

Language origins: Fitness consequences, platform of trust, cooperation, and turn-taking

Sławomir Wacewicz^{1*} Przemysław Żywicznyński¹

¹ Center for Language Evolution Studies, Nicolaus Copernicus University, Toruń, Poland

* Correspondence

Sławomir Wacewicz

Center for Language Evolution Studies, Nicolaus Copernicus University

Bojarskiego 1 (Room C.3.32), 87-100 Toruń, Poland; wacewicz [at] umk.pl

Przemysław Żywicznyński

Center for Language Evolution Studies, Nicolaus Copernicus University

Bojarskiego 1 (Room C.3.32), 87-100 Toruń, Poland; przemek [at] umk.pl

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Abstract

In this paper, we complement proximate or ‘how’ explanations for the origins of language, broadening our perspective to include fitness-consequences explanations, i.e. ultimate, or ‘why’ explanations. We identify the *platform of trust* as a fundamental prerequisite for the development of a language-like system of symbolic communication. The platform of trust is a social niche in which cheap but honest communication with non-kin is possible, because messages tend to be trusted as a default. We briefly consider the place of the platform of trust on the road map as laid out in the Mirror System Hypothesis. We then turn to recent research on turn-taking in primates, which has been proposed as a precursor of the cooperative structuring of conversation in humans. We suggest, instead, that human turn-taking, in its full richness that makes it an interesting explanatory target, may only appear in a communicative system that is already founded on a community-wide, cooperative platform of trust.

1. Introduction

Human communication is uniquely founded on a “platform of trust” (Wacewicz 2015): we tend to accept utterances even if no immediate evidence is present to back them up. While deception is always a possibility, it is nevertheless generally contained within manageable limits, and humans typically use language to provide non-kin with cheap but honest information (see Rossano, this issue), which is trusted at least as a default. Although intuitively obvious, this type of behavior is an evolutionary puzzle and its emergence runs counter to the predictions of evolutionary game theory – as we explain in section 4.

We consider the cooperative platform of trust to be a “deep” design feature of language, i.e., one that is not immediately visible on the surface-level as a structural property or a cognitive requirement for language. For this reason, the platform of trust is absent from the

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standard lists of design features of language (Hockett, 1960; but also cf. Hauser et al., 2002). This “deep design feature” is also conspicuously missing from the Mirror System Hypothesis (MSH; Arbib, 2012, 2016), which is otherwise arguably the most complete account of language origins at the level of implementation mechanisms. In what follows, we depart from the level of implementation and rigorously assess the “fitness consequences” of the evolution of the platform of trust, which allows us to demonstrate its importance to language origins hypotheses, including the MSH. Importantly, the platform of trust is understood in socio-ecological terms, so e.g. no psychological sense of trust is implied. Our core “platform of trust” argument is an extension of that put forward by Knight (e.g. 1998), and in a larger sense we take it to be a version of a consensus view that is different from previous proposals (e.g. Tomasello 2008; Zlatev 2014; see section 4) mostly in a consistent focus on the fitness-consequences perspective.

2. Communication: A fitness-consequences perspective

Following Tinbergen (1963), behavioral science distinguishes between several levels of analysis which, rather than being mutually exclusive, are all needed for an integrative understanding of an adaptation (whether morphological or behavioral). A majority of contributions in the present issue work from the perspective of phylogenetic continuity, often with a focus on *proximate* mechanisms (“what” or “how” explanations). This paper is different in having behavioral ecology as its point of departure, and consequently starting from what have been called *ultimate* (or “why”) explanations which are “concerned with the fitness consequences of a trait or behavior and whether it is (or is not) selected” (Scott-Phillips et al., 2011: 38) and abstract away from implementation details. For behavioral adaptations, rather than assessing their engineering viability, this perspective focuses on the ecological and especially *socio-ecological* conditions under which a behavioral strategy can invade a population and become *evolutionarily stable*.

The difference between the “engineering” and Darwinian “fitness consequences” perspectives is particularly important for studying interaction between multiple agents. Communication in non-human animals is one such example. From the genetic “fitness consequences” perspective the details of neurocognitive implementation are irrelevant; instead what distinguishes communicative from praxic action is the nature of payoff. In praxic action the payoff is direct, unlike in communicative action, where it depends on the praxic action of another (cf. communication as “a means by which one animal makes use of another animal’s muscle power”, Krebs and Dawkins, 1984). Successful reaching requires good motor skills, but a successful request requires compliance of the requestee (who typically prefers to tend to their own wellbeing). To be evolutionarily successful in a Darwinian world, individuals use heuristic calculations of costs and benefits to assess what course of action is *profitable*, including whether it *pays* to produce honest signals or react to the signals of others.

3. The platform of trust

It is typically assumed that in most animal populations, including primate societies, the default result of these subconscious quasi-economic calculations is negative. Under standard circumstances, the strategy of producing honest informative signals, or reacting to the signals of others, is outcompeted by alternative strategies. In most contexts, communicating “dishonestly” and manipulating the receiver to one’s own advantage will result in greater fitness benefits than communicating “truthfully”, leading natural selection to favor

manipulators over “honest” signalers. The presence of manipulators, in turn, puts the receivers at risk of losing fitness from “deceit”. As a result, they are selected to consider signals as potentially deceptive - a default that only changes when signal honesty can be reliably ascertained on independent grounds. By this simple logic, first expounded by Krebs and Dawkins (1984), honest communication is not an evolutionarily stable strategy and is not normally expected to evolve.

Exceptions abound due to several mechanisms that remove the above honesty constraint by making dishonesty impossible or counterproductive (e.g. Maynard Smith and Harper, 2003; Fitch, 2004; Waciewicz and Zywicki, 2012). Main examples include *handicaps* (inherently high signal cost, see esp. Zahavi and Zahavi 1997), *indexes* (content strictly dependent on form), *kin selection* (messages selectively directed to one’s relatives), *reciprocity* (e.g. exchange of mutually honest signals over a history of repeated interactions), or *normative regulations* (e.g. external penalty for signaling deceptively). Importantly, none of them explains the emergence of language, which is cheap to produce, arbitrary, not limited to kin or stable dyads, and is itself the medium necessary for formulating explicit codices.

From this perspective, the most important and most unusual property of language is large-scale “information donation” (e.g. van Schaik, 2016): communicators share honest messages with biologically unrelated individuals, who, in their turn, mostly accept such messages without demanding evidence. The qualitative difference between human and animal communication is thus flipping the default setting from expecting manipulation to expecting honesty. In other words, language is founded on a *global*, i.e. community-wide, *platform of trust* (Waciewicz, 2015)¹. Note that lying, common in human communication, is a case in point rather than a counterexample, because it constitutively requires trust: it is not possible to lie unless receivers are predisposed to trust the message at face value.

Information donation does exist in other animals, including primates, as exemplified by food calls and alarm calls. However, such information donation is limited to a small, closed set of narrowly specified contexts, and honesty appears to be externally guaranteed by ecological factors such as minimizing predation risk in food calling, or by kin selection and handicaps in alarm calls (see Maynard Smith and Harper, 2003; Zahavi and Zahavi, 1997). This is in stark contrast with language, where the sharing of information is ubiquitous, pervasive and domain-independent. Indeed, the very powerful human “drive or need to share thoughts and feelings”, has been proposed as one of the most distinctive characteristic of our species (Fitch, 2010: 140).

4. Cooperation

In language evolution research, many see the above honesty constraint as the single most important constraint on the emergence of language (e.g. Power, 2014), and the origins of large-scale sharing of honest information as the “central puzzle” of language evolution (Knight, 1998; Fitch, 2010). A common understanding is that this qualifies as a subtype of the general problem of the evolution of cooperation.

The cooperative nature of language requires a comment. While there is broad agreement that human language is indeed a “cooperative” communication system, attention to definitions is important (as is generally the case in interdisciplinary research). To different researchers, the cooperative nature of language may manifest itself, for example, in the

¹ See also Tan et al. 2017 for a similar concept of “circle of trust”; and Knight 1998 for the original argument on trust.

collaborative design of conversation (Grice, 1975; Clark, 1996), in the rules of collaborative face maintenance (cf. Hurford, 2007: 274), or in the use of symbolic communication for better coordination of multiperson collaborative tasks (Gärdenfors, 2004). Similarly, in the various literatures relevant to language evolution, “cooperation” more generally is used in a loose way close to the fuzzy vernacular meaning, and may simply indicate “collective action” of more than one individual resulting in a net benefit (e.g. Rossano, this issue), or even coordinated joint action in general. In such contexts, we prefer the term *collaboration*. In contrast, for reasons explained in (Waciewicz et al., 2017) and consistent with the fitness consequences perspective, we follow here the game-theoretic construal of cooperation.

Cooperative behavior is a classic problem in game theory because non-cooperative behavior typically pays off more, i.e. “purely selfish alternatives most often provide superior fitness” (Sachs and Rubenstein, 2007). Information donation – providing others with veridical information – meets the technical definition of cooperation (e.g. West et al., 2011), and as such, information donation is subject to similar game-theoretic constraints as the well-known constraints on evolution and stability of cooperative behavior in general (Axelrod, 1984), most importantly vulnerability to “cheaters” (see also Fitch, 2010: 414-417 for an explanation). Just like large-scale cooperation is the exception rather than the rule in animal behavior more generally, large-scale information donation is similarly the exception rather than the rule in animal *communicative* behavior².

4.1. The evolutionary origins of human cooperation

What are the phylogenetic roots of cooperative signaling in humans? One possibility is that “low-level” interactive mechanisms already present in the LCA-a (as inferred from studies on extant apes) - such as proxemic alignment, postural mirroring or the matching of mannerisms - could scale up to yield a level of trust necessary to support a cooperative signaling system. In a recent paper (Waciewicz et al., 2017) we review a number of mechanisms, e.g. building psychological affiliation based on the similarity of subtle nonverbal cues, which could help stabilize the precarious cooperative character of a signaling system. Although evidence shows that such mechanisms indeed work to bolster cooperation, it is highly unlikely that they would *alone* suffice to install a platform of trust. Note that when such mechanisms are at work in non-human apes, they tend to be limited to strongly bonded dyads, suggesting that they could at best install isolated islands of trust but not a group-wide platform of trust.

The alternative is that the platform of trust is a result of deeper and more overarching human cooperative dispositions. From a game-theoretic perspective, cooperatively informing genetically unrelated individuals is not qualitatively different from other manifestations of cooperation, including the more obvious kind of information donation, i.e. teaching, but also active food sharing or joint alloparental care for immature offspring. What they have in common in terms of fitness is that they all contradict the “economicus” stance of maximizing short-term gains. Humans exhibit a large suite of such cooperative behaviors, which has been taken to suggest that these behaviors all stem from a common, underlying cooperative basis,

² Communication in honeybees constitutes a well-known example of reliable and systematic information donation. This is consistent with the present account, because cooperative communication, together with other cooperative behaviors within the bee colony, is stabilised against defection by kin selection. Here, selfish alternatives are not superior, because hymenopteran full sisters are very close genetic kin, so any “cheating” would automatically lower their own inclusive genetic fitness (see Krebs and Dawkins, 1984, for discussion).

domain-general rather than limited to communication (e.g. Hare 2017; Knight and Lewis 2017; Burkart et al. 2009, Burkart et al. 2014, see also Burkart et al., this issue).

Importantly, humans demonstrate the above behaviors uniquely among apes, and near-uniquely among primates (see below). Conversely, available ethological (e.g. Mitani 2009) and experimental (e.g. Tomasello 2008) evidence suggests that cooperation, while not completely absent, is severely limited in non-human apes: “it is arguably true that cooperation, with kin and nonkin alike, is a hallmark of humankind, setting us apart in a significant way from our closest living relatives” (Mitani 2009). Consequently, an emerging consensus – largely based on the work of Tomasello and collaborators – is that the foundation for human cooperation is at least partly hardwired as a biological adaptation.

The most recent accounts of the evolutionary emergence of cooperation and prosociality in humans (see, e.g., Zlatev, 2014, for review) tend to underscore the role of alloparenting in humans, who are the only cooperative breeders among apes (see esp. Hrdy 2009; Burkart et al. 2014). The cooperative breeding hypothesis (CBH) rests on the example of callitrichid monkeys (tamarins and marmosets), who are the only other cooperative breeders among primates and also exhibit a suite of cooperative behaviors, including teaching, food sharing, and joint vigilance (Burkart et al. 2009; Burkart et al., this issue), all supported by a *proactive* prosocial motivation (Jaeggi et al. 2010). Incorporating insights from CBH, Tomasello has updated his earlier Interdependence Hypothesis by which human cooperativeness originally arose from ecological constraints, i.e. obligate collaborative foraging (Tomasello et al. 2012). The more recent “composite account” (Tomasello and Gonzalez-Cabrera 2017) additionally explains a suite of prosocial characteristics that appear early in human ontogeny as adaptations for interaction with alloparents.

5. The platform of trust and the Mirror System Hypothesis

As we have seen, the emphasis on fitness points to the platform of trust as a central precondition for language emergence, because only the platform of trust provides a social niche in which language generates net fitness benefits rather than costs. We understand the platform of trust non-psychologically, as a social niche in which large-scale cheap but honest communication is possible because messages tend to be trusted as a default. But on the individual level, it must of course be underpinned by the relevant neuronal, cognitive and behavioral adaptations.

The platform of trust is not explicitly identified as an explanatory target in the 2012 and 2016 “roadmaps” (versions of MSH as laid out in Arbib 2012, 2016). How and where should it be added? Two sorts of considerations suggest a relatively early (even if gradual) emergence, that is placing the platform of trust together with the first seven properties of language readiness (Arbib 2012: 164, 2016: 10), which require a biological anchoring. Firstly, the research reviewed in section 4 points to biological roots of human cooperation, identifying it as part of our species-specific endowment. Secondly, on the present account even the simplest forms of honest informative communication that qualify as information donation (e.g., pantomime) are subject to the honesty constraint and therefore the platform of trust must predate any such forms of early communication.

As for the proximate-level implementation, the existence of a community-wide platform of trust must translate into relevant motivational dispositions (cf. van Schaik 2016: 423 “[evidence] strongly suggests that the most important limitation to the evolution of human-like language was indeed the *motivation* to share information, rather than the *cognitive ability*

to do so". In line with section 4.1, we suggest that the relevant cooperative disposition in humans is general rather than specific to the domain of communication: a *proactive* prosocial motivation, i.e., psychological mechanisms that generate prosocial behavior relatively spontaneously and across a wide variety of contexts rather than being conditional on specific triggering stimuli (Jaeggi et al. 2010).

One example where such a motivation component would be required is the ontogenetic ritualization (OR) model that Arbib et al. (2014) provide to exemplify a more general idea of dyadic brain modelling. The OR model transforms a praxic action into a communicative signal over a series of interactions in a Mother-Child ape dyad. From a fitness-consequences perspective, the model works because of the local alignment of interests between the mother and the child: a local "island of trust" emerges. Although the initial goal-states of the mother and the child are different, they naturally converge on the common goal of bonding, and this common goal determines the desirability values of potentially executable actions.

From the present perspective, this model would be difficult to scale up to the community at large. The high level alignment of interests in the Mother-Child dyad cannot be realistically expected of other dyads, so the local Mother-Child "island of trust" would not extend to form a more global platform of trust. Conflicting interests would lead to conflicting goals, which would influence the desirability values of joint action. What is needed from the implementation perspective is a "prosocial" motivation mechanism that would assign relatively high desirability values to joint action, including joint communicative action, that would remain high in the absence of immediate payoff and across different dyad compositions within a community. What is needed from a fitness-consequences perspective is a socio-ecological niche in which such a mechanism would not result in negative fitness.

6. Turn-taking

Recent primatological research identifies an apparent counterexample to our account: "turn-taking" behaviors in non-human primates that putatively exemplify cooperative communication (vocal in monkeys: e.g. Ghazanfar and Takahashi, 2014; Takahashi et al., 2013; gestural in apes: Fröhlich et al. 2016, Fröhlich et al. 2017). In line with Levinson's (2006) "interaction engine" hypothesis, this comparative evidence is sometimes used to assert a continuity view, where turn-taking behaviors in nonhuman primates would be a "precursor" of human communicative turn-taking (Rossano, 2013; Fröhlich et al., 2016; Fröhlich et al. 2017, Levinson, 2016). In our opinion, the distribution of turn-taking behaviors among various primate and non-primate taxa seems point to convergent evolution rather than evolutionary continuity (also see Burkart et al., this issue). Accordingly, contrary to the continuity view, we argue that a cooperative basis – or the platform of trust – is a necessary requirement for language, including the type of turn-taking characteristic of language.

Again, definitions are important. In many such comparative studies turn-taking, or specifically linguistic turn-taking, is defined rather loosely (see Rossano, this issue, for a similar conclusion). Below, we break down linguistic turn-taking into the features of *alternation*, *synchrony* (online timing), *conditional relevance* and egalitarian *role-reversibility*, showing that the primate studies mentioned above focus on the aspect of interactional synchrony, without paying due attention to the other properties (see Rossano, this issue).

6.1. Alternation

In the various literatures relevant to language evolution research, some uses of “turn-taking” only depend on the minimal requirement of alternation between two parties; more specifically, interacting parties must execute their appropriate actions in a coordinated fashion. Interestingly, examples of turn-taking given in the classic text by Sacks et al. (1974) – moves in games, terms of political office, traffic at intersections or service of customers at business establishments – fit into this conceptualization. In like fashion, in primatological literature “turn-taking” is sometimes used loosely to denote alternation at a joint activity, such as grooming, or even a competitive activity, such as feeding (e.g. Hare, 2017).

6.2. Synchrony (fast-paced temporal coordination)

Much of the recent spike of interest in linguistic turn-taking results from the temporal dynamics of conversations: specifically, the speed and efficiency with which floor transfers take place. Accordingly, turn-taking results from the interaction between two pressures – the pressure to minimize gaps between conversants’ respective turns and the pressure to avoid overlaps between these turns (Sacks et al., 1974). This perspective highlights synchronization, i.e., it involves reciprocal temporal adjustment of interactional roles (Wacewicz et al., 2017). As such it belongs to a large group of behaviors that depend on the abilities “to anticipate, attend and adapt to each other’s actions in real time” (Keller et al., 2014).

What has made linguistic turn-taking an interesting research problem is that the turn-transitions are extremely fast when compared to how much time it takes to plan for another turn-contribution. Studies employing the measure of Floor Transfer Offset (FTO), calculated as the duration between the end and beginning of two adjacent turns, indicate that FTO values are similar in different languages (e.g. Stivers et al., 2009; cf. Levinson and Torreira, 2015; Roberts et al., 2015). Most turn reactions, irrespective of the context, come within up to 500 ms from the end of the preceding turn. Levinson and Torreira (2015) stress that this time is impressively short, if we consider that it takes 600 ms to plan for the articulation of a single lexeme (Levelt et al., 1999) and as much as 1500 ms for the articulation of a simple utterance (Griffin and Bock, 2000). Extensive research into turn-taking has shown that its rapidity and precision depends on a combination of lexico-syntactic (e.g. Ruitter et al., 2006) and prosodic signals (e.g. Couper-Kuhlen and Setling, 1996) as well as visually transmitted cues, such as hand movements (gestures: e.g. Kendon, 2004; adaptors: Zywiczyński et al., 2017).

In comparative research, turn-taking has come to be understood primarily in temporal terms as the FTO between a signal from one animal and a signal or behavior from the other animal. Such an approach can be seen in the studies on primate calls, e.g. contact calls in Campbell’s, squirrel monkeys and Diana monkeys or social-qua-grooming calls in marmosets (e.g. Masataka and Biben, 1987; Takahashi et al., 2013; Chow et al., 2015; see also Fedurek et al., 2015 for the role of lip-smacking, an audio-visual signal which apparently plays a role in coordinating grooming bouts in chimpanzees) and gestural signals (e.g., soliciting carries in bonobos: Rossano, 2013; joint-travel initiations in bonobos and common chimps, Fröhlich et al., 2016). These works attend to the ecological and interpersonal context to determine when such exchanges can legitimately count as initiations and responses. Some authors, controversially, use this for advancing claims that the studied behaviors “resemble cooperative turn-taking sequences in human conversation” (Fröhlich et al., 2016).

6.3. Conditional relevance

In our view, the above conclusions are erroneous because they miss the crucial point for the understanding of linguistic turn-taking, which can be expressed by the question: *Why does linguistic turn-taking constitute an explanatory target?* The answer is not that it is so fast, but because it is so fast *even though the content needs to be planned*: it's no challenge to say fast just anything, the challenge is to say fast something that *makes sense*. Due to the semantically open-ended nature of linguistic communication, the length and type of successive contributions do not follow a prescribed format – conversants produce turns of varying length and with various functions and meanings. This open-ended character of conversational interaction relates to what Levinson (1983), specifically referring to adjacency pairs, describes as *conditional relevance*: linguistic turn-taking is possible because conversants are able to interpret each other's contributions in an online fashion – both their length and type, and adjust their responses accordingly (cf. *relevance*; Sperber and Wilson 1986). The computational challenge that makes linguistic turn-taking such a fascinating phenomenon will not arise from time constraints alone: it only emerges when the time constraints of real-time communication are imposed on the transmission of semantically complex, open-ended propositional content.

From our perspective, a key insight apparently missing from the turn-taking literature is that what a person says *has fitness consequences*. In a propositional communication system, each individual utterance has a potential to affect one's (inclusive) fitness, sometimes in very dramatic ways. Examples include revealing a secret, or displaying own incompetence in public, not to mention a witty retort that can win a presidential debate, or an unwitting insult that can start a clan war. The tight temporal perspective set by the turn-taking requirements of human language magnifies the challenge: it is not sufficient for the answer to be relevant, but it needs to be *optimized in terms of its social consequences*. In human language, the computations of the fitness consequences of each potential reply – selected from an open-ended repertoire of propositions – need to be squeezed into the 200-500 ms window of the average turn transition.

Conditional relevance is thus crucially important for linguistic turn-taking, and it is absent from the examples of non-human primate turn-taking, which does not present similar challenges of semantic fit. There, the repertoire of possible "moves" available to each interactant at any given point is not only finite but appears to be limited to a small number of options, so the successive contributions are selected from a closed set rather than compiled online. This is a qualitative difference that we trace back to the platform of trust: absent in non-human primates and present in humans. As we have argued, open-ended compositionality requires a global platform of trust. It cannot be implemented in a standard animal communication system, where each individual meaning has to be backed up by costly evidence, because combining such meanings would also exponentially increase the associated costs. Only when the default has changed to "trust unless disconfirmed" can complex communication get off the ground (see Okanoya, 2012; Knight, 1998).

6.4. (Egalitarian) role reversibility

An essential quality of linguistic turn-taking is the egalitarian reversibility of the speaker/hearer roles (cf. Levinson, 2006). In fact, the turn-taking rules, such as the rules for nominating next speaker (Sacks et al., 1978), testify to the egalitarian character of conversational interaction: since there is no rigid ascription of interactional roles in

conversation (as is the case in many forms of communication, e.g. in courtship, e.g. Wagner, 2011; or predator-prey interaction, e.g. Vega-Redondo and Hasson, 1993), conversants must abide by the turn-taking rules to meet the timing requirements, i.e., to minimize gaps between turns and avoid overlaps between them (see 6.2). Conversational interaction is then both egalitarian and organized, the combination of which is seen as an important feature of human social organization (see e.g. Schegloff, 2000).

The criterion of egalitarian reversibility of the speaker/hearer roles is not always met in the coordinative behaviors of non-human primates that have been described as turn-taking. Egalitarian role-reversibility as described above seems to present in antiphonal (call-and-response) calling in callitrichids (Takahashi et al. 2013), who characteristically are the only cooperative breeders among primates, excepting humans (cf. Burkart et al., this issue). By contrast, in many cases of ape gestural communication the roles of sender and receiver are predetermined by the relationships between the members of the communicating dyads. For example, the solicitation of carries in bonobo mother-infant dyads is necessarily initiated by the young (Rossano, 2013), while join-travel sequences in bonobo and common chimp mother-infant dyads tends to be initiated by the mother (Fröhlich et al., 2016).

7. Towards a new Road Map

How did the platform of trust emerge in the course of human evolution? One possibility is that local “islands of trust” between individuals with unusually well-aligned interests, such as in mothers and offspring, could somehow scale up to the society at large (e.g. Fitch 2004, see also section 5). However, as we discussed in 4.1., a more likely scenario is that the platform of trust was itself founded on more general cooperative dispositions that extend beyond communication to permeate human sociality. The origins of human cooperation continue to present a major puzzle, but a number of influential accounts see a role for cooperative breeding (e.g. Hrdy, 2009; Burkart et al., this issue; see also Tomasello and Gonzalez-Cabrera, 2017; and Zlatev, 2014).

When did the platform of trust emerge in the course of human evolution? Its absence in extant nonhuman apes strongly suggests it was not present in LCA-c, i.e. the last common ancestor of the genera *Homo* and *Pan*. However, if the present argument stands, a global (society-wide) platform of trust is a logically necessary prerequisite for any large-scale information donation, which includes not only language but also e.g. pedagogy as well as any form of communication not based on costly signals (cf. sections 4 and 5). The appearance of the first forms of open-ended communication, whether pantomimic as proposed by the MSH (Arbib 2012, 2016) or otherwise, would have only been possible with the platform of trust firmly in place, because without it, even agents capable of producing and understanding pantomime would have simply chosen to ignore any pantomimic messages, except those backed up by independent evidence.

The platform of trust, a socio-ecological niche in which messages tend to be trusted as a default, is an ultimate-level category that on the level of implementation would translate into *motivation* to share honest information (cf. section 5). From that perspective, the minimal requirements for successful pantomimic communication extend beyond the *cognitive* abilities of complex action recognition and imitation and need to be complemented by a *socio-cognitive* trait of motivation: of the producer (i) to inform the receiver and (ii) to do it truthfully, and of the receiver to (i) trust such messages as non-deceptive and (ii) to respond

appropriately. This points to the studies on the human motivation to talk – and being talked to – as perhaps the most promising direction in language evolution research.

What do we want to talk? One perspective is afforded by studying human clinical populations, specifically individuals suffering from Williams Syndrome, a neurodevelopmental disorder that affects motivation for social interaction (Semendeferi, this issue). On the level of brain implementation, oxytocin – neurochemical often linked to trust (but see Neva et al., 2017) – has been recently suggested as implicated in the social motivation for vocal learning (Theofanopoulou et al., 2017) and in the propensity to share knowledge as well as material resources (de Boer et al. 2017). The parallels between the motivation to donate information and to donate other resources such as food are currently explored in the cooperatively breeding callitrichids (Burkart et al., this issue), showing the relevance of comparative research. Importantly, both the “engineering” and “fitness consequences” levels of analysis need to be considered for a full, integrative understanding of the origins of the uniquely trust-based human communication system.

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References

- Arbib, M. (2012). *How the brain got language*. Oxford: OUP.
- Arbib, M., Ganesh, V., & Gasser, B. (2014). Dyadic brain modelling, mirror systems and the ontogenetic ritualization of ape gesture. *Phil. Trans. R. Soc. B*, 369(1644), 20130414.
- Arbib, M. A. (2016). Towards a computational comparative neuroprimatology: framing the language-ready brain. *Physics of life reviews*, 16, 1-54.
- Axelrod, R. (1984). *The Evolution of Cooperation*. New York: Basic Books.
- Burkart, J. M., Hrdy, S. B., and Van Schaik, C. P. (2009). Cooperative breeding and human cognitive evolution. *Evolutionary Anthropology: Issues, News, and Reviews* 18(5), 175-186.
- Burkart, J. M., Allon, O., Amici, F., Fichtel, C., Finkenwirth, C., Heschl, A., ... and Meulman, E. J. (2014). The evolutionary origin of human hyper-cooperation. *Nature communications* 5, 4747.
- Burkart, J., Eloísa, G., Miss, F., Zuercher, Y. (this issue)
- Chow, C.P., Mitchell, J.F., and Miller, C.T., 2015. Vocal turn-taking in a non-human primate is learned during ontogeny. *Proc. R. Soc. Lond. B Biol. Sci.* 282 (1807), 20150069.
- Clark, H.H., 1996. *Using language*, Cambridge: CUP.
- Couper-Kuhlen, E, and Selting, M. (1996). “Towards an interactional perspective on prosody and a prosodic perspective on interaction,” in *Prosody in Conversation*, eds. E. Couper-Kuhlen and M. Selting (Cambridge: CUP), 11-56.

de Boer, M., Kokal, I., Blokpoel, M., Liu, R., Stolk, A., Roelofs, K., ... & Toni, I. (2017). Oxytocin modulates human communication by enhancing cognitive exploration. *Psychoneuroendocrinology* 86, 64-72.

Dor, D., Knight, C. and Lewis, J. (2014). "Introduction: a Social Perspective on How Language Evolved", in *The Social Origins of Language*, eds. D. Dor, C. Knight and J. Lewis (Oxford: OUP), 1-12.

Fedurek, P., Slocombe, K. E., Hartel, J. A., and Zuberbühler, K. (2015). Chimpanzee lip-smacking facilitates cooperative behavior. *Scientific reports*, 5.

Fitch, T. (2004). "Kin selection and 'mother tongues': a neglected component in language evolution", in *Evolution of communication systems: A comparative approach*, eds. D. K. Oller and U. Griebel (Cambridge, MA: MIT Press), 275–296.

Fitch, T. (2010). *The Evolution of Language*. Cambridge: CUP.

Fröhlich, M., Kuchenbuch, P., Müller, G., Fruth, B., Furuichi, T., Wittig, R. M. and Pika, S. (2016). Unpeeling the layers of language: Bonobos and chimpanzees engage in cooperative turn-taking sequences. *Scientific reports*, 6, 25887.

Fröhlich, M. (2017). Taking turns across channels: Conversation-analytic tools in animal communication. *Neuroscience & Biobehavioral Reviews* 80, 201-209

Gärdenfors, P., 2004. Cooperation and the evolution of symbolic communication. In: Oller, K., Griebel, U. (Eds) *The Evolution of Communication Systems*. MIT Press, Cambridge, pp. 237-256.

Ghazanfar, A.A. and Takahashi, D.Y. (2014). The evolution of speech: vision, rhythm, cooperation. *Trends in Cognitive Science* 18(10), 543–553.

Grice, H.P. (1975). "Logic and conversation", in *Syntax and Semantics, Speech Acts* (vol. 3), eds. P. Cole and J. Morgan (New York: Academic Press), 41–58.

Griffin, Z. M. and Bock, K. (2000). What the eyes say about speaking. *Psychological Science* 4, 274–279.

Hare, B. (2017). Survival of the friendliest: Homo sapiens evolved via selection for prosociality. *Annual review of psychology* 68, 155-186.

Hauser, M. D., Chomsky, N. A., and Fitch, T. (2002). The faculty of language: What is it, who has it, and how did it evolve? *Science* 298, 1569–1579.

Hockett, C. F. 1966. "The Problem of Universals in Language" in J. Greenberg (ed.), *Universals of Language*. Cambridge, MA: MIT Press, 1-29.

Hrdy, S. 2009. *Mothers and others*. London: HUP.

Hurford, J. (2007). *The origins of meaning. Language in the light of evolution*. Oxford: OUP.

Jaeggi, A. V., Burkart, J. M., & Van Schaik, C. P. (2010). On the psychology of cooperation in humans and other primates: combining the natural history and experimental evidence of prosociality. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 365(1553), 2723-2735.

Keller, P.E., Novembre, G. and Hove, M.J. (2014). Rhythm in joint action: psychological and neurophysiological mechanisms for real-time interpersonal coordination. *Phil. Trans. R. Soc. B* 369 (1658), 20130394.

Kendon, A. (2004). *Gesture. Visible Action as Utterance*. Cambridge: CUP.

Knight, C. (1998). Ritual/speech coevolution: A solution to the problem of deception. In Hurford, J. et al. (Eds.), *Approaches to the Evolution of Language*, Cambridge: CUP, 68-91.

Knight, C., and Lewis, J. D. (2017). Wild Voices: Mimicry, Reversal, Metaphor, and the Emergence of Language. *Current Anthropology*, 58(4), 435-453, 10.1086/692905

Krebs, J.R., Dawkins, R. (1984). "Animal Signals: Mind-Reading and Manipulation", in J. R. Krebs and R. Dawkins (Eds.), *Behavioral Ecology*. Oxford: Blackwell, 380–402.

Levelt, W. M. (1999). "Producing spoken language: a blueprint of the speaker," in *The Neurocognition of Language*, eds. C. Brown and P. Hagoort, Oxford: OUP, 83- 122.

Levinson, S. (1983). *Pragmatics*. Cambridge: CUP.

Levinson, S.C., 2006. On the human "interaction engine". In: Enfield, N.J., Levinson, S.C. (Eds.), *Roots of Human Sociality: Culture, Cognition and Interaction*. Berg, Oxford, pp. 39–69.

Levinson, S.C., 2016. Turn-taking in human communication, origins, and implications for language processing. *Trends Cogn. Sci.* 20 (1), 6–14.

Levinson, S., and Torreira, F. (2015). Timing in turn-taking and its implications for processing models of language. *Frontiers in Psychology* 6: 731. doi: 10.3389/fpsyg.2015.00731

Masataka, N., and Biben, M. (1987). Temporal rules regulating affiliative vocal exchanges of squirrel monkeys. *Behavior* 101 (4), 311–319.

Maynard Smith, J., and Harper, D. (2003). *Animal Signals*. Oxford: OUP.

Mitani, J. C. (2009). Cooperation and competition in chimpanzees: current understanding and future challenges. *Evolutionary Anthropology: Issues, News, and Reviews* 18(5), 215-227.

Nave, G., Camerer, C., & McCullough, M. (2015). Does oxytocin increase trust in humans? *Perspectives on Psychological Science*, 10(6), 772-789.

Okanoya, K., 2002. Sexual display as a syntactical vehicle: the evolution of syntax in birdsong and human language through sexual selection. In: Wray, A. (Ed.), *The Transition to Language*. Oxford: OUP, 46-63.

Power, C. (2014). "Female philopatry and egalitarianism and conditions for the emergence of intersubjectivity". In Cartmill, E. et al. (eds.), *Proceedings of the 10th Evolang*, Singapore: World Scientific, pp. 252-259. https://doi.org/10.1142/9789814603638_0032

Roberts, S. G., Torreira, F., and Levinson, S. C. (2015). The effects of processing and sequence organization on the timing of turn-taking: a corpus study. *Frontiers in Psychology* 6:509. doi: 10.3389/fpsyg.2015.00509

Rossano, F. (2013). Sequence organization and timing of bonobo mother-infant interactions. *Interact. Stud.* 14(2), 160–189.

Rossano, F. (this issue)

Ruiter, de, J. P., Mitterer, H., and Enfield, N. J. (2006). Projecting the end of a speaker's turn: A cognitive cornerstone of conversation. *Language* 82, 515-535.

Sachs, J. L., and Rubenstein, D. R. (2007). The evolution of cooperative breeding; is there cheating? *Behavioral Processes* 76(2), 131-137.

Sacks, H., Schegloff, E.A. and Jefferson, G. (1974). A simplest systematics for the organization of turn-taking in conversation. *Language* 50, 696–735.

Sacks, Harvey, Emmanuel Schegloff, and Gail Jefferson. 1978. "A Simplest Systematic for the Organization of Turn-Taking in Conversation," in *Studies in the Organization of Conversational Interaction*, ed. Jim Schenkein (New York: Academic Press), 7–55.

Schaik, van, C.P. (2016). *The primate origins of human nature*. New York: Wiley.

Schegloff, E. A. (2000). Overlapping Talk and the Organization of Turn-Taking for Conversation. *Language and Society* 29, 1-63.

Scott-Phillips, T. C., Dickins, T. E., and West, S. A. (2011). Evolutionary theory and the ultimate–proximate distinction in the human behavioral sciences. *Perspectives on Psychological Science*, 6(1), 38–47.

Semendeferi, K. (this issue) Why do we want to talk?

Sperber, D., and Wilson, D. (1986). *Relevance*. Oxford: Blackwell

Stivers, T., Enfield, N. J., Brown, P., Englert, C., Hayashi, M., Heinemann, T. and Levinson, S. C. (2009). Universals and cultural variation in turn-taking in conversation. *Proceedings of the National Academy of Sciences* 106(26), 10587–10592. doi: 10.1073/pnas.0903616106.

Takahashi, D.Y., Narayanan, D.Z. and Ghazanfar, A.A. (2013). Coupled oscillator dynamics of vocal turn-taking in monkeys. *Curr. Biol.* 23(21), 2162–2168.

Tan, J., Ariely, D., and Hare, B. (2017). Bonobos respond prosocially toward members of other groups. *Scientific reports*, 7(1), 14733.

Theofanopoulou, C., Boeckx, C., Jarvis, E. D. (2017). A hypothesis on a role of oxytocin in the social mechanisms of speech and vocal learning. *Proc. R. Soc. B* 284: 20170988.

Tomasello, M. (2008). *Origins of Human Communication*. Cambridge, MA: MIT Press.

Tomasello, M., Melis, A. P., Tennie, C., Wyman, E., and Herrmann, E. (2012). Two key steps in the evolution of human cooperation. *Current Anthropology* 53(6), 673–692.

Tomasello, M., & Gonzalez-Cabrera, I. (2017). The role of ontogeny in the evolution of human cooperation. *Human Nature*, 1–15.

Tinbergen, N. (1963). On aims and methods of ethology. *Zeitschrift für Tierpsychologie* 20(4), 410–433.

Vega-Redondo, F., and Hasson, O. (1993). A Game-theoretic Model of Predator—Prey Signaling. *Journal of Theoretical Biology*, 162(3), 309–319.

Waciewicz, S., Żywicznyński, P. (2012). Human honest signalling and nonverbal communication. *Psychology of Language and Communication* 16 (2), 113–130.

Waciewicz, S. (2015). The shades of social. A discussion of "The social origins of language", ed. Daniel Dor, Chris Knight and Jerome Lewis. *Theoria et Historia Scientiarum*, 11, 191–208.

Waciewicz, S., Żywicznyński, P., and Chiera, A. (2017). An evolutionary approach to low-level conversational cooperation. *Language Sciences*, 10.1016/j.langsci.2017.01.005

Wagner, W. E. (2011). Direct benefits and the evolution of female mating preferences: conceptual problems, potential solutions, and a field cricket. *Advances in the Study of Behavior* 43(273), e319.

West, S. A., El Mouden, C., and Gardner, A. (2011). Sixteen common misconceptions about the evolution of cooperation in humans. *Evolution and Human Behavior* 32(4), 231–262.

Zlatev, J. (2014). "The co-evolution of human intersubjectivity, morality, and language", in *The Social Origins of Language*, eds. D. Dor, C. Knight and J. Lewis (Oxford: OUP), 249–266.

Zywicznyński, P., Orzechowski, S., and Waciewicz, S. (2017). Adaptors and the Turn-Taking Mechanism: The Distribution of Adaptors Relative to Turn Borders in Dyadic Conversation. *Interaction Studies* 18(2), is.18.2.07zyw