Remarks on culture (mostly, language) evolution

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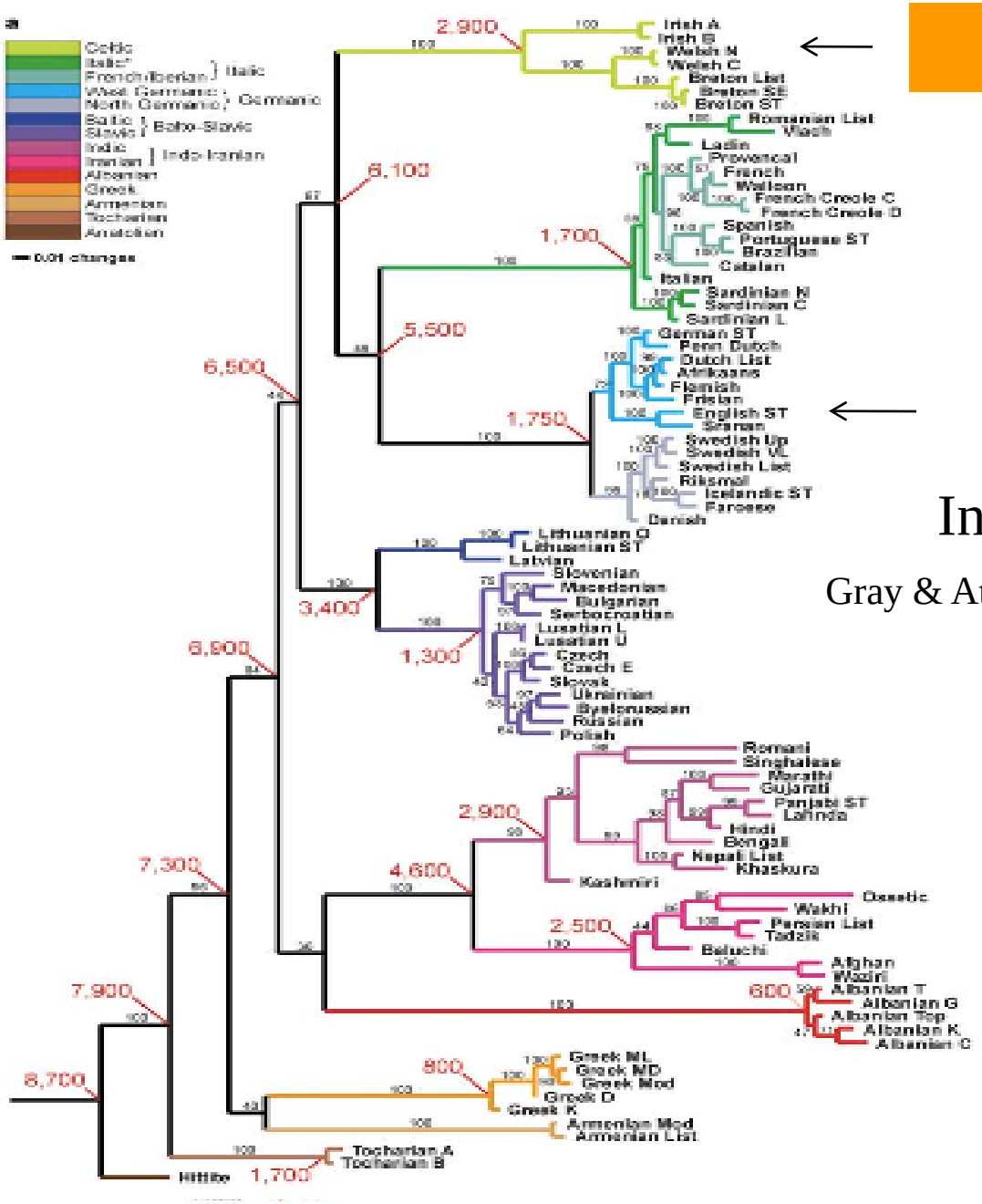
Why language?

“Language is too important to be left to the linguists”

adapted from Georges Clemenceau, Premier of France, World War I

Glottochronology



Indo-European family tree

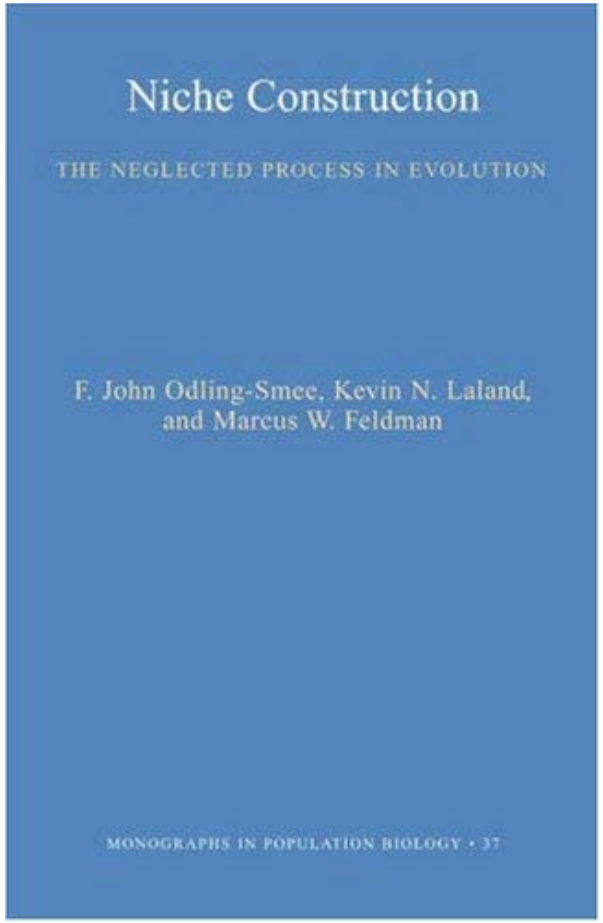
Gray & Atkinson, *Nature* **423**: 435-439 (2003)

cognates from
Swadesh lists

How culture shaped the human genome: bringing genetics and the human sciences together

Genes	Function or phenotype	Inferred cultural selection pressure
LCT, *MAN2A1*, *SI*, *SLC27A4*, *PPARD*, *SLC25A20*, *NCOA1*, *LEPR*, *LEPR*, *ADAMTS19*, *ADAMTS20*, *APEH*, *PLAU*, *HDAC8*, *UBR1*, *USP26*, *SCP2*, *NKX2-2*, *AMY1*, *ADH*, *NPY1R*, *NPY5R*	Digestion of milk and dairy products; metabolism of carbohydrates, starch, proteins, lipids and phosphates; alcohol metabolism	Dairy farming and milk usage; dietary preferences; alcohol consumption
Cytochrome P450 genes (*CYP3A5*, *CYP2E1*, *CYP1A2* and *CYP2D6*)	Detoxification of plant secondary compounds	Domestication of plants
CD58, *APOBEC3F*, *CD72*, *FCRL2*, *TSLP*, *RAG1*, *RAG2*, *CD226*, *IGJ*, *TJP1*, *VPS37C*, *CSF2*, *CCNT2*, *DEFB118*, *STAB1*, *SP1*, *ZAP70*, *BIRC6*, *CUGBP1*, *DLG3*, *HMGCR*, *STS*, *XRN2*, *ATRN*, *G6PD*, *TNFSF5*, *HbC*, *HbE*, *HbS*, *Duffy*, α-globin	Immunity, pathogen response; resistance to malaria and other crowd diseases	Dispersal, agriculture, aggregation and subsequent exposure to new pathogens; farming
LEPR, *PON1*, *RAPTOR*, *MAPK14*, *CD36*, *DSCR1*, *FABP2*, *SOD1*, *CETP*, *EGFR*, *NPPA*, *EPHX2*, *MAPK1*, *UCP3*, *LPA*, *MMRN1*	Energy metabolism, hot or cold tolerance; heat-shock genes	Dispersal and subsequent exposure to novel climates
SLC24A5, *SLC25A2*, *EDAR*, *EDA2R*, *SLC24A4*, *KITLG*, *TYR*, *6p25.3*, *OCA2*, *MC1R*, *MYO5A*, *DTNBP1*, *TYRP1*, *RAB27A*, *MATP*, *MC2R*, *ATRN*, *TRPM1*, *SILV*, *KRTAPs*, *DCT*	The externally visible phenotype (skin pigmentation, hair thickness, eye and hair colour, and freckles)	Dispersal and local adaptation and/or sexual selection
CDK5RAP2, *CENPJ*, *GABRA4*, *PSEN1*, *SYT1*, *SLC6A4*, *SNTG1*, *GRM3*, *GRM1*, *GLRA2*, *OR4C13*, *OR2B6*, *RAPSN*, *ASPM*, *RNT1*, *SV2B*, *SKP1A*, *DAB1*, *APPBP2*, *APBA2*, *PCDH15*, *PHACTR1*, *ALG10*, *PREP*, *GPM6A*, *DGKI*, *ASPM*, *MCPH1*, *FOXP2*	Nervous system, brain function and development; language skills and vocal learning	Complex cognition on which culture is reliant; social intelligence; language use and vocal learning
BMP3, *BMPR2*, *BMP5*, *GDF5*	Skeletal development	Dispersal and sexual selection
MYH16, *ENAM*	Jaw muscle fibres; tooth-enamel thickness	Invention of cooking; diet

Laland, Odling-Smee & Myles, *Nat. Gen.* **11**: 137-148 (2010)



Niche Construction

"acquired characteristics play a role in evolution by their influence on selective environments through niche construction."

"modification of an environment requires temporal persistence and accumulative effects…"

$$R_t = \sum_{i=t-m+1}^{t} \pi_i v_i$$

environmental resource: depends on *m* previous generations

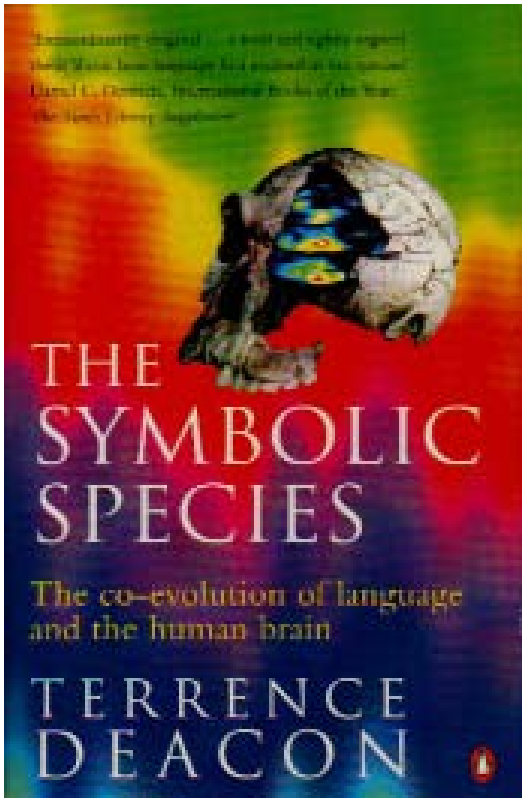
frequency of niche constructors

weights

$$\sum_{i=t-m+1}^{t} \pi_i = 1$$

The parasite hypothesis

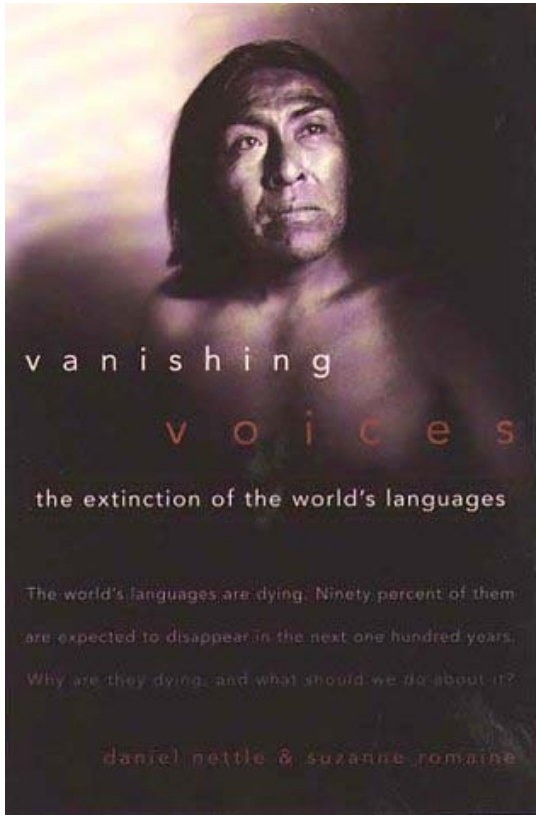
Deacon, 97: The Symbolic Species



Language co-evolves with children's minds!

"A struggle for life is constantly going on amongst the words and grammatical forms in each language. The better, the shorter, the easier forms are constantly gaining the upper hand, and they owe their success to their own inherent virtue." Max Müller, 1899

Language diversity



The world's languages are dying. Ninety percent of them are expected to disappear in the next one hundred years. Why are they dying, and what should we do about it?

Nettle & Romaine, 2000

7000-6700 languages in the world today

the hundred largest – 90% of population

Mandarin, English, Spanish, Bengali, Hindi, Portuguese, Russian, Japanese, German,…

Modelling the dynamics of language death

x: fraction of population that speaks W
$y = 1 - x$

$$\frac{dx}{dt} = yP_{yx}(x,s) - xP_{xy}(x,s)$$

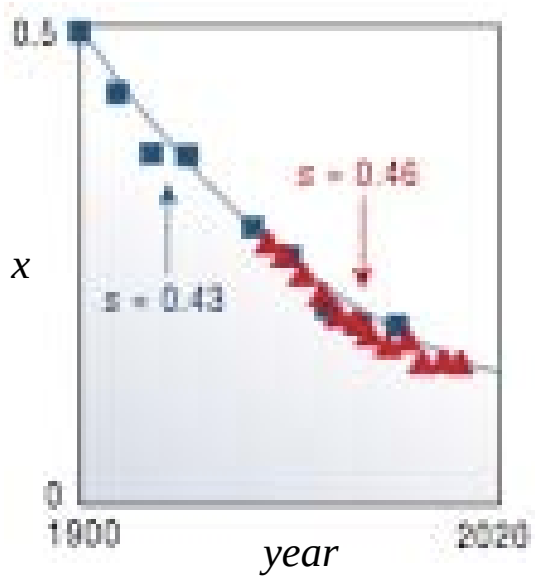
$$P_{yx}(x,s) = cx^a s$$

status of W

$$P_{xy}(x,s) = c(1-x)^a(1-s)$$

four free-parameters: c, s, a, $x(0)$

Welsh in Wales



$a \approx 1.31$

Abrams & Strogatz, *Nature*, **424**: 900 (2003)

Three-generational pattern (two languages W and E)

First generation: monolingual in W

Second generation: bilingual in W and E

Third generation: monolingual in E

the dominant language

children don't speak their grandparent's language

Are you currently expecting a baby, or already have young children?

Of course, you will be eager to ensure that you give your child the best every time - good food, safe toys, then the best education. But one of the things that you may not have thought about is which language to speak with your child.

Twf
Cymraeg o'r Crud
2 Languages from Day 1

One of the best gifts you can give a child is the skill of speaking two languages. Why not start introducing the Welsh language to your child once it is born.

http://www.northwestwales.org/WiSSCMS-en-199.aspx

Population dynamics approach

v_t fraction of adults that speak W at generation t

u_t fraction of adults that do not speak W at generation t

$$u_t + v_t = 1$$

$$u' = u_t + (1-b)v_t$$
$$v' = bv_t$$

vertical transmission
(learning W from parents)

$b \in [0,1]$ efficiency of vertical transmission

vertical + oblique transmission (learning W from adults other than parents)

$$v' = bv_t + f_{vu} v_t u_t + (1-b) v_t f_{vv} \Lambda_n(v_t)$$

children of parents that speak W who learned W from them

children of parents that do not speak W who learned W from teachers

random meetings

children of parents that speak W who failed to learn from them but succeeded to learn from teachers.

$$\Lambda_1(v_t) = v_t$$

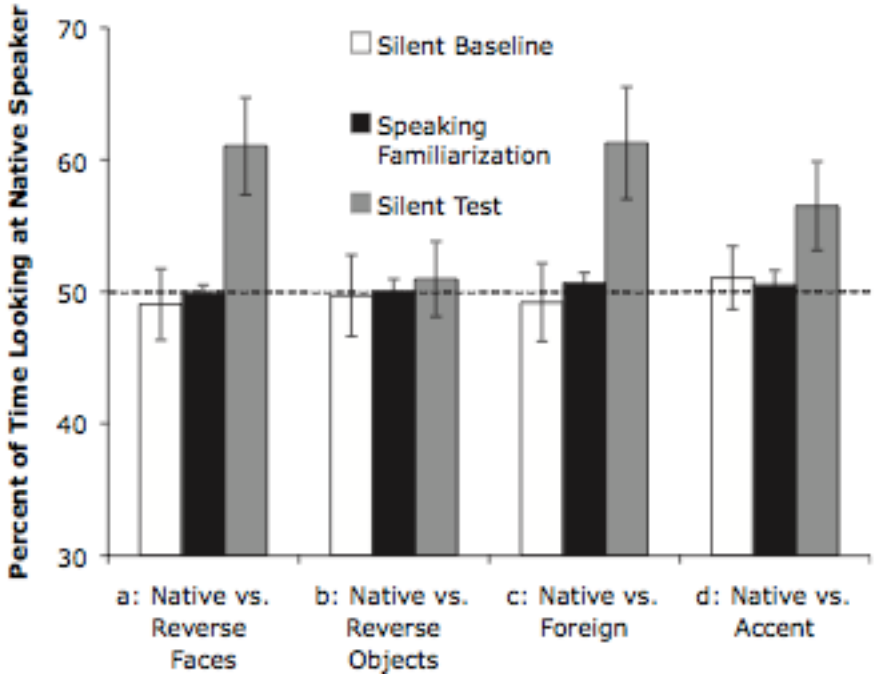
random meetings

$f_{vv,vu} \in [0,1]$ efficiency of oblique transmission

The native language of social cognition

Kinzler, Dupoux & Spelke: *PNAS* **104**: 12577-12580 (2007)

5- to 6- month-old infants prefer to look at (and interact with) a person who previously spoke their native language!



active search for speakers of W

$$\Lambda_n(v_t) = 1-(1-v_t)^n$$

probability of finding a teacher in *n* random attempts

$$\Lambda_1(v_t) = v_t \qquad \Lambda_\infty(v_t) = 1$$

random meetings

viability selection (advantage or not of speaking W)

$(1+s)$ fitness of adults that speak W

1 fitness of adults that do not speak W

$s \in [-1,1]$

recursion equation $$v_{t+1} = \frac{v''(1+s)}{u''+v''(1+s)} = \frac{v''(1+s)}{1+sv''}$$

Analysis of the equilibrium solutions

$$\nu_t = \nu_{t+1} = \nu$$

$\nu = 0$ is always a fixed point

(speakers of W gone for good)

$\nu = 1$ is not a fixed point

$$(1+s)(b+f_{vu}) < 1 \qquad \text{finite } n$$

stability of $\nu = 0$

$$(1+s)\left[f_{vv}(1-b)+(b+f_{vu})\right] < 1 \qquad \text{infinite } n$$

Main result

$$f_{vu} = 0$$

$$\Lambda = 1$$

(best case)

If speakers of E do not learn W then W will be extinct regardless of any effort the W-speaking community can make to improve vertical transmission (b) or learning efficiency (f_{vv}), except for increasing the relative status of W (s):

$$s > \frac{(1-b)(1-f_{vv})}{f_{vv} + b(1-f_{vv})}$$

1978 - Galician becomes co-official with Castilian
1993 - Welsh Language Act
2005 - Gaelic Language (Scotland) Act

Diolch

thanks in W