



Center for the Interdisciplinary Study of Language Evolution (ISLE)
University of Zurich
Inaugural Workshop
Zurich 4. - 5. March 2019

The Evolution of Language: Bridging the natural and cognitive sciences

<https://www.isle.uzh.ch/en/Events.html>

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Welcome to the Workshop

The aim of the workshop, and the mission of the Center for the Interdisciplinary Study of Language Evolution (ISLE), is to bridge between different approaches working on language evolution, specifically between the natural and cognitive sciences. Although much progress has been made in the past two decades, comparative research on animal communication and work on human language have traditionally been undertaken in isolation, a division often reinforced by how departments and faculties are typically organized. We aim at breaking this tradition and bring the full force of each discipline, its theories and methods, to bear on all questions relating to the phylogeny, ontogeny, and dynamics (cultural evolution and variability) of language and animal communication. We would like to ask all presenter to keep in mind that kicking off such an interdisciplinary endeavor will require an extra effort of each participant in making their research accessible to researchers from other disciplines. To enter such a dialogue be aware the participants might not have a background in your field and please avoid any technical jargon.

Workshop Format

The ISLE Inaugural Workshop will last for two full days (4-5 March, 2019). Our program comprises four keynote addresses, six paper sessions and a poster session. As speakers for the four keynote addresses we are happy to welcome Susan Goldin-Meadow (University of Chicago), Morten Christiansen (Cornell University), Simon Kirby (University of Edinburgh) and Tecumseh Fitch (University of Vienna). The paper sessions include two to four 20-minutes presentations and enough time for feedback and discussion. Each session will combine presentations from different disciplinary backgrounds. In addition to the paper sessions, we schedule one poster session. On Monday evening (March 4, 2019), a workshop dinner will create the opportunity to socialize with the participants.

Slides and posters

To ensure a smooth running of the presentations, we kindly ask all presenters to hand in your presentation slides (PowerPoint, Keynote or PDF) to our administrative coordinator at the latest at the beginning of the break preceding your talk. You can also send them beforehand by [e-mail](#).

Please bring your poster at the registration on Tuesday morning 5 March.

Workshop Program

Day 1: Monday, 4 March 2019

Location

University of Zurich main building KOL, [Rämistrasse 71, Zurich](#)
Room [KOL-G-217](#)

08h15 – 08h40	Registration
08h45 – 08h55	Welcome from the President of the University
08h55 – 09h15	Introduction
09h15 – 10h15	Keynote: Susan Goldin-Meadow What small data can tell us about the resilience of language that big data can't
10h15 – 10h45	Coffee break
10h45 – 12h45	Paper session 1 (details see below) Chair: Carel van Schaik
12h45 – 14h00	Lunch
14h00 – 16h00	Paper session 2 (details see below) Chair: Klaus Zuberbühler
16h00 – 16h30	Coffee break
16h30 – 17h30	Paper session 3 (details see below) Chair: Martin Meyer
17h30 – 18h30	Keynote: Morten Christiansen Language Acquisition as Skill Learning
19h30 – 22h00	Workshop Dinner @ Linde Oberstrass

Paper session 1Monday, 4 March 2019 (10h45 – 12h45), Room [KOL-G-217](#)

Chair: Carel van Schaik

- 10h45 – 11h15 **The evolution of the primate larynx**
Dunn JC, Bowling DL, Garcia M, Smaers J, Kerney M, Stewart A, Hanke G, Kitchener A, Handschuhe S, Degg S, Gumpenberger M & Fitch WTS
- 11h15 – 11h45 **A biologically grounded aerodynamic bias has created global sound patterns in speech**
Everett C
- 11h45 – 12h15 **Gravettian hand stencils as sign language formatives**
Etxepare R & Irurtzun A
- 12h15 – 12h45 **Language evolution and the cerebellum**
Barton R

Paper session 2Monday, 4 March 2019 (14h00 – 16h00), Room [KOL-G-217](#)

Chair: Klaus Zuberbühler

- 14h00 – 14h30 **Finding structure in continuous signals to understand evolution of speech**
de Boer B, Jadoul Y & Van Soom M
- 14h30 – 15h00 **Chestnut-crowned babblers construct calls from meaningless, shared building blocks**
Engesser S, Holub JL, O'Neill LG, Russell AF & Townsend SW
- 15h00 – 15h30 **Testing Processes of Semantic Diversification in Primates**
Thouzeau V, Dezechache G, Dunbar E, Schlenker P, Chemla E & Ryder R
- 15h30 – 16h00 **Probing the evolutionary origins of the agent preference in human language**
Sauppe S & Bickel B

Paper session 3Monday, 4 March 2019 (16h30 – 17h30), Room [KOL-G-217](#)

Chair: Martin Meyer

- 16h30 – 17h00 **Vocal communication of emotion: A biologically universal code underpinning language evolution**
Filippi P
- 17h00 – 17h30 **Human screams' roughness and pitch synergistically and simultaneously contribute to trigger efficient neural and behavioral responses**
Arnal LH, Mégevand P & Giraud AL

Day 2: Tuesday, 5 March 2019**Location**

University of Zurich RAA building, [Rämistrasse 59, Zurich](#)
Room [RAA-G-01](#)

The poster session will take place at the *Lichthof* (ground floor) of the same RAA building.

- | | |
|---------------|--|
| 08h15 – 08h25 | Registration |
| 08h30 – 09h30 | Keynote: Simon Kirby
How cultural evolution and self-domestication created structure in language |
| 09h30 – 10h30 | Paper session 4 (details see below)
Chair: Balthasar Bickel |
| 10h30 – 11h00 | Coffee break |
| 11h00 – 13h00 | Paper session 5 (details see below)
Chair: Judith Burkart |
| 13h00 – 14h15 | Lunch |
| 14h15 – 15h45 | Paper session 6 (details see below)
Chair: Chiara Barbieri |
| 15h45 – 17h00 | Coffee with poster session (details see below) |
| 17h00 – 18h00 | Keynote: Tecumseh Fitch |
| 18h00 – 18h30 | Conclusion |

Paper session 4Tuesday, 5 March 2019 (09h30 – 10h30), Room [RAA-G-01](#)

Chair: Balthasar Bickel

- 09h30 – 10h00 **Mapping out the evolutionary trajectory of iconicity and combinatorial structure**
Hofer M, Tenenbaum J & Levy R
- 10h00 – 10h30 **The Sources of Meaning in the Initial Stages of a Natural Language**
Ergin R & Jackendoff R

Paper session 5Tuesday, 5 March 2019 (11h00 – 13h00), Room [RAA-G-01](#)

Chair: Judith Burkart

- 11h00 – 11h30 **Entering and exiting joint actions in great apes: A pragmatic approach to studying language evolution**
Heesen R, Genty E, Rossano F, Zuberbühler K & Bangerter A
- 11h30 – 12h00 **Cultural variation in quantities of language input directed to infants: A systematic review**
Cristia A
- 12h00 – 12h30 **Vocal individuality depending on call function in a non-primate mammal**
Wyman MT, Stauber C, Rauber R & Manser MB
- 12h30 – 13h00 **Language-gene mismatches in global human history**
Barbieri C, Blasi D, Forkel R, Hammarström H, Wichmann S, Greenhill S, Gray R, Shimizu KK & Bickel B

Paper session 6Tuesday, 5 March 2019 (14h15 – 15h45), Room [RAA-G-01](#)

Chair: Chiara Barbieri

- 14h15 – 14h45 **The first evolutionary step towards human language and culture**
Jon-And A, Lind J, Ghirlanda S & Enquist M
- 14h45 – 15h15 **A hypothesis concerning how the evolution of prosociality impacted vocal learning**
Martins PT, O'Rourke T, Andirkó A, Sturm S & Boeckx C
- 15h15 – 15h45 **The evolution of language families is shaped by the environment beyond neutral drift**
Bentz C, Dediu D, Verkerk A & Jäger G

Poster session

Tuesday, 5 March 2019 (15h45 – 17h00), [RAA Lichthof](#) (ground floor)

Language-readiness: Descent, modification, and further modification

Andirkó A, O'Rourke T, Morianos J & Boeckx C

Gricean animal communication and niche construction

Burlak S

How social complexity can favour call diversification

Crockford C

Thought for Food: Intentional communication between wild bonnet macaques and humans

Deshpande A, Gupta S & Sinha A

Transitions of carrying roles of gestures and vocalization during the early evolution of language

Fröhlich M, Sievers C, Townsend SW, Gruber T and van Schaik CP

Modelling lexical interactions in diachronic corpora

Karjus A, Blythe RA, Kirby S & Smith K

Investigating the conditions allowing for sign language persistence

Mudd K & de Boer B

Language contact, language evolution, and flexible constituent order

Namboodiripad S

Idiosyncratic vocal sequences in wild bonobos

Needle D, Dahl C, Zuberbühler K & Clay Z

The Origin of Pointing: Evidence for the Touch Hypothesis

O'Madagain C, Kachel G & Strickland B

Input variability promotes the emergence of linguistic structure

Raviv L, Meyer A & Lev-Ari S

CHIELD: The Causal Hypotheses in Evolutionary Linguistics Database

Roberts SG

Language Input in a small-scale society: Estimations from daylong recordings in a Tsimane' village

Scaff C, Stieglitz J, Casillas M & Cristia A

Effects of Compositionality, Number of Grammatical Distinctions and L1 on L2 Learning Difficulty and Morphological Simplification

Semenuks A et al.

The role of redundant marking in language learning

Tal S & Arnon I

Vocal accommodation and pair bonds in common marmosets

Zürcher Y & Burkart JM

Venue and Transportation

On **Day 1** (4 March), the workshop will take place at room [KOL-G-217](#) in the main building of the University of Zurich ([Rämistrasse 71, Zurich](#)).
Building: KOL / Floor: G / Room number: 217

On **Day 2** (5 March), the workshop will take place at room [RAA-G-01](#) of the University of Zurich ([Rämistrasse 59, Zurich](#)).
Building: RAA / Floor: G / Room number: 01
The poster session will take place at the *Lichthof* (ground floor) of the same RAA building.

The two buildings are located in the center of Zurich and can easily be reached from the airport and the central train station. The closest tram stops are "ETH/Universitätsspital" (trams 6, 9 and 10) and "Kantonsschule" (trams 5 and 9).

Public transport

If you use public transport to move around Zurich, we recommend to purchase day cards as these are valid for 24 hours and cost the same as two one-way tickets. If you are traveling only within Zurich city, you need to purchase a ticket for zone 110 (counting as 2 zones). If you are traveling from the airport, you need to purchase a ticket for zones 121 and 110 (counting as 3 zones).

Traveling from the airport:

Train to Zurich main station (15-20 min, every 2-10 min)
Tram 10 to downtown Zurich (35 min, every 7-15 min)

Traveling to the two buildings:

Tram 5 and 9 to tram station "*Kantonsschule*"
Tram 6, 9 and 10 to tram station "*ETH/Universitätsspital*"

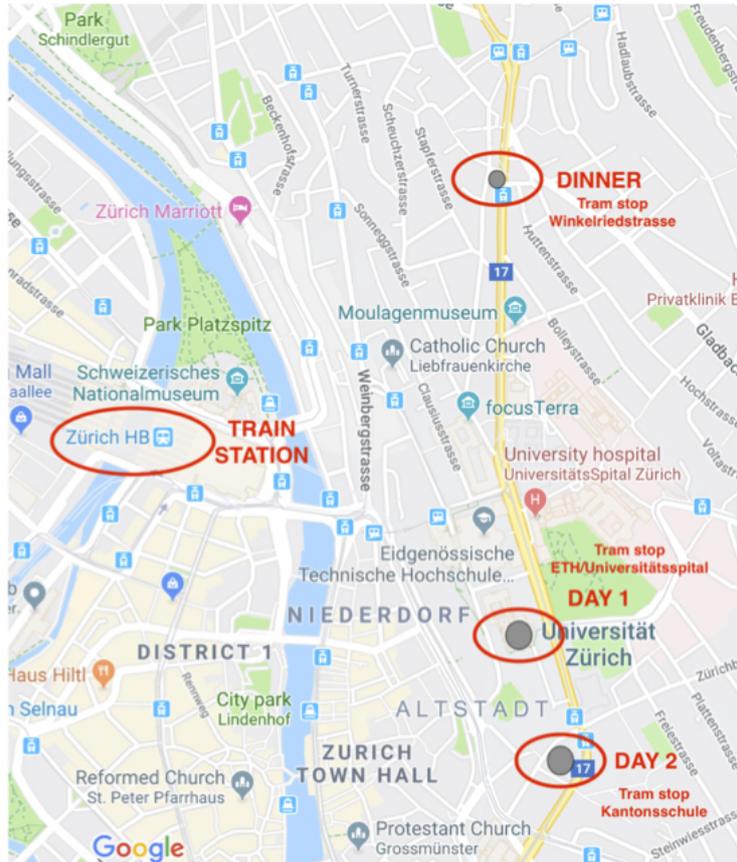
Timetables:

<https://www.google.com/maps>
<https://online.fahrplan.zvv.ch/bin/query.exe/en>

Prices:

Daycard Zone 110 (24 hours): CHF 8.80.- (CHF 6.20.- with Swiss half-tax)
Daycard Zones 121 and 110 (24 hours): CHF 13.60.- (CHF 6.80.- with Swiss half-tax)
One-way Zone 110 (1 hour): CHF 4.40.- (CHF 3.10.- with Swiss half-tax)
One-way Zones 121 and 110 (1 hour): CHF 6.80.- (CHF 3.40.- with Swiss half-tax)

Map and pictures



Day 1: main building KOL



Day 2: building RAA

Social dinner

Our workshop dinner will take place on Monday (4 March) at the *Zunftsaal* - first floor - of the restaurant Linde Oberstrass ([Universitätstrasse 91, 8006 Zürich](#)). The restaurant is located 15 minutes by foot or 2 tram stations of the University of Zurich main building.

The 3-course menu will cost between CHF 40.00.- and CHF 50.00 without alcoholic beverages. Please help us to smooth the paying process by a) bringing cash so that not everyone needs to pay with card and b) remembering what you ordered in terms of food and drinks.



General information

Registration

There is no registration fee to attend the workshop but we kindly ask you to participate to the costs of the lunches and coffee breaks which we will provide. For both days, please bring CHF 50.00.- (CHF 30.00.- for students) in cash at the registration. For one day please bring CHF 25.00.- (CHF 15.00.- for students) in cash at the registration. We will provide a receipt.

To help us with the registration process, we kindly ask you to arrive early at the registration on Day 1. You will also be able to register during coffee breaks.

People attending only on Day 2 will be able to register in the morning as well as during the first coffee break.

WiFi access

To access the Wi-Fi you will have to visit the following page: <http://t.uzh.ch/coa> and insert this event ID: **19ISLE2975**

Please note that you need an internet connection in order to request a WiFi account. Accounts can be requested starting February 26 and will be valid until March 7.

For members of the University of Zurich, please use your own credentials to access the WiFi.

ATM

An ATM is located on floor D of the University of Zurich main building KOL.

There is also an ATM near the restaurant Linde Oberstrass where the social dinner will take place.

Acknowledgments

We would like thank the University of Zurich for its support.



Organizers

Sabine Stoll
Marta Manser

Organizing committee

Balthasar Bickel
Martin Meyer
Carel van Schaik
Simon Townsend
Klaus Zuberbühler

For any questions, feel free to contact us or our administrative coordinator at any time

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Paper abstracts

The evolution of the primate larynx

Dunn JC^{1,1}, Bowling DL³, Garcia M^{3,4}, Smaers J⁵, Stewart A⁶, Hanke G⁷, Kitchener A⁷, Handschuhe S⁸, Dengg S⁹, Gumpenberger M⁹ and Fitch WTS³

¹Behavioural Ecology Research Group, Anglia Ruskin University; ²Department of Archaeology, University of Cambridge; ³Department of Cognitive Biology, University of Vienna; ⁴L'Equipe de Neuro-Ethologie Sensorielle, Université de Lyon/Saint Etienne; ⁵Department of Anthropology, Stony Brook University; ⁶Center for Language Evolution, University of Edinburgh; ⁷Department of Natural Sciences, National Museums Scotland; ⁸VetCore Facility for Research, University of Veterinary Medicine, Vienna; ⁹Klinische Abteilung für Bildgebende Diagnostik, University of Veterinary Medicine, Vienna

Understanding the evolution of vocal communication requires detailed knowledge of the sound production mechanism, which in mammals centres on the larynx. The mammalian larynx is a key target for selection, particularly in species with highly developed auditory-vocal communication. Identifying the resulting adaptive modifications depends on understanding laryngeal morphology in phylogenetic context. Using state-of-the-art phylogenetic comparative methods and a novel database of digital measurements obtained from 3-dimensional CT scans, we compare and contrast laryngeal specimens from 26 primate and 29 carnivoran species, covering nearly the full body size range in both orders. Our results show that the primate larynx has evolved more rapidly than the carnivoran larynx, resulting in a pattern of larger overall size and increased deviation from expected allometry with body size. We also show that residual larynx size is a strong predictor of call fundamental frequency in our sample, underscoring the relevance of our results for the evolution of vocal communication. Using excised larynx experiments, we show that, across species, vocal fold length predicts minimum fundamental frequency much better than body size, clearly demonstrating the potential for decoupling between larynx size and body size. Overall, these results imply that selective pressures on the mechanistic determinants of vocalization may be especially strong in primates, consistent with the hypothesis that the complexity of primate social organization is a key driver underlying vocal complexity. Such inference may provide insight into mechanisms underlying vocal complexity and the evolution of speech.

A biologically grounded aerodynamic bias has created global sound patterns in speech

Everett, Caleb

University of Miami, Anthropology & Psychology

Vocal cord vibration is theoretically more difficult to achieve for stop consonants articulated near the glottis since such sounds limit transglottal airflow. [1,2] Yet physical modeling suggests this aerodynamic bias is minor and typological data are somewhat equivocal vis-à-vis the effect of the bias on phoneme inventories. [3-5] Ongoing work seeks to illuminate this potential bias by considering the rates at which sounds occur in phonetically transcribed word lists for about 4500 languages and in transcriptions of discourse for those languages tested in greater detail. [5,6, here] This work suggests languages systematically disprefer voiced consonants made closer to the glottis. Globally, voiced velar stops are three times less common than voiceless velar stops. In contrast, voiced alveolar stops are about half as common as their voiceless counterparts, while voiced and voiceless bilabial stops are approximately equi-frequent. These tendencies surface even within languages that have both voiced and voiceless phonemes at the relevant places of articulation. The word list patterns are robust to confounds like language relatedness and contact, judging from the results of random sampling tests and linear mixed modeling. [5] In this talk it is shown that the relevant patterns surface a) across all major geographic regions and across the vast majority of 300+ language families/isolates tested, b) within those corpora of transcribed discourse so far tested and, c) in field recordings of Tupi-Karitiãna. In short, the patterns are evident in granular intralinguistic data, much as they are in thousands of phonetically transcribed word lists. The results presented suggest that the relevant minor aerodynamic bias, motivated by human vocal tract morphology, has played an under-appreciated role in shaping sound patterns in speech. Given that the relevant characteristics of the vocal tract predate the global spread of sapiens, this role is likely an ancient one.

1. Gordon, Matthew. 2016. *Phonological Typology*. Oxford: Oxford University Press.
2. Napoli, Donna Jo, Nathan Sanders and Rebecca Wright. 2014. On the linguistic effects of articulatory ease, with a focus on sign languages. *Language* 90. 424–56.
3. Ohala, John. 1983. The origin of sound patterns in vocal tract constraints. *The production of speech*, ed. by Peter MacNeilage, 189–216. New York: Springer.
4. Maddieson, Ian. 2013. Voicing and gaps in plosive systems. *The world atlas of language structures online*, ed. by Matthew Dryer and Martin Haspelmath. Leipzig: Max Planck Institute for Evolutionary Anthropology. Online: <http://wals.info/chapter/5>.
5. Everett, Caleb. In press. *Language*.
6. Everett, Caleb. 2018. *Language Sciences*.

Gravettian hand stencils as sign language formatives

Etxepare, Ricardo¹ and Irurtzun, Aritz²

¹CNRS, IKER UMR 5478; ²CNRS, IKER UMR 5478

Several archeological sites display hand stencils with so-called ‘mutilated’ fingers (Fig. 1). We explore the hypothesis that they represent configurations resulting from the deliberate folding of fingers, intentionally projected as a negative figure onto the wall (Leroi-Gourhan, 1967). The issue is what kind of signs these could be. Archaeological work talks loosely about conventional signs associated to hunting or counting (Rouillon, 2006; Overman, 2014). Leaving aside conjectures about their meaning, we explore the hypothesis that they represent the type of handshape ordinarily found in the phonology of sign languages. In other words, that these handshapes are sign language formatives. We propose a three-step study: (i) the analysis of the biomechanics of the handshape, analyzing articulatory effort (adapting Ann’s (1996) physiological metric); (ii) the analysis of the handshapes in terms of the constraints and categories specific to sign language phonology; (iii) the systematic comparison of the handshapes across Gravettian sites. As an illustration, the easiness of articulation (EAS) of the most common stencil “O” in Gargas (Figure 1) can be calculated to be 0, i.e. ‘easy’. However, even though they are producible as stencils against walls, configurations I, J, L and M are unattested. This correlates with the fact that their corresponding handshapes are physically unarticulable in the air (all with EAS ≤ 4), which suggests a correspondence between hand stencils and handshape signs. The EAS will lay out the ground for asking about specific constraints identified in sign language phonology, such as aperture and joint configuration of Selected Fingers (Brentari, 1998), the Unselected Finger Constraint (Sandler, 2012), or the number and frequency of Selected Fingers (Baker et al, 2016). We discuss the potential relevance of the presence of sign language in the Upper Paleolithic through comparison with more recent instances of bona fide bimodal bilingualism in aboriginal communities (Kendon, 1988).

Ann, J. 1996. On the relation between ease of articulation and frequency of occurrence of handshapes in two sign languages. *Lingua* 98: 19-41.

Baker, A., B. van den Bogaerde, R. Pfau & T. Schermer. 2016. *The Linguistics of Sign Languages. An Introduction*. Amsterdam & Philadelphia: John Benjamins.

Brentari, D. 1998. *A Prosodic Model of Sign Language Phonology*. Cambridge: MIT Press.

Clottes, J. J. Courtin & L. Vanrell (2005). *Cosquer redécouvert*. Paris: Seuil.

Groenen, M. 1988. Les représentations de mains négatives dans les grottes de Gargas et de Tibiran (Hautes Pyrénées). Approche méthodologique. *Bulletin de la Société royale belge d’Anthropologie et de Préhistoire* 99: 81-113.

HandPas Project: <http://handpas.juntaex.es/>

Kendon, A. 1988 [re-issued 2013]. *Sign Languages of Aboriginal Australia: Cultural, Semiotic and Communicative Perspectives*. Cambridge: Cambridge University Press.

Leroi-Gourhan, A. 1967. Les mains de Gargas. Essai pour une étude d’ensemble. *Bulletin de la société préhistorique française. Etudes et travaux* 64-1: 107-122.

Rouillon, A. 2006. Au Gravettien, dans la grotte Cosquer (Marseille, Bouches-du-Rhône), l’Homme a-t-il compté sur ses doigts? *L’anthropologie* 110: 500-509.

Overman, K.A. 2014. Finger-counting in the Upper Palaeolithic. *Rock Art Research* 31.1: 63-80.

Sandler, W. 2012. The Phonological Organization of Sign Languages. *Language and Linguist Compass* 6-3 : 162-182.

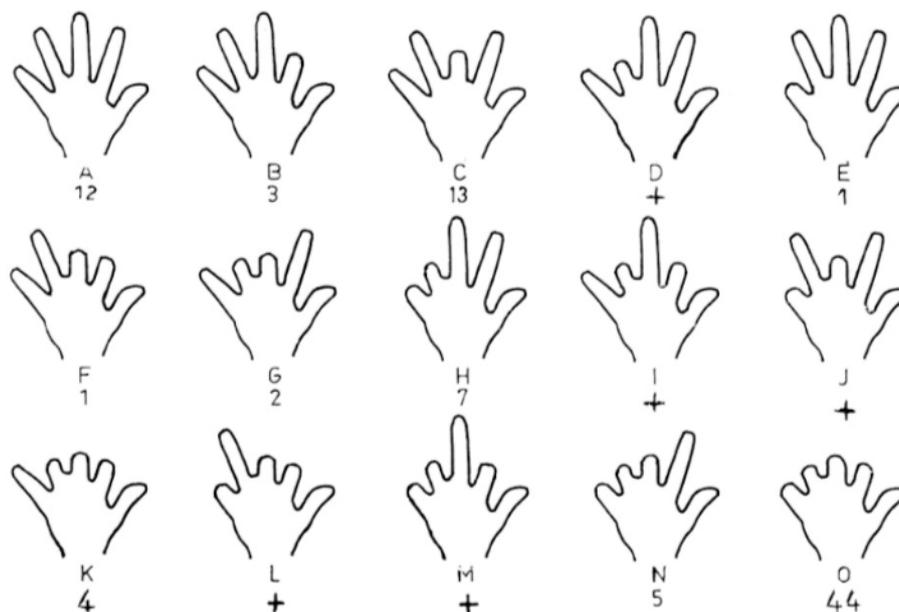


Fig. 1. — Tableau des formules digitales avec leur fréquence. Les formules non représentées sont marquées d'une croix. Dans la seconde ligne la formule index-auriculaire repliée a été omise (J) ; elle n'offre pas de représentation.

Fig. 1. Gargas hand stencils, as described by Leroi-Gourhan (1967). Configurations identified by a cross below are not attested.

Language evolution and the cerebellum

Barton, Robert

Evolutionary Anthropology Research Group, Durham University

There has been considerable interest in the idea that the capacity for language evolved from adaptations for the control of complex motor sequences involved in the production and use of tools. Evidence to date is of three main forms: (i) behavioural and computational parallels between the control of speech and of other complex motor acts, (ii) overlap between brain areas involved in tool-making and speech, (iii) phylogenetic and ontogenetic correlations between these behaviours. This work has focused primarily on the development of tool cultures in the human lineage after divergence from other apes, and on cortical mechanisms. Recently, converging evidence from cognitive neuroscience and ape behavior in the wild suggests new hypotheses about the neural basis and antiquity of the possible pre-adaptations for language. First, a key role has been postulated for the cerebellum in the control and comprehension of sequences, including speech. Second, all great apes appear to have some facility for such control and comprehension in the context of their

extractive foraging techniques, even species that do not habitually use tools in the wild. Third, phylogenetic comparative analyses demonstrate a marked acceleration in the rate of cerebellar expansion in apes, greater than that predicted from overall brain size or neocortex size, indicating selection specifically on cerebellar-mediated computations within this clade. The acceleration started at the origin of all apes but increased during the evolution of great apes, suggesting that it may have been initiated by below-branch locomotion and route planning in large-bodied animals, later becoming co-opted for sequential processing involved in extractive foraging, and eventually language.

Finding structure in continuous signals to understand evolution of speech

de Boer, Bart, Jadoul, Yannick and Van Soom, Marnix
AI-lab, Vrije Universiteit Brussel

When studying the evolution of speech, an intriguing difference between humans and other primates is humans' ability to find structure in continuous signals: we are able to split up the continuous, noisy acoustic (or visual) signals we perceive into discrete building blocks, and we are able to learn the rules of how to combine these building blocks into larger utterances. This lies at the basis of our ability use language in an unlimited way. The underlying mechanisms, however, are largely unknown. We apply techniques from artificial intelligence, data mining and machine learning to build cognitively plausible models for investigating candidate mechanisms that underlie these abilities, and for investigating possible scenarios for how they could have evolved from known abilities of other primates. More precisely, at the moment we focus on frequent sequence mining and on probabilistic approaches for analysis of speech as candidate techniques for learning structure in continuous, noisy signals. The sequence mining approach fits into a family of data mining techniques called frequent pattern mining (Aggarwal & Han, 2014). These algorithms are used to extract simple and explainable patterns from a large corpus of data, based on the occurrence frequency of said patterns, but existing methods focus on discrete, symbolic data. Probabilistic approaches to analysis of speech directly model the statistical inference process done by humans to distinguish and recognize the signal's components (Jaynes 1987; Chater et al. 2010). This approach aims to understand why human speech recognition is so robust and needs so little data compared to computer speech recognition. Although we are aware that these are undoubtedly not precisely the mechanisms that exist in humans, having more insight in these candidate mechanisms will help to better understand what may have happened in the evolution of speech.

Aggarwal, C. C., & Han, J. (Eds.). (2014). *Frequent pattern mining*. Springer, Dordrecht.

Jaynes, E. T. (1987). Bayesian spectrum and chirp analysis. In *Maximum-Entropy and Bayesian Spectral Analysis and Estimation Problems* (pp. 1-37). Springer, Dordrecht.

Chater, N., Oaksford, M., Hahn, U. & Heit, E. (2010) Bayesian models of cognition. *Wiley Interdisciplinary Reviews: Cognitive Science* 1, 811–823.

Chestnut-crowned babblers construct calls from meaningless, shared building blocks

Engesser S¹, Holub JL², O'Neill NG³, Russell AF⁴ and Townsend SW^{1,5}

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⁵Department of Psychology, University of Warwick

A core component of human language is its combinatorial sound system: a finite set of meaningless speech sounds can be used in myriad combinations to build an open-ended set of meaningful signals [1]. Whether non-human communication systems are characterized by similar forms of sound combinations has been hampered by difficulties in identifying the meaningless (shared) building blocks in animal vocalizations [2, 3]. Here we present a novel approach that allows combinatorial systems in animals to be more tractably identified. By focusing on the acoustic distinctiveness of sound elements we decompose a pair of functionally distinct chestnut-crowned babbler (*Pomatostomus ruficeps*) vocalisations into perceptibly distinct, meaningless entities that are shared across different vocalisations. Specifically, using a habituation-discrimination paradigm on wild-caught babblers under a standardised aviary set-up, we show that two multi-element calls – bi element flight and tri-element prompt calls – are composed of the same two perceptibly distinct (i.e. discriminated) sounds that are reused in different arrangements across the two calls. Furthermore, we show that none of the five elements constituting the two call types elicited differential responses in the birds, suggesting that the individual sounds do not themselves convey functionally relevant information and hence are, by definition, meaningless. By demonstrating that animal vocalizations can be resolved into smaller, meaningless building blocks that are recombined to generate meaningful signals, our work provides striking insights into the similarities between animal and human combinatoriality. Our results support the hypothesis that language's combinatorial system may have been preceded by a 'superficial' stage, where signalers neither need to be cognitively aware of the combinatorial strategy in place, nor of its building blocks [4-6].

1. Hockett CF (1960) The Origin of Speech. *Sci Am* 203:88-111.
2. Yip MJ (2006) The search for phonology in other species. *Trends Cogn Sci* 10(10):442-446.
3. Bowling DL, Fitch WT (2015) Do Animal Communication Systems Have Phonemes? *Trends Cogn Sci* 19(10):555-557.
4. de Boer B, Zuidema W (2010) Multi-Agent Simulations of the Evolution of Combinatorial Phonology. *Adapt Behav* 18(2):141-154.
5. Zuidema W, de Boer B (2009) The evolution of combinatorial phonology. *J Phon* 37(2):125-144.
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Testing Processes of Semantic Diversification in Primates

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Many living species are known to use communication systems. In particular, several primates species produce sets of calls that are well described by ethologists. While the history of human languages has been extensively studied using modern statistical methods, little is known about how primate languages evolved. We studied the process by which new calls arose over 80 million years of primate evolution: we tested whether primate calls appear first in general contexts (e.g. alarm call) and then specialised (e.g. terrestrial predator alarm call), or if a new call appears independently of existing calls. We formalised two models of the evolution of calls and applied several Approximate Bayesian Computation methods to perform model choice. Our methodology was validated by an extensive study of simulated data. Our results favored the model in which new calls appear independently from existing calls. This suggests that, during primate evolution, early calls were not necessarily general calls, but could have been used in specific contexts. Our results demonstrate it is feasible to study the linguistic history of non-human species using recent machine learning methods. This opens new avenues for inferring the evolutionary history of communication systems.

Probing the evolutionary origins of the agent preference in human language

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Most human languages refer to agents as unmarked (simple, plain) expressions, placed initially in sentences. Although there are notable exceptions (known as 'ergative and 'object-initial' languages), the overall preference for unmarked initial agents has been amply demonstrated in cross-linguistic studies [1–5] and has been argued to be rooted in a corresponding agent preference during language processing [3, 6–10]. However, it remains unclear whether this preference continues an evolutionarily old and fixed principle, possibly homologous to mechanisms of preferential agent detection in other species [11], or whether the preference is plastic and can be modulated by linguistic experience. Also, it is unclear whether the preference only holds in comprehension or also in production.

Here we discuss electrophysiological studies on language comprehension in Hindi [3] and Äiwoo (Austronesian, Solomon Is.) [12]. Results show that the agent preference can be overridden if agents are systematically coded as marked and non initial

expressions (Äiwoo), but not if such coding is merely a context-dependent option (Hindi).

We furthermore discuss eye-tracking studies on language production in Hindi [13], Basque [14], German [14], and Tagalog [15]. While the details of sentence planning are modulated by the affordances of each language, we find a general preference for agent attention, regardless of whether agents are initial or not, and regardless of whether they are unmarked or not.

We conclude that the agent preference is a stable principle in production, while it can be overridden under extreme conditions in comprehension. Together, these findings suggest that the preference might indeed continue an evolutionarily old principle, with only marginal plasticity.

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Vocal communication of emotion: A biologically universal code underpinning language evolution

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In *The descent of man*, Darwin hypothesized that the ability to modulate the voice to express emotions, which is shared across animal species, might have evolved into the ability to express emotional content in words. This would have, thus, started the path of language evolution. Yet, our understanding of the role of vocal expression of emotions in language evolution remains the same today as when Darwin first tackled it in 1871. In this talk, I will describe recent findings that advance our understanding of this issue. Firstly, I will use a cross-species comparative approach to describe the acoustic parameters of voice modulation as universals that enable the perception of emotional states. For instance, in a recent study, we found that humans from three language groups (English, German and Mandarin) use information related to the fundamental frequency of vocalizations to identify emotional content in species of amphibia, reptilia, and mammalia. Based on this data, I will argue that adaptive mechanisms of vocal emotional expression are widely shared among vocalizing vertebrates and might represent a biologically universal signaling system. The question then remains as to whether these biological mechanisms for emotion expression paved the way to the evolution of language. One way of addressing this question empirically is to explore the relative salience of emotional voice modulation and lexical information in emotional word processing, as an indicator of the biological role of voice modulation in the emergence of language. To support this, I will present recent empirical data on the cognitive prominence of voice modulation over lexical information in emotional word meaning identification tasks. Finally, within this research framework, through a comparative approach to vocalizing animals, I will emphasize the key role of emotional voice modulation within social interactions in the emergence of linguistic communication.

Human screams' roughness and pitch synergistically and simultaneously contribute to trigger efficient neural and behavioral responses

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The ability to rapidly communicate danger using vocal signals is essential to warn conspecifics and promote our survival. Human screams constitute complex signals that exploit a combination of attributes (roughness, pitch) to convey a mixture of ecologically relevant information (about danger and emitter's gender/age, respectively) to elicit adapted reactions by the receiver.

We previously identified roughness as the key acoustic features to selectively inform conspecifics about danger. Here, we consider another attribute, the pitch, as relevant to the receiver in a dangerous situation. For instance, it might be the case that a child's high-pitched scream induces a distinct, faster reaction than an adult's one. Whether these distinct features are concurrently or sequentially encoded in the brain and how they contribute to elicit adaptive behavioral responses is unknown. Here, we used electroencephalographic (EEG) and intracranial recordings iEEG to investigate the neural encoding of pitch and roughness in the human brain. Sixteen participants (nine females) were required to spatially localize natural and synthetic vocalizations that varied along both pitch and roughness dimensions. We used a general linear model approach to measure the respective influence of these two fundamental features on neural and behavioral responses. We identified that early neural signals (P1, 50ms post stimulus onset) simultaneously represent these two features in a concurrent way, revealing a simultaneous encoding strategy. We further quantify the relative effect of these features on localization speed and show that these two features synergistically contribute to trigger rapid reactions to danger. These results show that human screams provide a sophisticated signaling system that rapidly elicits reactions optimally adapted to the ecological relevance of the situation.

Mapping out the evolutionary trajectory of iconicity and combinatorial structure

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One hallmark feature of human language is its combinatorial structure. Virtually universally, linguistic signals are constructed from smaller inventories of discrete building blocks, such as phonemes or syllables. Recent experiments have addressed the question of how combinatorial structure could have evolved culturally when languages adapt to cognitive biases in language use and transmission. Here we focus on the role of meaning in the evolution of signal structure: While iconicity, the existence of signals that resemble aspects of their meanings, is hypothesized to be present early to facilitate communication and other processes, signals must eventually lose this iconic structure when they become the meaningless building blocks of a combinatorial system. Experimentally assessing these and other possible tradeoffs in more precise, quantitative terms has proven difficult. To better understand the co-evolutionary dynamics of iconicity and combinatoriality we conducted an online iterated learning experiment, adapting the slide whistle paradigm from Verhoef, Kirby and de Boer (2014). We focus on a more tractable form of iconicity and measure the degree to which complex signals are paired with conceptually complex meanings when this association is initially at chance. Besides replicating the emergence of combinatorial structure, our main finding is that iconicity develops rapidly but is gradually lost over successive generations. This is despite the existence of strong iconicity biases, as revealed in a guessing game, in which participants reliably picked complexity-matching referents for each signal. We further describe our data in the form of a vector field model. Consistent with the account sketched above,

the model suggests that robust forms of iconic structure only exist when languages are still relatively unstructured. Combinatorial structure, however, already begins to develop well before these earlier forms of iconicity are lost. Taken together, these findings help clarify the role of iconicity in the emergence of signal structure.

The Sources of Meaning in the Initial Stages of a Natural Language

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According to Hauser, Chomsky, and Fitch (2002) the source of the vast expressive power of language is syntactic recursion. As an alternative to this view, Meir (2018) suggests that although syntactic recursion indeed produces open-ended sentence complexity, it is not the only way to accomplish open-ended message complexity, the ability to express an unlimited number of thoughts. For Meir (2018), a further source of open-endedness in language comes through meaning extensions.

In this study, we second the proposal made by Meir (2018) and provide further evidence for the existence of meaning extensions facilitating topic open-endedness in the initial stages of a young language: Central Taurus Sign Language (CTSL) (see Ergin 2017, Ergin et al. 2018 for further information about CTSL). We categorize the sources of meaning extensions in CTSL as metaphor, metonymy and polysemy compiled from spontaneous conversations and control elicitation tasks.

Metaphor: (1) exemplifies the extension of the literal meaning of hitting someone with stone to a metaphorical meaning for a probable punishment of the God in case of not fulfilling a duty.

(1)

CTSL: GOAT HERE / SLEEP / HUNGRY / POINT (to sky) HIT.ME.WITH.STONE¹

English: "(If the)² goat(s stay) here (and if they) sleep, (they get) hungry, (and if they get) hungry, God (punishes) me (by) hitting me (with a) stone."

Metonymy: Even in the relatively short span of a controlled elicitation task (15 minutes), CTSL signers invent name signs by selecting a distinctive physical feature of a character (e.g., BALD) and extend its meaning to refer to the character having this feature.

Polysemy: The sign CIRCLE may have various different real world referents depending on the context it is used. When compounded with DRINK, it contributes to the meaning of a place (2). The meaning of the same phonological form is extended to a circular object when compounded with COOK (3).

(2) [DRINK+CIRCshape] → lake

¹"/" refers to prosodic breaks. "." in between signs indicates simultaneous articulation

²The information presented in parentheses does not come from the actual CTSL utterance. It is our interpretation of the meaning of CTSL utterances in English.

(3) [COOK+CIRCshape] → cooking pot

All in all, echoing Meir (2018), we argue that mechanisms enabling users to refer to novel and displaced situations through meaning extensions are present even in the initial stages of a newly emerging language, and they enrich the expressive power of this syntactically simpler system.

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Entering and exiting joint actions in great apes: A pragmatic approach to studying language evolution

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One likely event predating the evolution of language is the transition of early hominins from an individualistic to a shared intentionality, promoting the performance of joint goals (Tomasello 2014). It has been argued that this manifestation of human cooperativeness has emerged as a solution to generic coordination problems faced in spontaneous joint action (Levinson 2006; De Ruiter and Levinson 2008). Past research on the ability of great apes to engage in shared intentionality delivered controversial results, with observational data suggesting the existence of this ability (Rossano 2013; Fröhlich et al. 2016) but experimental data discounting for it (Call 2009). Here, we deploy an analysis of natural behaviour of chimpanzees and bonobos, drawing on a joint action framework from the study of human social interaction (Clark 1996), where joint goals are mutually achieved via orderly coordination. To enter and exit joint actions, partners need to create and dissolve a state of “togetherness” characteristic for shared intentionality. We analysed whether apes produce recognizable entry and exit phases during social play and grooming, and whether these phases are affected by species, and partners’ social bond and rank distance. Using a comprehensive dataset (1129.35h observation; 42 subjects; three zoos), we analysed the duration and frequency of 1020 entry and 914 exit phases using Bayesian GLMMs. We found that both species produce entry and exit phases, but that bonobos produce phases more frequently than chimpanzees. Moreover, social variables affected phases differently across species; while bonobos produced shorter and fewer phases when social bond increases, chimpanzees produced particularly fewer exit phases when being higher-ranked. If shared intentionality represents a precursor for the evolution of language, our findings should highlight how natural selection has shaped human uniqueness from ancestral primate roots.

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Cultural variation in quantities of language input directed to infants: A systematic review

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Variation in the quantity of language directed to American infants as a function of their family's socio-economic status has been estimated to be 1:3 (Hart & Risley, 1995). That is, infants whose parents are professionals receive three times as much directed speech than infants whose parents are on welfare. Such differences in input quantity have been correlated with outcomes within the United States (e.g., Weisleder & Fernald, 2013), with an estimate for vocabulary sizes of 2:3. What is the extent of variation in input and outcomes across cultures? In this paper, we present data from a systematic review of 50 years of anthropological and psychological literature. The studies use either time sampling or audio/video-recordings to estimate the frequency or quantity of child-directed vocalizations. To allow integration, conversion factors are applied across methods. Results from 28 populations (1,223 children, observed an average of 3.2 times, often longitudinally) suggest a 1:51 ratio in input quantities. Modifying the conversion parameters lead to estimates varying from 1:20 to 1:100; in the former scenario, restricting analyses to non-extreme values leads to a ratio of 1:8. Thus, variation in infant-directed input quantities across cultures (1:8) is much greater than variation within cultures and across socio-economic statuses (1:3). If outcome differences across cultures correspond to those observed across socio-economic groups, we would expect considerable variation in language outcomes. We discuss the difficulties involved in testing this prediction, including (1) measuring language through tests that are culture-unbiased without removing the very differences we want to measure; and (2) relying on spontaneous samples that may mis-estimate differences due to cultural variation in how appropriate is for the child to take part in conversations.

Vocal individuality depending on call function in a non-primate mammal

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The use of individually distinct signals provides a basis for discriminating between different signalers and adapting responses to the signaler's identity. Individual distinctiveness and recognition can provide fitness benefits to both senders and receivers across a variety of interactions, e.g. dominance hierarchies, mate choice, kin recognition, parental investment, and cooperative behaviours. However, these adaptive benefits may vary based on social context and the characteristics or previous interactions of the sender or receivers. Within vocal signals, this may lead to varying levels of individuality across a species' call repertoire, with some call types being more individually distinct than others depending on the context and caller and/or receiver characteristics. We examined vocal individuality within and across two functionally and acoustically different call types in meerkats (*Suricata suricatta*), a cooperatively breeding mongoose. Meerkats use an elaborate vocal system to organize a variety of social behaviors, such as the contact calls ('close calls') used during foraging to facilitate group cohesion and movement, and the 'sentinel calming calls' emitted by guards to coordinate vigilance behavior. Both call types were recorded from 25 free-living adult meerkats in 11 social groups in the Kalahari Desert, South Africa. Acoustic parameters were extracted and analyzed to determine if calls carried information on individual identity and how levels of individuality differed between call types. We also investigated how individual variation in both call types was affected by the dominance status, sex, and age of the caller. Results show that vocal distinctiveness was present in both call types but was influenced by different predicting factors. These findings indicate that individual distinctiveness may vary across status, age, and sex classes depending on differing fitness benefits and the relative need of the caller to be recognized within different social contexts.

Language-gene mismatches in global human history

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Languages and genes are traditionally paired in multidisciplinary studies to reconstruct population origin, migration and contact. Linguistics provides insights on recent history and cultural phylogenetic relationships between groups; in return genetics provides direct estimates of relatedness between individuals and population samples. Genetic data can also reconstruct demographic dynamics and pinpoint

population changes in time, which are particularly relevant to understand the conditions behind language change and present diversity.

This multidisciplinary approach has a great potential for the field, but relies on the assumption that languages diffuse mostly through demographic events, and language contact corresponds to gene-flow. While many case studies proved this correspondence to hold true for specific regions and language families, the phenomenon was never systematically investigated on a global scale.

In this study we explored the limits of the language-gene match by focusing on cases of mismatch between genetic and linguistic diversity worldwide. We analyzed a newly assembled panel of genomic diversity from all continents which includes almost 350 populations, paired with unique language identifiers. Ten major language families represented by a minimum of five populations are considered for investigating the congruences at a local scale. We describe different patterns of demographic dispersion for each family, and compare different measures of genetic distances against within-family language distances. Cases of genetic proximity between pairs of populations who are affiliated with different language families are highlighted as potential mismatches. We propose different scenarios associated with these mismatches, such as language shift, maintenance of cultural identity and formation of language boundaries.

The first evolutionary step towards human language and culture

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Language and many other phenomena that stand out in humans, like music, imitation, planning and mathematics, depend on the ability to perceive, represent, store and recall sequential information. While animals have some ability to discriminate among stimulus sequences, they seem to lack the precision found in humans. Ghirlanda et al. (2017) show that animals' ability for sequence discrimination can be accounted for by trace memory, i.e. representation of stimuli as fading traces with no internal order. Trace memory can, however, not account for language and other human sequential abilities. Sequential learning has been pointed out as central for human language capacity (Christiansen et al 2002; Frank et al 2012; Christiansen & Chater 2016) but has rarely been singled out as uniquely human. Assuming that trace memory is the only general memory mechanism in animals, it seems plausible that sequence memory, i.e. an inborn ability to perceive and use temporal sequences of stimuli, is a necessary step in human evolution that must have predated other uniquely human abilities. In this paper we explore the theoretical basis for this hypothesis and suggest a potential evolutionary trajectory in human prehistory from trace memory to sequence memory. A central question is why sequence memory has only evolved in one species. With formal models and computational simulations, we explore under what circumstances evolution would favour different kinds of memory adaptations and identify costs and benefits with sequence memory. Responding to

stimulus sequences increases learning costs, something that can only be overcome with a long period of free learning. Furthermore, sequence memory is more likely to be selected for in an environment where sequences contain a lot of useful information.

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A hypothesis concerning how the evolution of prosociality impacted vocal learning

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The periaqueductal gray (PAG) is a midbrain area that is involved in stress modulation and the production of innate vocalizations. The PAG works as a gate to the premotor neurons of the brain stem. Lesions in this area cause loss of the ability to vocalize in mammals, but not comprehension or voluntary movement (Jürgens, 1994). The PAG receives input from the vocal motor control network, but also affects it through dopaminergic projections. It has recently been shown that the PAG in juvenile zebra finches releases dopamine in the HVC nucleus, which regulates song learning (Tanaka et al., 2018). Dopamine is known to play a key role in the auditory feedback circuitry that reinforces the copying of vocalizations (Hoffmann et al., 2016), and the PAG relays extensive dopaminergic efferents to the robust nucleus of the arcopallium (RA) (Liao et al., 2013).

The PAG receives extensive glutamatergic inputs from limbic and hypothalamic structures, which drives dopaminergic feedback to thalamic and hypothalamic structures, and is crucial for the mediation and modulation of the stress response (Jürgens, 1994). In the PAG of *P. discolor*, a bat species proposed to be a vocal learner (Rodenas-Cuadrado et al., 2015), *Foxp2* regulates expression networks encompassing several genes crucial for glutamatergic signaling. Importantly, some of the glutamate receptor genes most highly expressed in these regulatory networks play significant roles in the modulation of stress responses and in the maintenance of synaptic plasticity, thought to be crucial for in vocal learning species (Wada et al., 2004). Changes to glutamate receptor expression correlate with increased complexity in the song of the domesticated Bengalese Finch (*L. domestica*) compared to its wild counterpart (Okanoya, 2015), the white-rumped Munia (*L. striata*), and have been implicated more broadly in domestication and recent human evolution (O'Rourke and Boeckx, 2018).

We provide a mechanistic account of how changes to glutamatergic signaling affect the gating of dopaminergic outputs from the PAG, and make this an important step in the evolutionary tinkering of vocal learning capacities.

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The evolution of language families is shaped by the environment beyond neutral drift

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Languages constantly evolve. Language families unfold in time and space, and span the globe. A core question of evolutionary linguistics is whether this diversification is the outcome of neutral drift, or if further pressures relating to the environment systematically guide diversification.

We apply phylogenetic signal analyses to measure the reflection of geographic dimensions (longitudes, latitudes, altitudes), climate (principal components of overall 19 climatic variables), distance to water (oceans, lakes, rivers), and size of the speaker population on language family trees. We harness a collection of more than 6000 phylogenetic trees of 46 language families, built by various methods (Bayesian, Maximum likelihood, and others).

Phylogenetic signals of environmental factors on family trees are generally stronger than expected under the null hypothesis of completely independent evolution. Only in 0-4% of the analyzed cases there is no significant phylogenetic signal of environmental variables. Moreover, the prediction of neutral drift (signal of around one) is met in around 32% of the cases. In the majority of cases, however, signals are either weaker (around 45% of cases) or stronger (around 20% of cases) than expected

under neutral drift. This suggests that there are further adaptive and non-adaptive pressures at play when language families evolve and diversify. Based on systematic differences between language families we argue that these include convergent evolution, niche occupancy, heterogeneous rate drift and lateral transfer of lexical and structural material.

Finally, the strength of phylogenetic signals of particular environmental factors varies across language families. While large language families of Africa and Eurasia display particularly strong signals of longitudes, i.e. grouping along the east/west and west/east axis, language families of the Americas display strong latitudinal signals, i.e. grouping along the north/south and south/north axis. Thus, it appears that deep population history and migrations are reflected on language family trees.

Language-readiness: Descent, modification, and further modification

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In recent years, much attention has been focused on neurodevelopmental changes that may have enabled the remarkable human capacity for culture and language in particular. Specifically, relative to other primates, the human brain has been claimed to show “neoteny” features: slow maturation, the retention of structurally immature neurons throughout life, and enhanced synaptic plasticity (see, e.g., Bufill et al. 2011). This suite of characteristics has been claimed to increase our cortical complexity, and thereby cognitive capacity, by allowing a prolonged period of postnatal learning, such as is required to learn language (e.g., Sherwood & Gómez-Robles 2017). However, recent studies have revealed that Neanderthals, too, were a slow-maturing species (Rosas et al. 2017), suggesting that any hypotheses regarding the role of neoteny/plasticity in human cognitive evolution need refinement, if it is to account for sapiens-specific capacities.

Here we want to re-examine this issue by combining insights from numerous disciplines, from paleogenomics to developmental neuroscience, to characterize more precisely the set of sapiens-specific modifications (many of them revolving around myelination properties). In doing so, we observe that the effects of such modifications can only be properly understood in the context of previous modifications that created the niche for later tinkering steps. We conclude by stating that no change can be considered more central, and that the evolution of language-readiness is best conceived of as a continuum or mosaic.

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Gricean animal communication and niche construction

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It is widely assumed that perceivers fulfill their half of the Gricean equation in the animal kingdom (Fitch 2010) while signalers do not, because they produce signals unintentionally (Bar-On, Moore 2017). But, in fact, no intentionality is necessary in this case because index signals (as most animal signals are) are honest and relevant by definition, while natural selection eliminates signals that fail to be recognized because of being either not informative or not perspicuous enough. Thus, all communication systems can be viewed as having evolved not for transmitting but for acquiring information (Burlak 2017).

A pool of conspecifics ready to acquire information irrespective of its intendedness form a niche where the most easily recognizable signals are favored by natural selection. For example, an individual whose aggressive mood can easily be detected has better chances to avoid a traumatic physical contact.

This is a solution for the problem of gradual change in the evolution of human language: if we assume that natural selection favors not production but interpretation, then any minor behavior feature that may give a cue to the perceiving individual would be useful because it would help such an individual to obtain new information and thus to choose a more appropriate behavioral program.

So, even if the first precursors of language utterances in the genus *Homo* were inarticulate and unintentional, they must still have been favored by natural selection. Therefore, the human mind (its “System 1”, see Kahneman 2011) is predisposed to treat any utterance as following the Gricean maxims. In this sense, human language is far from being an optimal means of communication: the smarter is the listener, the less restrictions are necessary for the speaker. One can compare here the claim by Chomsky (2002, 2010) that language evolved not for communication but rather for internal thought.

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How social complexity can favour call diversification

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After 40 years of debate it remains unclear whether signallers produce vocalizations to provide receivers with information about external stimuli or call context. This has led some researchers to propose that call production is arousal- or affect-based. Although arousal influences certain acoustic parameters within a call type, I argue it cannot explain why individuals across vertebrates produce different call types. Given emerging evidence that calls are goal-based, I argue that call type signals the caller's goal to elicit a change in receiver behaviour. Illustrated using the chimpanzee hoo system, I discuss two benefits of viewing call production as signalling both caller goal (which determines call type) and caller arousal (which affects within-call-type variation). Such a framework can explain first, why a single class of calls is apparently given in multiple contexts, and, second, why some species have larger call repertoires than others. Some studies hypothesise links between sociality and repertoire size, but have not specified exactly why animals living in societies that are more complex might require a greater number of differentiated signals. The caller-goal framework clarifies how social complexity can favour call diversification. As social complexity increases, callers need to elicit a larger number of distinct behaviours from a wider range of distinct audiences.

Thought for food: Intentional and referential multimodal communication between wild bonnet macaques and humans

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Comparative studies of nonhuman communication systems could provide insights into the origins and evolution of two distinctive dimensions of human language: intentionality and referentiality. Recent studies have provided evidence for intentional and referential communication in different taxa, including fish, birds and nonhuman primates but generally in captive settings. We report here a, hitherto unreported, behaviour of food requesting from humans displayed by wild, individual bonnet macaques *Macaca radiata*, an Old World cercopithecine primate, in the Bandipur National Park of southern India. Using both natural observations and field experiments, we examined four different behavioural components of food requesting— (1) coo-calls, used in a novel context (2) a unique, previously unknown, hand- extension gesture (3) orientation movements and (4) monitoring behaviour—for their conformity with the established criteria of intentional communication. Our results suggest that all these behavioural acts, except coo-calls, met the criteria of intentionality

while the hand- extension gesture could be potentially referential in nature. We comment on plausible hypotheses for the origin and spread of this unusual behavioural strategy in the study macaque population and conclude that cognitive precursors for language production may be manifest in multimodal communication, which could have emerged first in simians, much earlier than in the anthropoid apes.

Transitions of carrying roles of gestures and vocalization during the early evolution of language

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In recent years, accumulating evidence from behavioural and neurobiological research has shown that both human and nonhuman primate communication is inherently multimodal. Nonetheless, both terminology and implications of multimodal approaches are still unclear, and vocal-first and gesture-first theories continue to persist in even the most recent literature. Integration of the study of gestural and vocal communication is therefore urgently needed, since the divergent and independent research traditions in the gestural and vocal domains of primate communication have resulted in major discrepancies in the definition and operationalization of cognitive concepts. Here, we review evidence demonstrating that there is no clear difference between primate gestures and vocalizations in the extent to which they show evidence for the presence of key language properties: intentionality, reference, iconicity and ontogenetic plasticity. In contrast to vocalizations, however, nonhuman primates do not show combinatorial capacities in their use of gestures. We note that in great apes, gestures seem to fulfil a carrying role in most contexts in close-range communication, whereas the opposite holds for face-to-face interactions of humans. This suggests an evolutionary shift from a carrying role of the gestural to the vocal stream. We hypothesize that the lack of combinatorial capacities in gestures explains this transition in the carrying modality, and by implication that the debate between the gesture-first versus vocal-first schools of thought on language origins can be considered resolved. Finally, we suggest that future studies should focus on the links between complex communication, sociality and cooperative tendency to strengthen the study of language origins.

Modelling lexical interactions in diachronic corpora

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Large diachronic text corpora enable a data-based approach to the study of language change dynamics. The development of unsupervised methods for the inference of semantic similarity, semantic change and polysemy from such large datasets mean that, in addition to measuring orthographic similarity or counting frequencies (e.g., Petersen et al. 2012, Bochkarev et al. 2015), it is also possible to measure meaning and therefore the evolution of semantics and discourse topics over time (e.g., Dubossarsky et al. 2016, Hamilton et al. 2016, Xu and Kemp 2015, Schlechtweg et al. 2017).

We present completed work on a baseline model of frequency change in corpora, the topical-cultural advection model (Karjus et al. 2018). This approach utilizes topic modelling to evaluate the extent which underlying topical fluctuations - variability in what is being talked and written about over time - have on observed frequency changes in lexical items. We also show that the same baseline is readily applicable to and describes a reasonable amount of variance in a number of other domains of cumulative culture, recorded in databases comparable to diachronic corpora in linguistics.

Finally, we discuss how the quantification of topical fluctuations (as a proxy to changing communicative need; Regier et al. 2016, Gibson et al. 2017) relates to ongoing research in modelling lexical interactions over time, such as competition in semantic subspaces. We define a simple variable capturing the extent of competition between a trending word and its closest semantic neighbours, using word embeddings and relative changes in probability mass. We demonstrate, using large diachronic corpora in multiple languages, that a predictive model incorporating the advection measure as a proxy to communicative need, and control variables including lexical dissemination (Stewart and Eisenstein 2018) and semantic change metrics, is capable of describing a considerable amount of variance in the competition variable.

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Investigating the conditions allowing for sign language persistence

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In the context of language evolution, the study of emerging sign languages has taught us a lot about the process of how new (sign) languages emerge, but it is still unclear when (i.e. under what conditions) they emerge. The following research focuses on shared sign languages, sign languages that are shared by deaf and hearing members of communities. They typically emerge in rural areas with a high incidence of hereditary deafness (de Vos & Pfau, 2015).

As shared sign languages vary on many levels (Zeshan & de Vos, 2012), researching the conditions allowing for their emergence requires an interdisciplinary approach: this includes studying the genetic foundations for deafness, the cultural transmission of language, and the sociocultural context in which interactions occur. So which variants of these features facilitate their emergence and evolution?

The present agent-based model is inspired by Aoki & Feldman's (1991) mathematical model of sign language persistence. In their model, persistence and transmission of deafness is determined by deaf alleles and by marriage patterns, while whether individuals are deaf or hearing determines the probability of sign language transmission from parents to offspring. In the current research, these components are implemented in an agent-based model, allowing us to observe random fluctuations and more easily incorporate community structure.

To understand which conditions permit shared sign languages to emerge and evolve, we analyze a variety of scenarios using the agent-based model. Focusing on marriage patterns (specifying the likelihood that deaf individuals will marry another deaf individual) and sign language transmission types (vertical, horizontal, oblique), we find that these two components affect the persistence of sign language and the number of signers in the population. This methodology flexibly allows for the investigation of influences on the persistence of sign languages. Through this, we can better understand the conditions under which languages emerge and evolve.

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Language contact, language evolution, and flexible constituent order

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How do languages change due to contact? This is not only of interest to contact linguists but is also relevant for understanding language evolution and emergence. Here, I focus on flexible constituent order, which is particularly susceptible to contact-induced change (e.g., Nichols 1992, Bickel et al. 2017). In addition, many have posited that SOV was the canonical order in protolanguage (Newmeyer 2000, Givón 1979), and subsequent empirical work has supported a bias for SOV, at least in some cases (Goldin-Meadow et al. 2008, Hall 2012). While flexibility has been cited as a facilitative factor for contact-induced change in constituent order (Aikhenvald 2003), it is often underdescribed and undertheorized (Harris Campbell 1995).

I present a series of acceptability judgment experiments which show similarities in how experience with English affects flexible constituent order in Malayalam and Korean. SOV is the canonical order in both Malayalam and Korean, and all other orderings of the major constituents are grammatical and have the same truth-conditional meaning. The results show that more experience with English corresponds to a greater relative preference for SOV sentences in Korean and Malayalam: decreased flexibility.

The association between English experience and reduced flexibility can be explained via the interaction between socio-historical factors and linguistic structure. Non-canonical constituent orders are associated with reduced acceptability (Weskott Fanselow 2011), which is more pronounced for those with reduced experience with the language (Caplan Waters 1999). Though contact does not uniformly lead to reduced flexibility, similarities between these two contact situations (education in English, reduced use of Malayalam and Korean over the lifespan) explain similar outcomes of contact.

Building on approaches from language evolution, which look processing preferences and population structure as causal factors in language creation and change (e.g. Christiansen Chater 2016, Wray Grace 2007, Lev-Ari 2017, Bentz Winter 2013), I consider factors like language attitudes and language policy as inherited contexts which systematically interact with the specific linguistic structures that speakers know. Thus, patterns of language evolution are derivable from research on how languages are differentially used in multilingual contexts.

Idiosyncratic vocal sequences in wild bonobos

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Comparative research has revealed that many of the building blocks of language are deeply rooted in our primate past. The vocalisations of some non-human primates, for instance, refer to external events and may be combined into syntactic-like sequences. Producing call combinations to vary signal information has been interpreted as a means for species with limited vocal learning capacities to escape the limitations of poor vocal control. Alternatively combinatoriality may be favoured in species that rely on individualised relationships but communicate in visually difficult environments. Cues to individuality can be provided by producing individually-distinctive vocalisations but also by combining calls in idiosyncratic ways. Beyond singing species, it remains unknown whether non-human animal species produce idiosyncratic vocal sequences to convey identity information when responding to external events. Here, we addressed this by investigating the idiosyncratic nature of vocal sequences of wild bonobos, our closest living relatives. Using a Markov Chain Analysis approach, we investigated transition probabilities in $N = 537$ call sequences of $N = 18$ wild bonobos within the context of food discovery. Analysis revealed substantial between-individual variation yet reliable within-individual stability in sequence structure, such that call sequences produced in response to high and low preference foods could be reliably distinguished if caller identity was known. Such structural idiosyncrasy implies that receivers need to integrate prior knowledge of the caller's identity and their food preferences in order to infer call sequence meaning. Bonobo idiosyncratic calling may have evolved to selectively benefit audiences most valuable to the caller, such as close affiliates or relatives. These results highlight a striking level of flexibility and complexity within the vocal communication system of our closest living relatives and provide new insights into the processes driving the evolution of the speech patterns seen in modern humans today.

The Origin of Pointing: Evidence for the Touch Hypothesis

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The Origin of Pointing: Evidence for the Touch Hypothesis The origins of pointing remain an open question (Tomasello 2008: 127). The studies reported here suggest pointing is developmentally rooted in touch. First, we found that when pointing, participants orient their fingers as though 'virtually touching' an object, rather than as if creating an 'arrow' directed at the object. We imposed two vectors (fig.1) on images we recorded of subjects pointing at targets – one through the participant's line-of-sight and finger-tip (the 'touch-line'), and one along the angle of the finger (the 'arrow-line'). Across four age groups (18mths, 3yrs, 6yrs, adults), the 'touch-line' was closer to the target than the arrow-line (n=55, z=5.592, p<0.001).

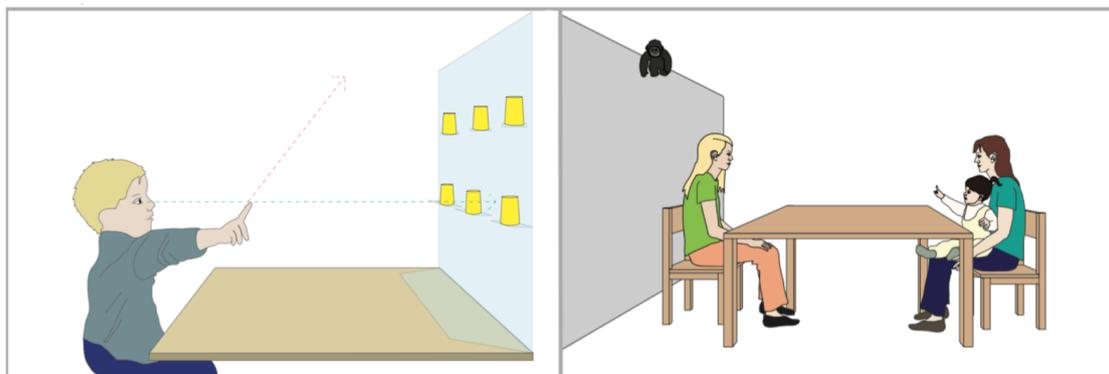


Figure 1: the 'touch-line' (green) is a better predictor of reference than the 'arrow-line' (red).

Second, we found that when pointing at a target at an angle, participants rotated their wrists as they would if they were trying to touch it. Targets were either attached to left and right sides of a box (fig.2), or on a flat surface. Participants rotated their wrists to the left and right more when the targets were on the sides of a box, than on the sides of a flat surface (n=55, $X^2 = 55.468$, $df = 4$, $p < 0.001$).

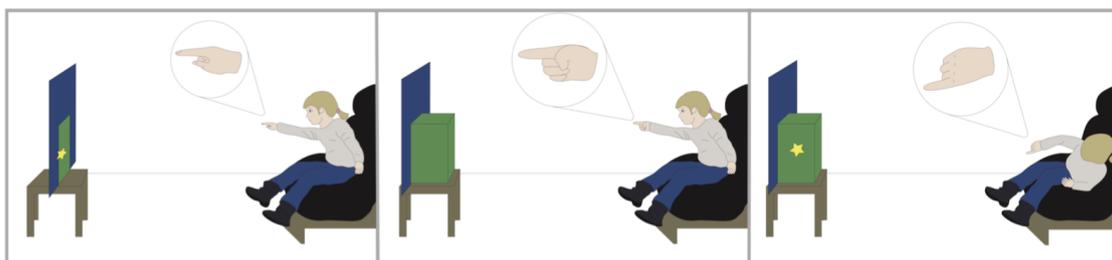


Figure 2: participant rotates her wrist as though trying to touch the target.

Finally, we found that younger participants interpret pointing gestures more like 'touch' than 'arrow' gestures. Participants viewed a figure pointing in an 'arrow' condition, where the figure looks at the object picked out by the 'arrow' of his finger, and in a 'touch' condition, where the figure looks at the object he is closest to touching (fig.3). 18mth- and 3yr-olds were at chance in interpreting the 'arrow' condition, but reliably picked the object the subject gazes at in

the touch condition; only 9yr-olds and adults reliably followed the ‘arrow’ gestures ($X^2 = 11.914$, $df = 4$, $p = 0.018$). Together, these results indicate an origin of pointing in touch.

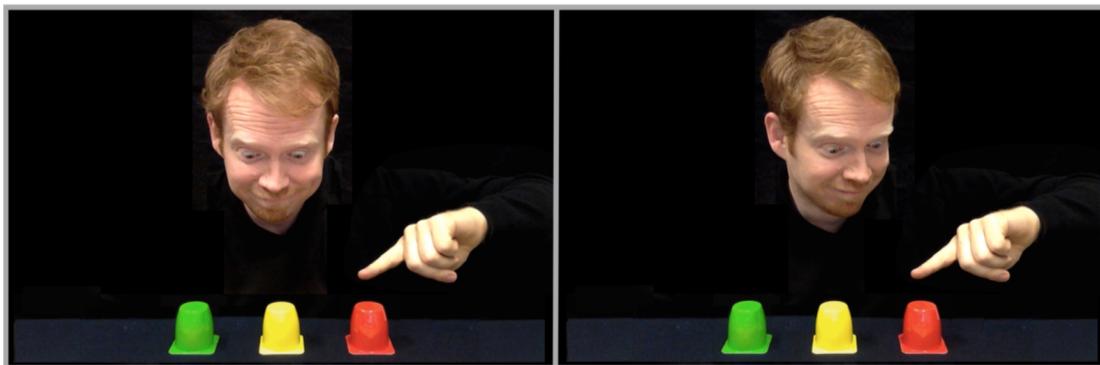


Figure 3: ‘arrow’ condition (left) and ‘touch’ condition (right).

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Input variability promotes the emergence of linguistic structure

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A recent study examined the effect of group size on the live formation of linguistic structure [1]. In that study, small and larger groups communicated in the lab about an unfamiliar set of meanings by creating a novel communication system. Results showed that larger groups developed more systematic languages over time, and did so faster and more consistently than small groups.

Here, we provide new analyses of the data in [1], showing that input variability is an important driver of these observed group size effects. Specifically, we argue that in the early stages of language evolution, interacting with more people introduces more input variability (i.e., more unique variants that need to be negotiated or remembered), which individuals in a larger community need to overcome before the community can reach mutual understanding [2-4]. This greater difficulty can be potentially relieved by developing languages with more systematic structures. Therefore, we hypothesize that members of larger communities may be more likely to favor linguistic variants that are simple, predictable, and more structured, as a means of overcoming their greater communicative challenge and memory constraints. Supporting this idea, language learning studies found that increasing input variability (i.e., by exposure to multiple speakers) boosts categorization, generalization, and pattern detection [e.g., 5-6].

To test this hypothesis, we quantified the degree of input variability in [1] at different time points, and used it to predict changes in languages’ structure over time.

As hypothesized, we found that more input variability at time point n predicted a greater increase in linguistic structure at time point $n+1$. This analysis also confirmed that larger groups were overall associated with greater input variability - a critical assumption in the literature and a premise for our hypothesis. Together, these findings shed light on the underlying mechanism of group size effects in language evolution.

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CHIELD: The Causal Hypotheses in Evolutionary Linguistics Database

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The Causal Hypotheses in Evolutionary Linguistics Database (CHIELD, <https://chield.excd.org>) is a tool for understanding the field of evolutionary linguistics and for designing effective research.

The study of language evolution draws on a wide range of disciplines and, by now, a deep history of research. This makes it hard to design effective studies that consider all the relevant research and focus on the most critical issues. There is also a lack of connection between various areas that should be informing each other, such as the origins of language and ongoing change, or between human and animal communication research.

CHIELD offers a solution: cut up hypotheses into smaller claims and represent them as formal causal graphs (nodes represent measurable quantities and edges represent causal influences). This makes the hypotheses, and links between them, searchable with ‘smart’ tools. For example, users can find all hypotheses which connect two variables, discover additional evidence for a causal link or compare hypotheses, locating points at which they overlap or disagree. CHIELD also codes the type of support each link has (experiment, statistical test, etc.), allowing users to visualise “robust links” that are well supported and “weak links” which have less empirical support, suggesting targets for future studies.

CHIELD currently includes over 2,000 causal links from 268 publications, hand-coded by a team of experts. In this talk, I will illustrate how to use CHIELD and

some of the insights it provides. Promisingly, about three quarters of these links form a single connected network, suggesting that there is a lot of scope for weaving theories together. The database is growing thanks to the online interface which allows any researcher to contribute, review or edit data. It's hoped that CHIELD will unify the field and help researchers design more effective studies.

Language Input in a small-scale society: Estimations from daylong recordings in a Tsimane' village

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If children growing up in some preindustrial societies experience little adult child-directed speech from adults, then such high quality directed input might not be necessary for typical language acquisition (e.g., Ochs Schieelin, 2001; Shneidman, 2010). There is little quantitative data assessing whether the if-premise is true (a summary in Cristia, Dupoux, Gurven Stieglitz, 2017), and much of it can be critiqued on the grounds of ecological validity and/or sample sizes. We report an ecologically-valid, large-scale analysis of speech experiences by infants and children growing up in a forager-horticulturalist population, the Tsimane of lowland Bolivia. The Tsimane of lowland Bolivia are composed of extended family clusters, who share food and labor. On average, women have their first child by 19 years of age, and a total fertility rate of about 9 births (Kaplan, Hooper, Stieglitz Gurven, 2015). Infants are kept close to their mothers, and regularly carried in a sling so that mothers can perform subsistence activities; toddlers are often cared for by older siblings or other kin. Such a setup could lead to small amounts of maternal speech directed to young children.

Children under age 6 years (n=25) wore daylong audio-recorders, samples of which were annotated by a trained phonetician. We found that young Tsimane children experienced little child-directed speech, with much higher levels of overheard input, and non-significant age effects. We estimate children experienced about 7 minutes of speech per waking hour, with maximally a quarter of that being directed to them. Most directed input was spoken by a main female adult voice for young infants. For older children the majority of the input came from siblings or from fellow children. We discuss implications of these results for language acquisition theories.

Effects of Compositionality, Number of Grammatical Distinctions and L1 on L2 Learning Difficulty and Morphological

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Why do languages have different structures? One hypothesis that has gained prominence in recent years states that large L2 speaker share in the population of a language could trigger its morphological simplification (Trudgill, 2011).

A number of studies (e.g. Bentz Winter, 2013) support this hypothesis, however, the exact mechanism is not yet clear. The difficulties of adults in learning morphology are often considered to directly lead to simplification (Wray Grace, 2007) and to be a crucial part of the mechanism (Lupyan Dale, 2010).

Analyses of creole languages by McWhorter (2001), however, show that the preponderance of morphologically simple strategies in a language does not itself suggest L2 influence, but a reduced number of grammatical distinctions does. This could indicate that certain morphological simplicity dimensions are not direct effects of L2 speaker presence, but by-products of other changes, such as fewer encoded grammatical distinctions.

To investigate this, we conducted two artificial language (AL) learning experiments. The ALs differed in the number of grammatical distinctions (person+number vs person) and how they were expressed (fusionally vs agglutinatively). The AL learning time was measured. In experiment 1, native English speakers learned ALs where person and number were expressed fusionally and agglutinatively equally fast, but slower than languages without number. However, the participants' native language pronouns' structure could have influenced the results.

In experiment 2, we recruited speakers of Mandarin, which expresses person and number in different morphemes in pronouns. Mandarin speakers learned ALs without number the fastest, but in contrast to English speakers, learned ALs with agglutinative expression of person and number faster than with fusional expression. The results suggest that descriptively simpler morphological systems are not always more learnable, and that future experiments investigating the effect of L2 speakers on morphological complexity need to take into account the participants' L1.

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The role of redundant marking in language learning

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Why do languages maintain redundant cues? Redundant marking is attested in different language systems: for example, several languages redundantly mark a single meaning using multiple morphological markers [1,2]. However, speakers seem to avoid redundancy, omitting (or reducing) predictable elements, a pattern consistent with a bias for efficient communication [3- 5]. How can we reconcile the presence of redundancy with speakers' tendency to avoid it in production? We propose learning as a possible link: redundant cues can be facilitative in certain learning situations, leading to increased redundancy when conversing with learners. While multiple cues can benefit learning [6-8], little work has examined the impact of having redundant linguistic cues. Here, we test the prediction that children's learning of a novel thematic assignment can be facilitated by the use of a redundant morpheme.

We asked how Hebrew-speaking children (mean age 7;9, N=56) learned an artificial language with a non-Hebrew like fixed OSV word order in two conditions. In the no-redundancy condition, the only cue for thematic assignment was the fixed word order. In the redundant- condition objects also had case marking: this cue was redundant because the fixed word order was a sufficient cue to thematic assignment. Following exposure (Figure 1), children's sentence comprehension was tested by asking them to match pictures to sentences. If redundant marking helps learning, then children should show better learning in the redundant-condition, despite its' greater complexity. Children successfully learned the language (better than chance, $p < 0.0001$) in both conditions. As predicted, children showed better learning in the redundant-condition (91% vs. 64%, $p < 0.0001$, Figure 2). These results show that redundancy can facilitate learning. We are currently conducting follow-up work to ask whether redundancy impacts children and adults differently, as predicted by the Linguistic Niche hypothesis [9]. We discuss possible implications for the link between language complexity and characteristics of interlocutors.

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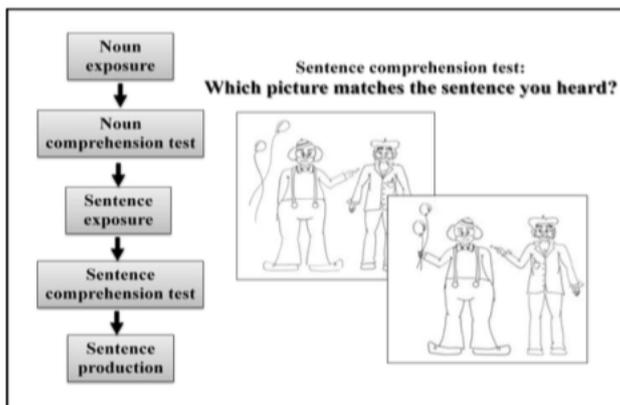


Figure 1: Experimental procedure; a trial example in the Sentence comprehension test phase

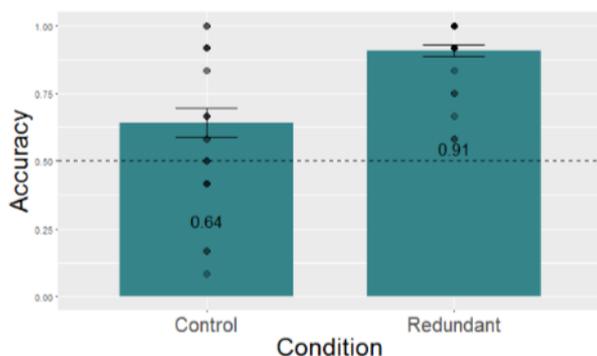


Figure 2: Accuracy scores by language condition. The dashed line indicates the chance level; error bars indicate standard errors of the means; individual points indicate by-participant means.

Evidence for vocal learning in a nonhuman primate, the common marmoset

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Traditionally, vocal learning has been considered rare or absent in nonhuman primates, but recent research on primate vocalizations increasingly suggests considerable vocal plasticity, especially, but not exclusively, in cooperatively breeding primates. Our goal was to use a set of translocation experiments to investigate to what extent vocal learning in the form of vocal accommodation was present in the common marmoset, a cooperatively breeding New World monkey ($n = 16-20$). First, we translocated individuals between different physical environments and recorded their vocalizations (three call types: phee calls, trill calls, and food calls) before and after the move. We found that the different physical environments did not change the acoustical structure of the three call types. Next, we translocated individuals

between different social environments, i.e. between colonies that differed in their dialects (vocal call structure) and found that they converged in phee and trill calls, but not in food calls. Finally, we followed individuals over the process of pair formation and found accommodation to new breeding partners, depending on the function of the call type. These results support the idea that nonhuman primates show vocal learning in the form of vocal accommodation. Reassessing the vocal learning potential in NHPs is of special interest when it comes to understanding the evolution of human language. Even though human language is a unique human feature, understanding potential precursors in closely related species is highly informative, and confirms them as valuable model system to study the evolution of human language.

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