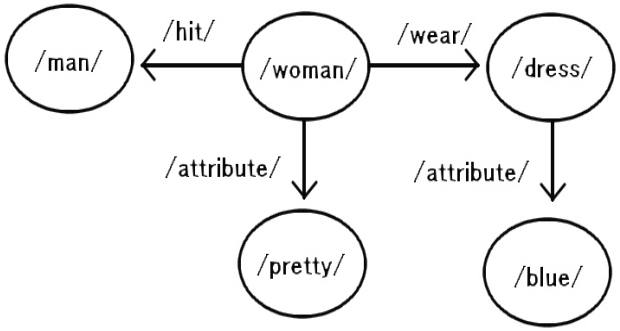
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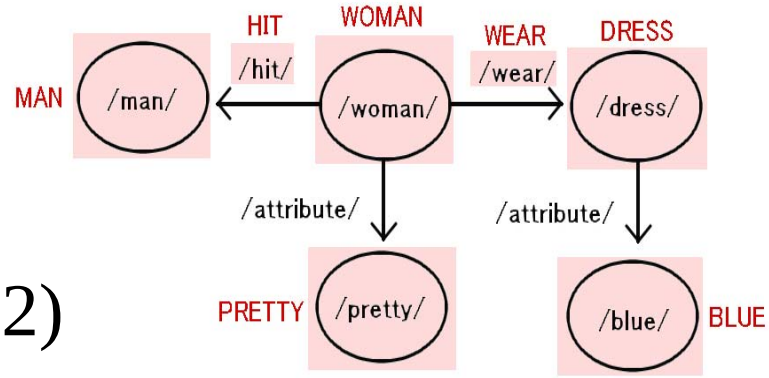
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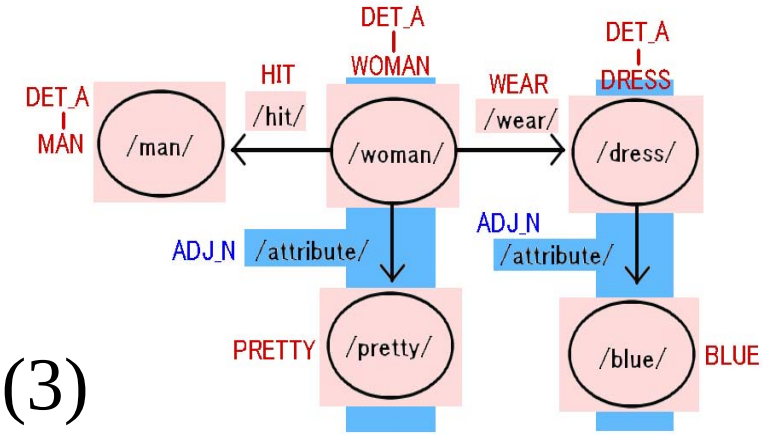
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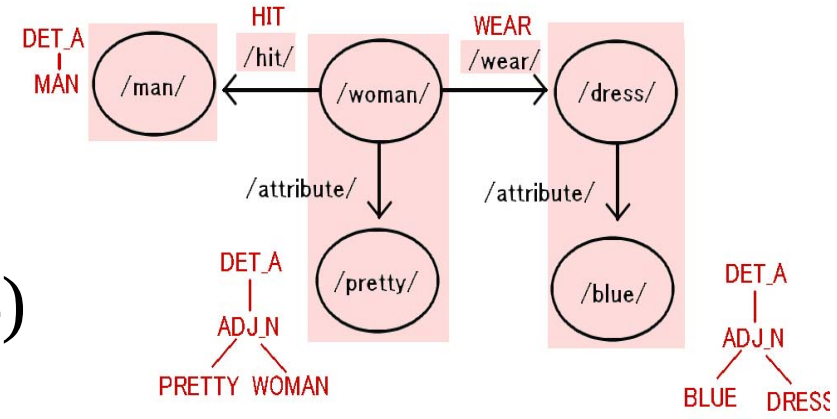
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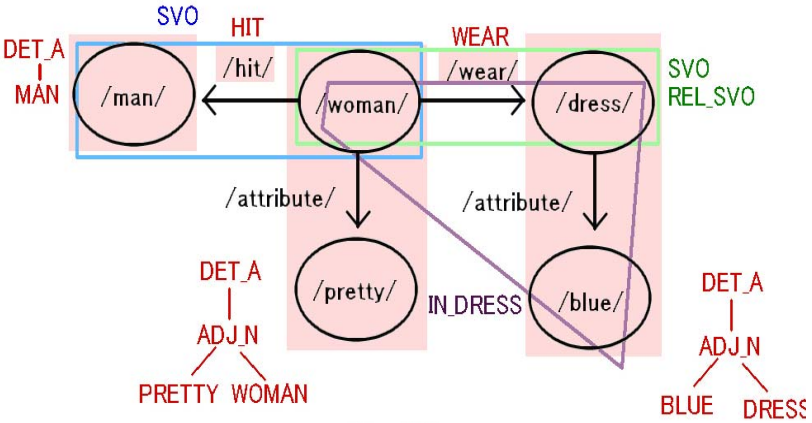
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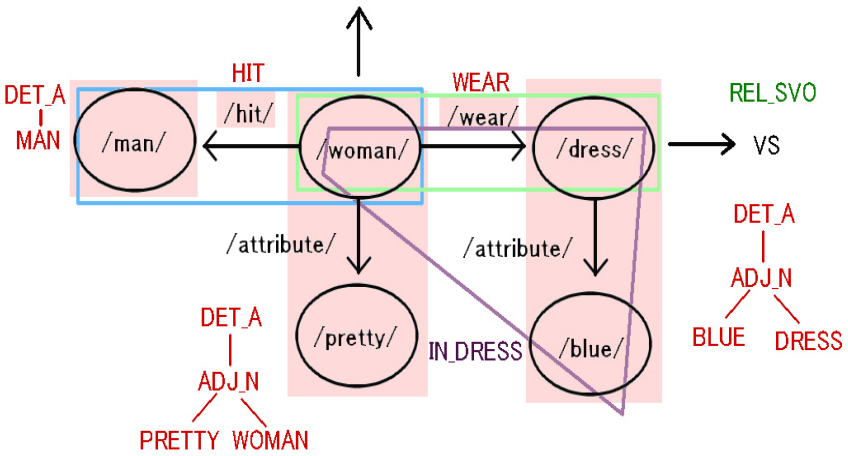
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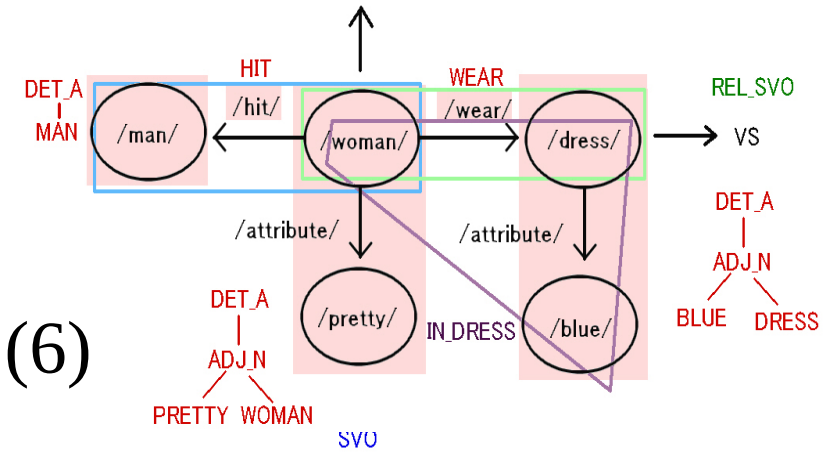
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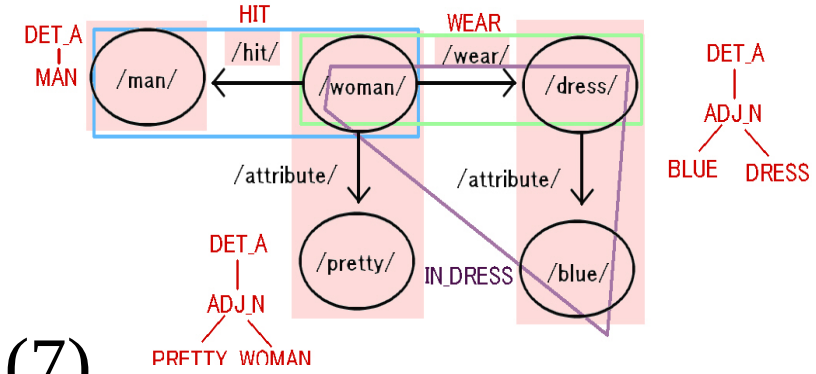
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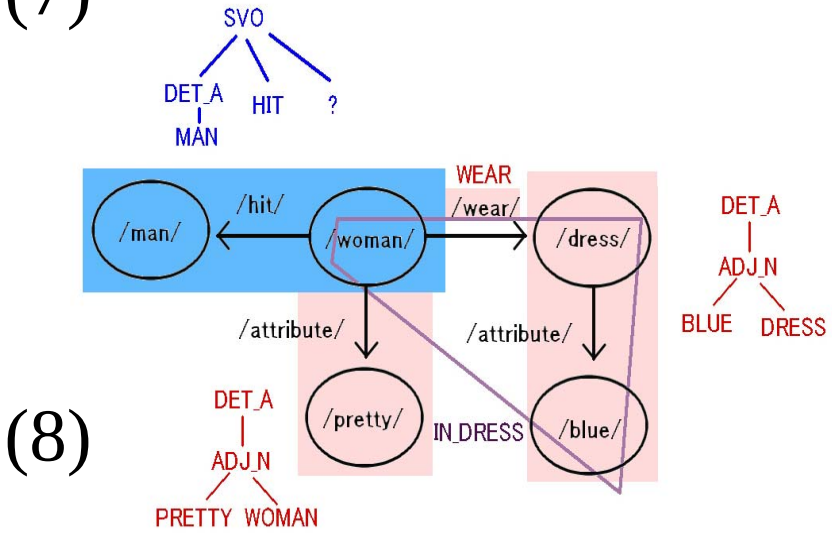
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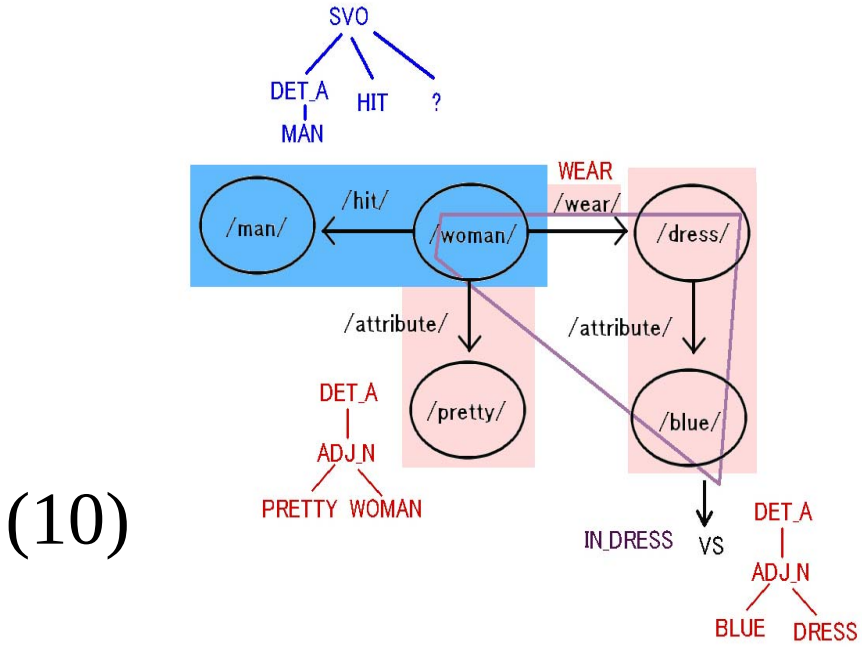
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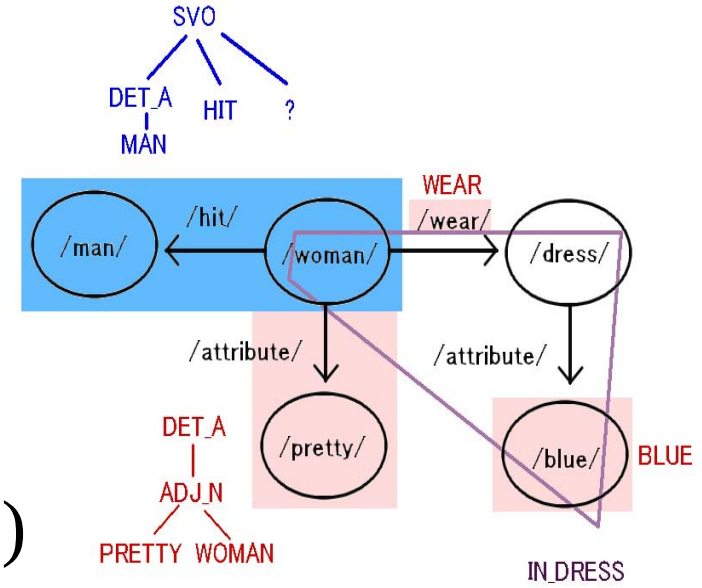
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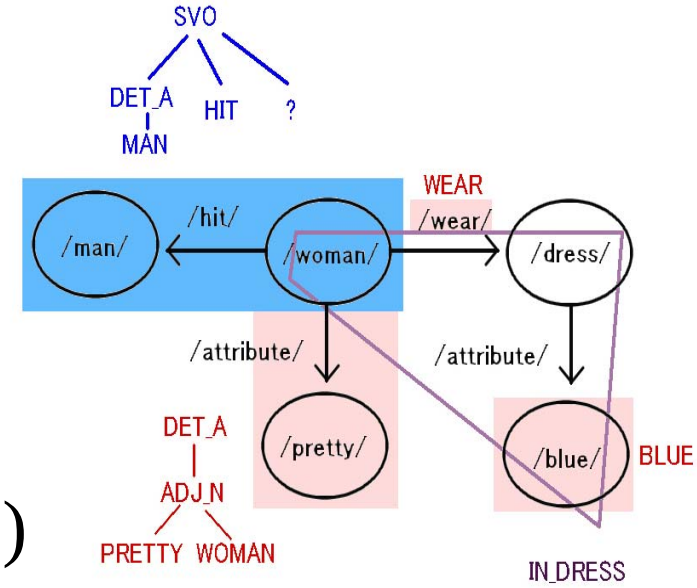
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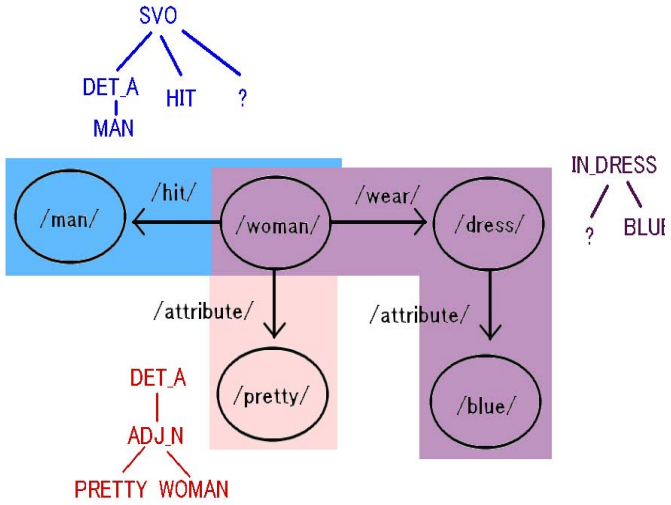
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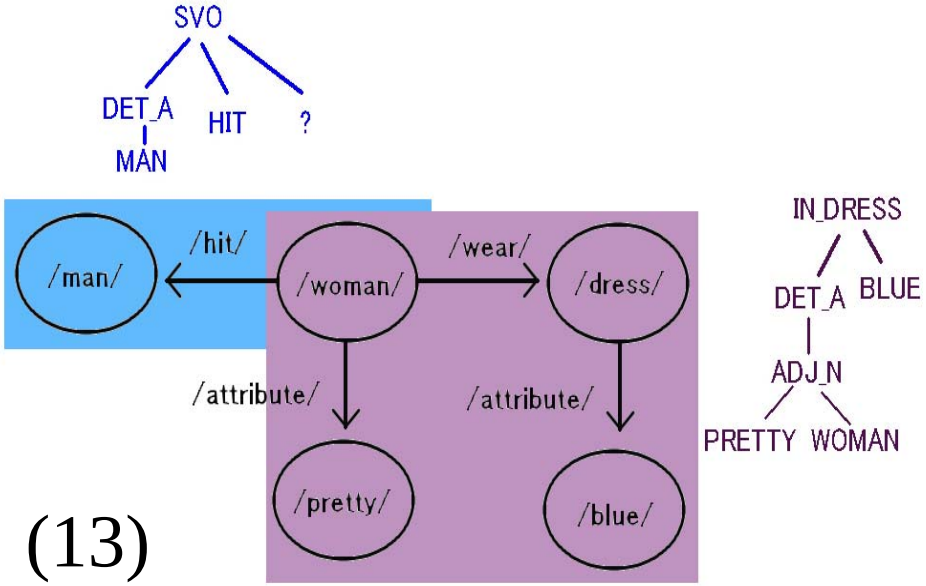
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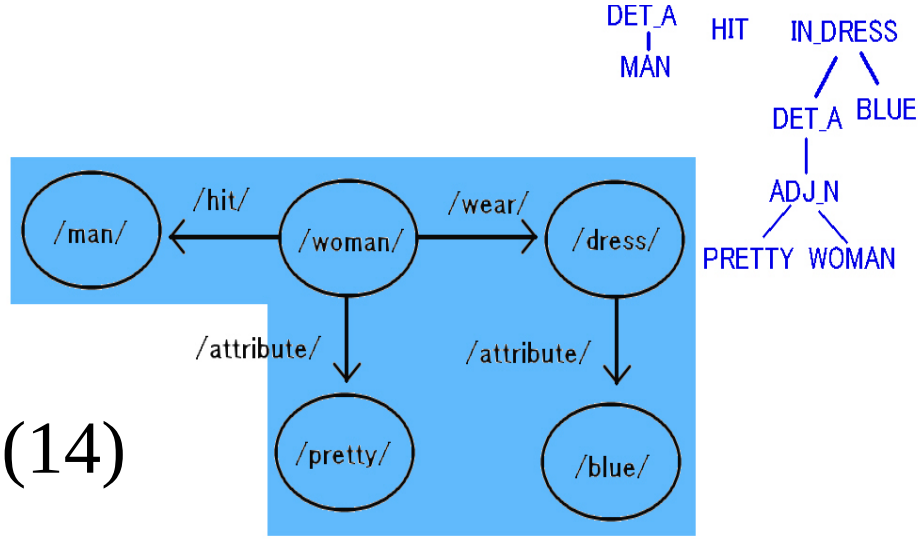
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Two Ways to Acquire a Language

Universal Grammar

- genetically encoded in humans such that it can establish within the infant brain a range of parameters which enable the child to acquire the syntax of its native language by setting each parameter simply by hearing a few sentences to determine which value of the parameter is consistent with them

Construction Grammar

- Hill (1983) showed that the child may first acquire what the adult perceives as two-word utterances as holophrases (e.g., “want-milk”) prior to developing a more general construction (e.g., “want x”) in which “x” can be replaced by the name of any “wantable thing”
- Further experience will yield more subtle constructions and the development of word classes like “noun” defined by **their** syntactic roles in a range of constructions rather than their meaning

Ontogeny does not recapitulate Phylogeny

Adult hunters and gatherers had to communicate about situations outside the range of a modern 2-year old

Protohumans were not communicating with adults who already used a large lexicon and set of constructions to generate complex sentences

Nonetheless, I argue that protolanguage and language emerged through the invention of an increasingly subtle interweaving of (proto)words and (proto)constructions, and that the same basic mechanisms may have served both protohumans inventing language and modern children acquiring the existing language of their community

Mechanisms serving inventing and acquiring a language 1

1. The ability to create a novel gesture or vocalization and associate it with a communicative goal
2. The ability to learn to perform and perceive such a gesture or vocalization, even if "invented" by another
3. Commonalities between two structures could yield
   - the isolation of that commonality as a gesture or vocalization betokening some shared aspect of the event, object or action denoted by each of the two structures
     - Wray 2000: how this might have operated in protohumans
     - Kirby 2000: a related computer model
   - which could in time lead to ***the emergence of a construction*** for "putting the pieces back together", with the pieces becoming instances of a widening class of slot fillers

Compare/contrast this "semantic fractionation" to define new meaningful elements with the "motor fractionation" (whether manual or vocal) that defines new meaningless elements as the basis for phonology.

Mechanisms serving inventing and acquiring a language 2

Complex imitation makes these processes possible:

- For protohumans: this could lead to the invention of new (proto)words and constructions.
- For the modern child: this provides the basis for understanding
  - that strings of sounds can be dissected into strings of words
  - that these words can be grouped by constructions.
- The constructions become of greater or more focused applicability
  - on a historical time-scale as new words and constructions are invented over the course of many generations
  - on a developmental time-scale as the child has more experience of using fragments of the ambient language to understand and be understood.

Being Born Profoundly Deaf

Deaf babies exposed to a sign language from birth follow a similar timetable of linguistic development to that of hearing children acquiring spoken language

But deaf children raised by non-signing parents do develop

home sign

- a rudimentary form of communication with family members
- a small “vocabulary” of signs together with
- a few strategies for combining signs into longer messages

"Direct Input"

Home sign does not rest on *direct* input from either a spoken language or a sign language since these are children of speaking parents who do not know sign language

But there is *indirect* input:

- seeing gestures – both deictic gestures and more descriptive gestures – used as part of speech acts
  - showing the child that pointing and pantomime can be used to communicate
- The "indirect input" from speech is even less direct
  - family members can be seen to take turns to speak and gesture, sometimes to no apparent end, but in other cases with clear links to emotional impact or achieving instrumental goals, creates an understanding of the general notion of dialogue conducted by a blend of gesture and facial expression

New Sign Languages

The first “signers” of ASBL and NSL

- when in fact there were no such languages, just a host of diverse, limited precursors)

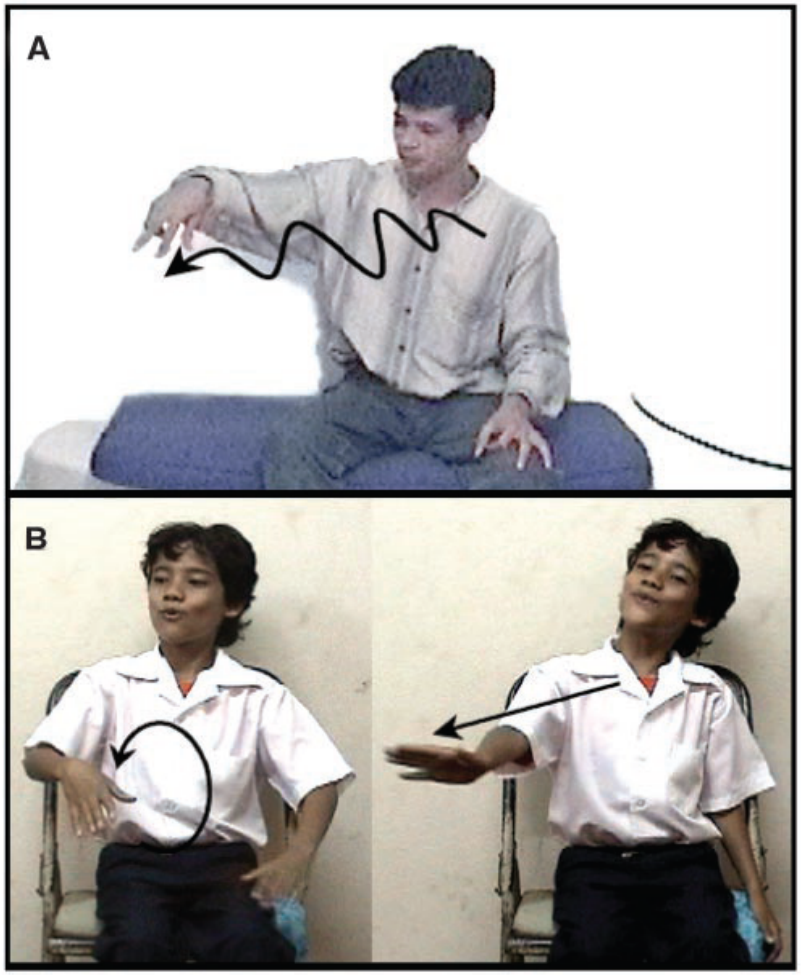
had the “Language is all around, I just can’t hear it” cues that are exploited by all home signers

The key to the transition from home sign to language was the creation of a community in which children could learn the creations of others and begin to build an expanding vocabulary and shared set of constructions.

Manner (rolling) and Path (down)

(**A**) Manner and path expressed simultaneously in the co-speech gesture of a Spanish speaker (also by early cohort NSL signers)

(**B**) Manner and path expressed sequentially by a third-cohort NSL signer



- NSL is not a copying of Spanish co-speech gestures. It is a novel conventionalization
- but many sign languages do express manner and path simultaneously

A Novel Construction

Recall: Commonalities between two structures could yield

- the isolation of that commonality as a gesture or vocalization betokening some shared aspect of the event, object or action denoted by each of the two structures
- which could in time lead to ***the emergence of a construction*** for "putting the pieces back together", with the pieces becoming instances of a widening class of slot fillers

If manner and path are expressed separately, it may no longer be clear that the two aspects of movement occurred within a single event.

- *Roll* followed by *downward* might mean "rolling, then descending".

Senghas et al. (2004) show NSL developed a way to put the pieces back together:

- NSL now has the X-Y-X construction, such as *roll-descend-roll*, to express simultaneity. This string can serve as a structural unit within a larger expression like *cat [roll descend roll]*, or it can even be nested, as in *waddle [roll descend roll] waddle*.
- This construction never appeared in the gestures of the Spanish speakers and is also quite unlike any construction of spoken Spanish

Variation in ABSL Signs "close" to pantomime

"banana"

"dog"

Aronoff et al. (2008) find an unexpectedly high degree of inter-signer variation in Al-Sayyid Bedouin Sign Language

- e.g., "tree" "dog" and "banana" remain close to pantomime though the signs within a family may be similar.

suggesting that linguistic proficiency *can* occur without duality of patterning

- a (sign) language can occur without phonology

The Emergence of the Nicaraguan Deaf Community

It has been claimed that NSL arose "from scratch" in that the community of deaf Nicaraguans who developed it "lacked exposure to a developed language"

But did deaf Nicaraguans "reinvent Language" or "invent *a* language"?

In the latter case we must understand how knowledge of other languages may have complemented the language-readiness of the brain in the development of NSL.

Linguistic analysis of changes in NSL from cohort to cohort are insightfully complemented by Laura Polich's book analyzing the changing social matrix that supported the emergence of NSL:

*The Emergence of the Nicaraguan Deaf Community in Nicaragua: "With Sign Language You Can **Learn** So Much"*

Social actor, peer group and *creating one's identity*

There is no evidence of sign language in use in Nicaragua in 1975.

But in the late 1970s, a vocational school was established that kept adolescents and young adults together

at a time when they were carving out their identities and craving a peer group in which to try out and enact their abilities to be social actors. (Polich, p.146)

The process that Polich charts is the transition

- from a deaf person in Nicaragua having no peer group and thus having the passive social role of an outcast
- to a person with a language which empowered them to be true social actors within the Deaf community created by the enriched communication that came with the expanding capabilities of NSL.

NSL did not develop in a Vacuum

Teachers played an important role in developing a community which provided social opportunities for the deaf children, going beyond the classroom.

Ruthy Doran, a hearing person who not only taught the deaf children at the vocational school but also did much to create a social environment for them, told Polich:

- There wasn't a sign language [around 1980] ... But we were able to understand one another. We would … use a lot of the gestures that everyone around here (in Nicaragua) uses and we had a set of some signs that the students made up. (They aren't used now.) We had special signs like for the days of the week that we had used with each other for years, and they had learned new signs … which they taught me. And when everything else failed, we would write words down, or else act it out.

Thus, in its early stages the community being formed included hearing people who spoke Spanish, while even those who could not speak had at least a small vocabulary of written Spanish.

An Important Distinction

The talk of community must not blind us to the fact that each aspect of the language has to meet two conditions:

(i) a specific individual *or dyad* used it for the first time (or the first time that they and others knew about) and

(ii) others, understanding its meaning, came to use it themselves.

True: "In the early 1980s, many deaf Nicaraguans knew no grammar"

False: "In the early 1980s, no deaf Nicaraguans knew grammar."

The impressive achievement of creating this new language, NSL, did not have to rest solely on innate capabilities of the human brain (which distinguish us from other primates, for example) but could indeed exploit the cultural innovations of existing language communities.

Individuals Played a Crucial Role

Many deaf adults who attended the early meetings of the deaf Association credit Javier Gómez López with teaching all the others the sign language. Javier's interest in sign language begun in the late 1970s when he was given a sign language dictionary during an athletic trip to Costa Rica.

- He was dedicated to making sign language a functional communication system for himself and his friends, and to sharing this knowledge with other deaf Nicaraguans.
- He would seek out anyone who knew sign language or had access to a dictionary to improve his vocabulary, and would simultaneously teach what he learned to the others. [The second cohort studied both Spanish dictionaries and ASL videos as a basis for devising new signs to expand NSL.]
- He was active in the workshops in the years around 1990 in which members of the association met in small groups to discuss which variations of signs should be adopted as the "standard" versions which members should use

Institutions Played a Crucial Role

In 1991, the Royal Swedish Deaf Association began to finance the collection of entries for a professionally published sign language dictionary, eventually published in March 1997.

- But the Swedes did not teach Swedish Sign Language. Rather, while helping the Nicaraguan systematize what they had achieved in the early stages of creating NSL, and provided models of expressiveness of sign language which would have spurred the development of new modes of expression in NSL.

What Took Us So Long?

It has been argued that the brain of *Homo sapiens* was biologically ready for language perhaps 200,000 years ago but, if increased complexity of artifacts like art and burial customs correlate with language of some subtlety, then human languages as we know them arose at most 50,000 to 90,000 years ago

But if one accepts the idea that it took humans with modern-like brains 100,000 years or more to invent language-as-we-know-it, one must ask what advantage the NSL and ABSL communities had that early humans lacked.

Hypothesis: ABSL and NSL differ from home sign because

i) The existence of a community provides more opportunities to use signs and choose signs, so that some get lost to the community while increasingly many gain power by being widely shared.

ii) Since knowledge of another language is possessed by some members of the community, they seek to translate this knowledge into the new medium (as is proven for the lexicon), but few attempts to capture a given property will become widespread in the community

ABSL and NSL would share (i) but not (ii) with early humans.

It seems almost inconceivable that the very idea of language had to be invented

But we know that writing was only invented some 5,000 years ago.

- And we believe that no brain changes were required to support literacy

Moreover, many societies have lasted till modern times with no written form for their spoken language.

Yet, once one has the *idea* of writing, it is a straightforward exercise to invent a writing system

- Around 1820, Sequoyah, a Cherokee who knew very little English and was illiterate invented a Cherokee syllabary, with 86 characters to represent the sounds of the Cherokee language, inspired solely by the *idea* of writing

Social cognitive neuroscience

Leslie Brothers (1997) ***Friday's Footprint*** asserts that the human brain has inborn mechanism for generating and perceiving "person", a construct that assigns subjectivity to individuals. – just as we are biologically prepared to learn a language.

> "The network of meanings we call culture arises from the *joint* activities of human brains. This network forms the living content of the mind, so that the mind is communal in its very nature: It cannot be derived from any single brain in isolation"

- Brothers offers data from primates for this biological substrate
- In addition, cultural evolution provides subtle and diverse variations on this biological theme.

Recent years have seen the formation of ***social cognitive neuroscience,*** e.g.:

- Ochsner, K.N., and Lieberman, M.D., 2001, The Emergence of Social Cognitive Neuroscience, *American Psychologist*, 56:717-734
- Adolphs, R., 2003, *Cognitive Neuroscience Of Human Social Behaviour Nature Reviews Neuroscience*, 4:165- 178.

Bringing in the Social Dimension

What makes us human?

- Our ***brains*** (and ***bodies***) and
- the ***societies*** which have developed to constrain and enrich them

Brothers' point: ***the brain evolved to support this social embedding of the self***.

Erving Goffman (1974) on *Frame Analysis*

- Our "choice" of schemas to control our current behavior reflects the "social frame" in which we find ourselves:
  - "How are you?": the "greetings frame" versus the "doctor–patient frame"

Michael Arbib & Mary Hesse:*The Construction of Reality.*
(1983 Gifford Lectures/1986 book)

- Seeking a shared epistemology linking Arbib's schema-based, action-oriented neuroscience to Hesse's "social construction" of science
- The outcome: extending schema theory to include not only ***individual schemas*** *(schemas in the head)* but also ***social schemas***
  - Example: The English language – there is no one place to define it

Schema Theory: A Framework for Future Analysis

"Pure" schema theory studies schemas as dynamical, interacting systems which underlie mental and overt behavior

- in contrast to classical "symbolic" AI or "Language of Thought" (the mental as a set of propositions)

"Neural" schema theory then analyzes data from neurophysiology, lesion studies and brain imaging to see how schemas are related to distributed neural mechanisms.

"Social" schema theory: The attempt to relate "schemas in the head" to the collective representation of a society – whether a language, religion, ideology, myth, or scientific society (Arbib and Hesse 1986)

- cf. Durkheim's "Collective Representations" and Dawkins' "Memes".

Neural schema theory extends basic schemas downward to neural mechanisms

Social schema theory extends basic schemas upwards to society – a separate (and much less developed) research program

Language: Co-Evolution and Bricolage

Brain Mechanisms
as charted in part by the Mirror System Hypothesis

and

A Virtuous Cycle of Cultural Evolution
of Social Schemas for Praxis, Social Praxis and Communication