Broad and Narrow Language Faculties

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Hauser, Chomsky and Fitch (2002) suggest that investigation into human language origins might profit by distinguishing a broad and a narrow and perspective on the language faculty (FL).

Broad View (FLB): the **sensory-motor system** (π) that creates expressions (vocal/manual gestures) +
the **conceptual-intensional system** (λ) that creates concepts (thoughts)   +
the **internal computational system** (C_{HL}) responsible for pairing expressions and concepts

$$\pi \leftarrow C_{HL} \rightarrow \lambda$$

Narrow View (FLN): the **internal computational system** (C_{HL}) alone.
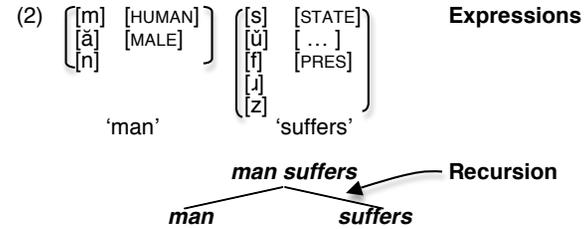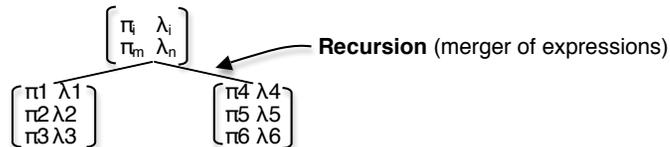
On the first, we see language (roughly) as the totality of meaning-expression pairings. On the second, we view it as the mechanism that effects the pairings.

Hauser, Chomsky and Fitch (2002) suggest this division as a way of conceiving the evolutionary innovations responsible for FL. Consider an advanced hominin ("Prometheus") with developed gestural (π) and conceptual (λ) systems. Deployment of a computational mechanism (C_{HL}) that could "read" the representations in both systems and relate them might yield language.
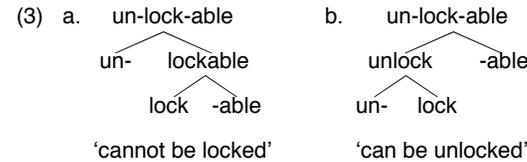
Before language: π λ
After language: $\pi \leftarrow \mathbf{C_{HL}} \rightarrow \lambda$

Hauser, Chomsky and Fitch (2002) suggest the core of C_{HL} is **narrow syntax** *aka* **recursion**: the formal operation that merges smaller expressions into larger ones and thus the basis of "discrete infinity".

(1) $\begin{bmatrix} \pi1\ \lambda1 \\ \pi2\ \lambda2 \\ \pi3\ \lambda3 \end{bmatrix}$ $\begin{bmatrix} \pi4\ \lambda4 \\ \pi5\ \lambda5 \\ \pi6\ \lambda6 \end{bmatrix}$ **Expressions** (complexes of instructions to π and to λ)

$\begin{bmatrix} \pi_i\ \lambda_i \\ \pi_m\ \lambda_n \end{bmatrix}$

Recursion (merger of expressions)

$\begin{bmatrix} \pi1\ \lambda1 \\ \pi2\ \lambda2 \\ \pi3\ \lambda3 \end{bmatrix}$ $\begin{bmatrix} \pi4\ \lambda4 \\ \pi5\ \lambda5 \\ \pi6\ \lambda6 \end{bmatrix}$

(2) $\begin{bmatrix} [m] & [\text{HUMAN}] \\ [\ddot{a}] & [\text{MALE}] \\ [n] \end{bmatrix}$ $\begin{bmatrix} [s] & [\text{STATE}] \\ [\acute{u}] & [\ …\ ] \\ [f] & [\text{PRES}] \\ [\textipa{R}] \\ [z] \end{bmatrix}$ **Expressions**

'man'   'suffers'

man suffers — **Recursion**

man   **suffers**

Expressions here include not only "words" in the informal sense, but subword elements as well ("atoms"):

(3) a.   un-lock-able   b.   un-lock-able

un-   lockable   unlock   -able

lock   -able   un-   lock

'cannot be locked'   'can be unlocked'

(similarly for *unfoldable*, *undressable*, etc.)

Summarizing (Chomsky 2010):

Interfaces (π, λ) + Recursion = Language

Questions & Puzzles:

- Under HCF (2002) one whole component of grammar – syntax – constitutes FLN; whereas other components (phonology, semantics) do not.
- Syntax = Recursion
- Recursion appears to play a key role in cognitive systems predating language; e.g., the visual system composes simplex visual representations (shapes, edges, areas) into representations of larger complex objects, which show formal properties similar to linguistic constructions (embedding, self-embedding, economy), etc.
- Recursion ("discrete infinity") did not arise with human language. In what sense then, was it "missing" in the pre-Promethean period.
- HCF (2002) is silent on the origins of expressions (linguistic atoms) themselves, suggesting that linguistic signs are also part of FLB; nothing uniquely human is involved in their creation. Is that correct?

In this talk:

- We look at the question of "sign formation" in two domains: logic and color.
- We argue that these domains show regularities suggesting a computational system below the level of combinatory syntax.
- This system does <u>not</u> exhaust the space of concepts available in the relevant domains. Part of the space is "logically structured," but part appears to be supplied through the operation of other capacities.

- ■ This suggests that narrow linguistic capacities may not be localized in a single component (syntax/recursion, lexicon, etc.) but rather present in subdomains of them.

1.0　The Logic of Logic

Western logic originates with Aristotle. In *De Interpretatione* and *Prior Analytics* Aristotle suggests that all propositions can be classfied according to their **Quality** (affirmative or negative) and their **Quantity** (universal vs. particular):

(4)

	Affirmative	**Negative**
Universal	*All men are mortal.*	*All men are not mortal.* 'No men are mortal'
Particular	*Some men are mortal.*	*Some men are not mortal.*

Pairs of these propositions exhibit different logical relations.

- ■ Some pairs cannot be true at the same time nor false at the same time. Such pairs are **contradictories**, e.g.:

　Some men are mortal. ⇐ **CONTRADICTORIES** ⇒ *No men are mortal.*

- ■ Some pairs cannot be true at the same time, but can be false at the same time. Such pairs are **contraries**, e.g.:

　All men are mortal. ⇐ **CONTRARIES** ⇒ *No men are mortal.*

　(Both can be false if only some men are mortal.)

- ■ Some pairs can be true at the same time, but cannot be false at the same time. Such pairs are **subcontraries**, e.g.:

　Some men are mortal. ⇐ **SUBCONTRARIES** ⇒ *Some men are not mortal.*

- ■ Some pairs are such that the truth of one requires the truth of the other. Such pairs are **subalterns**. The first **entails** the second, e.g.:

　All men are mortal. ⇐ **SUBALTERNS** ⇒ *Some men are mortal.*

Boethius summarized these relations in the **Square of Opposition**. Corners labeled A and I are affirmative (from *Affirmo*). Corners labeled E and O are negative (from *nEgO*).
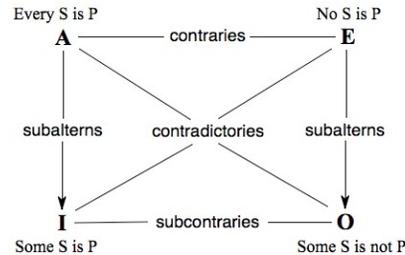

1.1　A Linguistic Puzzle

Horn (1989, 1990) notes that while there are individual words combining quantity and quality for the A, I and E corners, no such single word exists for the O corner - no word combining particular quantity (*some*) and negative quality (*not*), in the way that *no* combines universal quantity (*some*) and negative quality (*not*). The "missing" word would have the meaning 'not-all'.
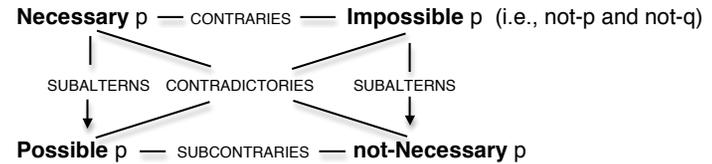
Question: Why no *Nall*?

Accident? Unlikely. No natural language is known to have such a form. Furthermore, English itself shows the gap is systematic in other "squares".

(5)　*Propositional Connectives*
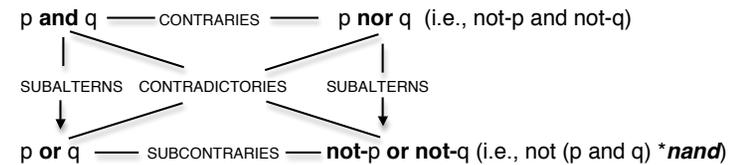
(6)　*Modal Operators*

NB: *Unnecessary* does not lexicalize the O corner. *Un-* is an expression: an atom for recursion. *Unnecessary* is thus a complex expression, not a word.

So why are they missing?

- ■ Non-natural languages (e.g., computer languages) use non-natural forms like *nand*.
- ■ We can express the relevant meanings in natural language by compositional means:

(7)　**Some** men **are not** mortal.　　　　　　　　Syntactic Formation
　　　Either John is**n't** leaving **or** Mary is**n't** leaving.
　　　This is **un**-necessary.　　　　　　　　　　Productive Morphology

1.2　More Empty Corners!

The issue of "missing words" in the space of logical concepts can be expanded by considering some additional issues.

1.2.1   New Propositional Corners

(8)   John is coming to the party or Mary is coming to the party.

Native speakers often judge (8) as <u>false</u> when both disjuncts are true; *or* typically carries the idea 'either one or the other, but not both'. Logicians typically hold (8) to be <u>true</u> when both disjuncts are true: that *or* means 'either one or the other, maybe both', with 'but not both" arising by extra-semantic/extra-logical inference.

Whoever we side with, 'either, maybe both,' and 'either, but not both' plainly represent distinct logical notions. Hence we should represent both & their logical relations. Add a new corner Y to the square, with relations in (9):

(9)   *Expanding the Square: Step 1*
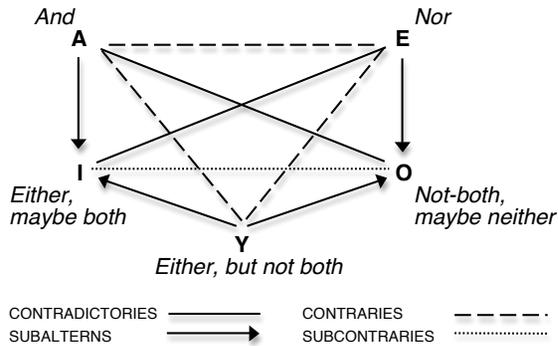
Consider also 'and or nor,' as in *Either John is coming and Mary is coming or John isn't coming and Mary isn't coming.* This, the contradictory of Y, is also missing from our domain. Add the new corner as U, with relations in (10):

(10)   *Expanding the Square: Step 2*
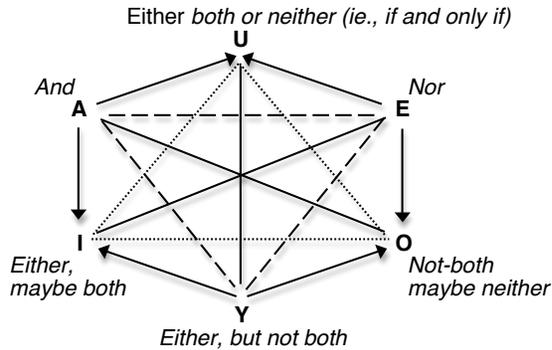
The **Blanché Hexagon** expands the Aristotelian Square of opposition, incorporating the additional notions of "some-but-not-all' and 'all-or-no'.

The expansion does not answer the "O-corner Question" but rather extends it.

(11) Non-lexicalized in natural language: O Corner   (*Not-both, maybe neither*)
　　　　　　　　　　　　　　　　　　　　　　　　　U Corner   (*Either both or neither, i.e., iff*)

1.2.2   New Quantificational Corners

Parallel issues arises with *some*:

(12) Some men are mortal.

Native speakers often judge (12) as <u>false</u> since it suggests some men are <u>not</u> mortal, i.e., *some* typically carries the idea 'some, but not all' - false in the present case. Logicians standardly hold (12) to be <u>true</u>: that *some* means 'some, maybe all', with 'but not all' arising by extra-semantic/extra-logical inference.

Again, 'some, maybe all,' and 'some, but not all' are plainly distinct logical concepts. We should add them and their logical relations to the square (13):

(13)   *All*   *No/none*
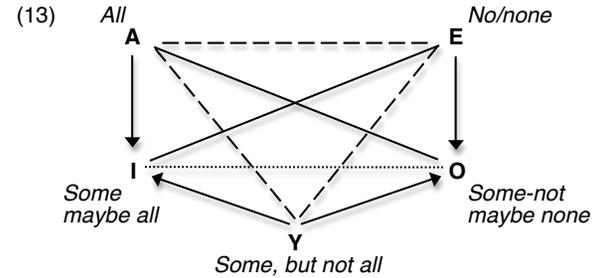
Consider also the quantity concept 'all or no,' as in *All or no students will be at my party.* This is the contradictory of *Some, but not all*. We add it as in (14).
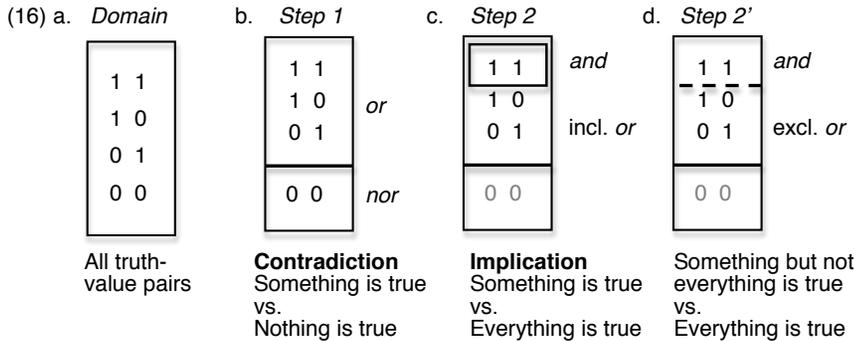
(14)   *All or No*
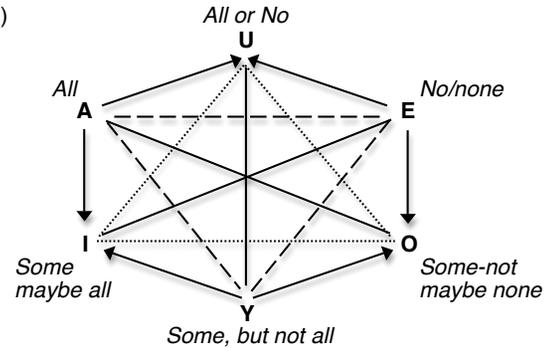
Again, expansion does not answer the "O-corner Question" but rather extends it.

(15) Non-lexicalized in natural language: O Corner (*Some-not, maybe none*)
   U Corner (*All or No*)

1.3 Oppositional Structure (Jaspers 2005)

Jaspers (2005) offers a solution to the lexicalization question. He derives logical concepts by making subtractions from a fixed domain space of values via a series of successive binary divisions. There is an initial exhaustive division between the contradictories Nor and Or (16a); within the remaining non-Nor space of values, we can either carve out the subset And, leaving inclusive Or as super set space (16b), or we can divide the inclusive Or space exclusively into And and exclusive Or (16c)
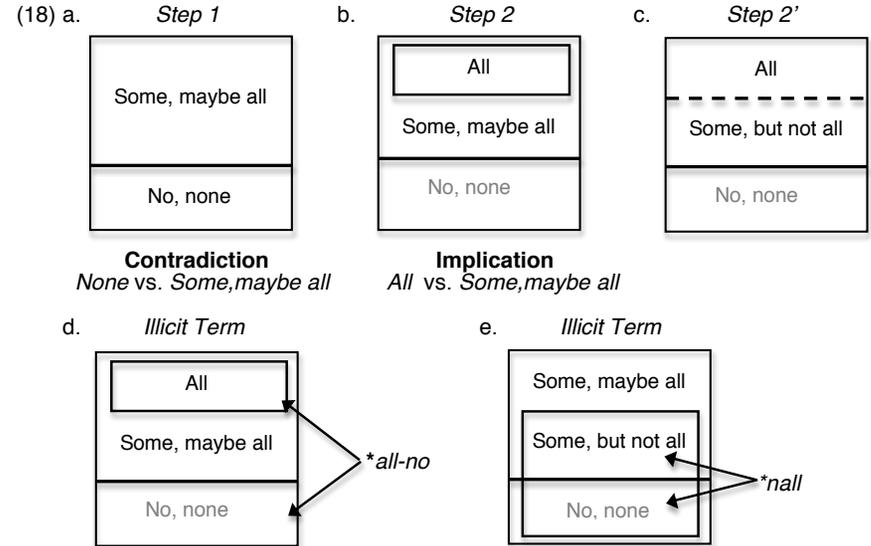
(16) a. *Domain*   b. *Step 1*   c. *Step 2*   d. *Step 2'*

All truth-value pairs

Contradiction
Something is true
vs.
Nothing is true

Implication
Something is true
vs.
Everything is true

Something but not everything is true
vs.
Everything is true

Natural logic terms correspond to concepts that match natural divisions of the concept space.

Non-naturalness with **nand* and **iff* follows from their concepts being non-congruent with natural divisions of the concept space; both cut across the basic Nor-Or division (26a,b):

(17) a. *Illicit Term*   b. *Illicit Term*

*nand   *iff
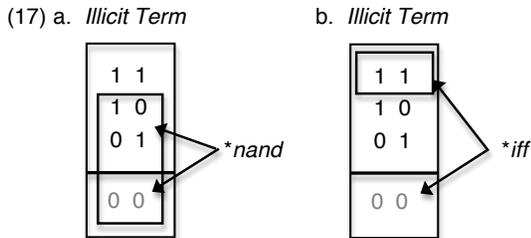
Exactly parallel considerations apply to the set of quantificational concepts and the terms for them (18a-18e):

(18) a. *Step 1*   b. *Step 2*   c. *Step 2'*

Contradiction
None vs. *Some,maybe all*

Implication
All vs. *Some,maybe all*

d. *Illicit Term*   e. *Illicit Term*

*all-no   *nall

Summary:

Human cognition appears to deploy constraints on logical concept formation:

- Reflected in the availability of naturally occurring words for certain concepts, but not in availability *per se*. Non-natural concepts in the domain (*nand*, *nall*, *nnecessary*) can be lexified by system-external means, or by productive, compositional means. They are unavailable as "natural" atoms, but this mechanism structures only a subpart of the domain.
- The constraints are not on combinatorics of syntactic elements (not on "narrow syntax"), but rather on the systematic partitioning of an antecedently given conceptual space. Crucial is the principle: divisions are made within existing divisions, and not across them. This accounts for "missing words".

2.0 The Logic of Color

Colors have long been thought to embody a "logic".

- The focal, achromatic color opposition black/white, representing absence/presence of all colors, appears analogous to false/true.
- Colors exhibit binary/ternary relationships reminiscent of logical ones.

Complementary colors: colors that, mixed in proper proportion, yield an achromatic/neutral color (black/white/grey). Reminiscent of **contradiction**.

Primary colors: triads of colors that, mixed in proper proportion, yield the space of all chromatic colors.

> **Additive Primaries**: colors whose **lights** combine to yield the space of all chromatic colors. E.g., Red-Green-Blue (RGB)

> **Subtractive Primaries**: colors whose **pigments** combine yield the space of all chromatic colors. E.g., Cyan-Yellow- Magenta (CYM)

Additive primaries work together by **adding** lights of different wavelengths; combination of the three additive primaries yields **white**, the presence of all colors.

Subtractive primaries work together by **removing** lights of different wavelengths from the reflectance of an object; combination of the three subtractive primaries yields **black** (dark brown), the absence of all color.

The additive primaries have their complementaries in the subtractive primaries:

(18) **RBG   CYM**
Red   –   Cyan
Blue –   Yellow
Green–   Magenta

Furthermore, subtractive primaries are (perceptual or non-perceptual) combinations of additive primaries:

(19) a.   Magenta (reddish-blue)   b.   Cyan (blue-green)

Red   Blue   Blue   Green

c.   Yellow

Red   Green

Following Jaspers (2011), we may arrange the two triangles of primaries with their relations of complementarity as in (20):

(20)

COMPLEMENTARIES ———————   SUBTRACTIVE PRIMARIES ··················
ADDITIVE PRIMARIES – – – – – ·
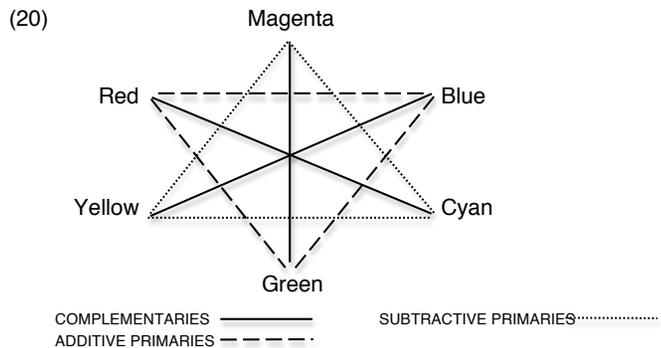
Adding relations of combination derives the hexagon (21):

(21)

COMPLEMENTARIES ———————   SUBTRACTIVE PRIMARIES ··················
COMBINATION ——————▶   ADDITIVE PRIMARIES – – – – – ·
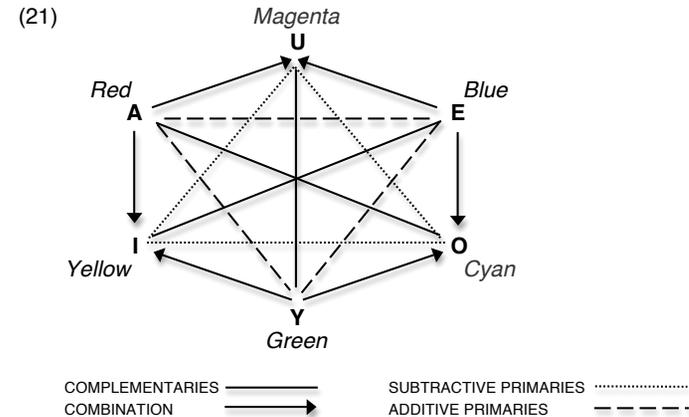
The corner labeling is intended to draw out lexicalization parallelisms between this figure, and (10)/(14) for the logical relations.

- Of the six color terms present in the hexagon, only four are felt as "natural": RBYG.
- The two non-natural words (CM) occupy the O and U corners

The correctness of this mapping is further supported by the special status of yellow.

2.1   The Special Status of Yellow

(21) reveals an asymmetry between CM vs. Y:

- CM are **perceptual combinations** of their contributing additive primaries (RB/BG, resp.).
- Y is **not a perceptual combination** of RG; i.e., Y is not perceived as reddish-green or greenish-red, but as a distinct, **unary color**.
- Y seems to enter into its own perceptual combinations with RG: Y + R = Orange; Y + G = Yellow-Green

Y's apparent status as a unary color led to vigorous debate about the true identity of the additive primaries.

2.1.1   Is Yellow a Primary?

RGBers: RGB is the true triad: R corresponds to activation of long-wavelength-sensitive (L) retinal cone cells, G corresponds to activation of medium-wavelength-sensitive (M) cone cells, and B corresponds to activation of short-wavelength-sensitive (S) cone cells.

RYBers: RYB is the true triad: R corresponds to activation of (L) cones, Y corresponds to activation of L+M cones, and B corresponds to activation of (S) cones.

Jaspers (2011) notes that this debate strongly parallels those in logic regarding the status of middle terms (*or*, *some*) - whether they are **exclusive** or **inclusive**:

(22) *Competing Primary Color Models*

Percept Source	RGB Model	RYB Model	
L-cone	Red	Red	
M-cone	Green		Yellow
S-cone	Blue	Blue	

(23) *Competing Logical Models*

Concept Type	Exclusive *Or*	Inclusive *Or*	
Conjoined affirmative	And	And	Either,
Disjoined affirmative	Either, but not both		maybe both
Conjoined negative	Nor	Nor	

| Concept Type	Exclusive *Some*	Inclusive *Some*	
Universal affirmative	All	All	Some,
Particular affirmative	Some, but not all		maybe all
Universal negative	No/None	No/None	

RGBers argue for an **exclusive middle color**; RYBers argue for an **inclusive** one.

2.1.2   Binary Color Oppositions

Hering (1964/1920) proposes the RGB base has supermiposed on it **a pair of binary oppositions that do not yield mixed colors**: B – Y and R – G.

B + Y =   B when S-cone activation is dominant (darker B = more S)
            W when L+M = S
            Y when L+M-cone activation is dominant (darker Y = more L+M)

R + G =   R when L-cone activation is maximal
            Orange as L-cone activation decreases, but L > M
            Y when L = M
            YG as M-cone activation increases, but L < M
   G when M-cone activation is maximal

(24)
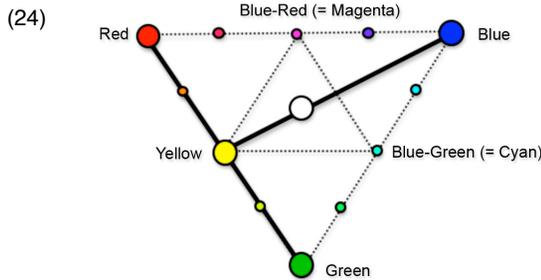
Hering's proposal has support from comparative/evolutionary studies of primate color vision.

■ Dichromactic color vision is the historic and contemporary mammalian norm (Jacobs 2009a, 2009b).
■ Trichromacy appears to have arisen in primates from a dichromat state by development of a novel M/L photopigment (Jacobs 2009b) – i.e., elaboration at the yellow pole.
■ Ability to discriminate red-green may have been selectively advantageous in distinguishing fruits from a foliage background (Jacobs 2005), or in distinguishing immature, easily digested, protein-rich foliage (which often flushes red in the tropics) from mature green foliage (Dominy and Lucas 2001).

2.1.3   Deriving Color Terms (Jaspers 2011)

The parallelism in the logic and color term hexagons, and the two polar oppositions B – Y and R – G in the latter, suggests an approach to "non-natural" color words similar to that deployed for logic.

Suppose the basic domain is color percepts. The initial division in the space is between the (S-cone) Blue and its (L+M) complementary Yellow (25a). Within the residue non-Blue percept space, we can either carve out the subset Red (L), leaving Yellow as the super set space (L+M) (25b), or we can divide the Yellow percept space exhaustively into Red (L) and non-Red (M) (25c):

(25) a.   *Step 1*   b.   *Step 2*   c.   *Step 2'*
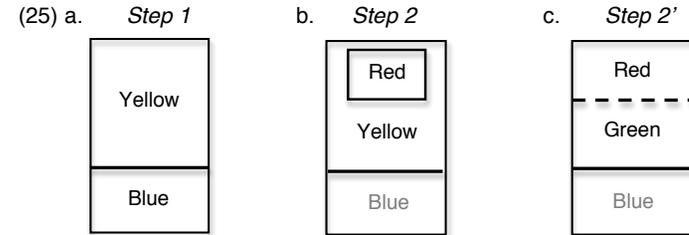
Natural color terms match natural divisions of the percept space.

Non-naturalness of *cyan and *magenta follows from their percepts' noncongruency with natural divisions of the percept space; both cut across the B – Y division (26a,b):

(26) a.   *Illicit Step*   b.   *Illicit Step*

11   12
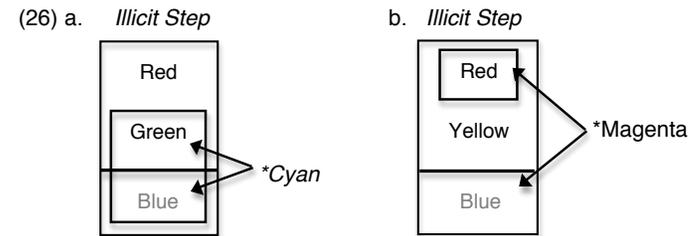
Summary:

Human cognition appears to deploy parallel constraints on logical concept formation and color percept formation:

- Observed in the availability of naturally occurring words for certain logic/color percepts, but not in availability *per se*. Non-natural concepts in the respective domains can be lexified by system external means (*nand, iff, nall / magenta, cyan*), or by productive, compositional means (*if and only if, all or no / redish-blue, blue-green*).
- The constraints are on the systematic partioning of an antecedently given conceptual or perceptual space. Divisions are made within existing divisions, and not across them. This accounts for "missing words".
- The structures for logic concepts and color percepts appear to be isomorphic: the same system is in play in both,

3.0   Broad and Narrow Lexical Domains

These results imply that the lexicon for logical and color concepts/percepts has distinct sources:

- A formal system (C-P) like that proposed in Jaspers (2005, 2011), deriving concepts-percepts by application of formal operations (the Peircean NEC operator) to a space of entities (propositional values, wavelengths), and obeying formal constraints ("make divisions within divisions").
- Other systems of concept-percept formation (C-P', C-P", etc.) applicable to the same space, but not subject to (the same) formal principles, and constraints.

(27) a.

1 1	→	C-P	→	Nor, Or, And, (Excl, Or)
1 0	→	C-P'	→	Nall, Iff
0 1				
0 0				

b.

→ C-P → Blue, Yellow, Red, (Green)

→ C-P' → Magenta, Cyan, Orange, Yellow-Green, Bluish Cyan, etc.

→ C-P"→ Slate, Ash, Sky Blue, Blood Red, Forest Green, etc.

C-P' appears to allow us to take concepts-percepts from the structured space produced by C-P and create binary combinations of them by "Boolean" operations (union, intersection, mereological sum, mereological product), without respecting the divisions of the space induced by C-P.

- Whereas C-P produces unary concepts, C-P' produces binary ones.
- Unary concepts appear to be the "natural" target of word formation.

C-P" appears to allow us to take percepts from the unstructured percept space and create concepts according to their **prototypical association** with entities in the domain of "objects" (Goddard 1998).

It seems plausible that considerations of broad and narrow faculties apply here.

- C-P represents a "narrow faculty" underlying natural word formation in its domains and hence arguably part of FLN,
- C-P' represents a combinatorical mechanism ("make one out of two"), and possibly the result of recursion at this level. Its status FLN/FLB depends on the status of Recursion/Merge itself.
- C-P" represents a broader cognitive mechanism associated with prototype formation generally and plausibly part of FLB,

This would imply that HCF (2002)'s proposal that FLN is confined exclusively to narrow syntax would not be correct: subdomains of other components of language (here, the lexicon) would show the presence of FLN capacities.

An intriguing potential implication of Jaspers (2011) is that C-P in the domain of color percepts underlies the development of logic: that latter arose through a "digitalization" of color percept structure. Mereological operations on the continuous domain of wavelengths were instantiated as corresponding set-theoretic operations on a discrete space (situations, interpreted model-theoretically).

We leave this speculation for further research.

Thank you!

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