

The "why" of human reasoning and
communication:
Cognitive capacities through the lens of evolution

Flip Lijnzaad
Supervisor: Karolina Krzyżanowska

March 26, 2024

Introduction

{sec:introduction}

1: Don't overuse passive voice. Don't make sentences too long (rule of thumb: not longer than two lines). Don't abuse semicolons. Don't have too long NPs before the VP comes. Watch out for Dutch word order. Explain technical terms always, to fix their meaning. Give examples (and keep them as familiar as possible). Don't undersell your points, be confident! Don't vary terminology for the sake of variation.

Two cognitive skills that are often considered to set humans apart from their evolutionarily closest relatives are on the one hand our outstanding capacity for reasoning, and on the other our profound communicative abilities. Broadly considered to be unmatched in the animal kingdom (Cheney and Seyfarth, 1997) are on the one hand our sophisticated reasoning abilities

2: This paragraph is saying the same thing twice, and word order is funky

3: Explicate this; cite a source

and on the other hand our communication using languages that are infinitely creative in enabling the production of complex sentences.

Our reasoning and communication are intertwined with each other in different ways; it is hard to imagine our communication without reasoning. In our everyday lives, a lot of the content we intend to convey to others, we relay pragmatically: we do not literally spell out these things, but rather hope and expect our interlocutors to infer the intended message from the communicated content. When I ask my dinner partner if they can pass me the salt, they infer that I am not interested in learning about their ability to pass me the salt but rather that I am requesting to be passed the salt. When I give feedback on an interlocutor's behavior, I first reason about how my words will come across to her in order to minimize social conflict.

It is thus easy to see that reasoning and communication are intricately linked. But what exactly is the extent and nature of this link? In 2011, Hugo Mercier and Dan Sperber proposed a revolutionary theory of reasoning that intended to account for a number of long-standing issues in the experimental psychology of reasoning. According to their *argumentative theory of reasoning*, the main function of reasoning in humans is argumentative; that is, reasoning evolved in humans in order to devise arguments and evaluate those of others. Their theory is able to explain a number of purported 'flaws' of human reasoning, such as poor performance on standard reasoning tasks such as the Wason selection task; confirmation bias; and the phenomenon of motivated reasoning leading to attitude polarization.

In the words of Mercier and Sperber,

Reasoning has evolved and persisted mainly because it makes human communication more effective and advantageous. (Mercier and Sperber, 2011, p. 60)

4: Add a few words about why this thesis is worth scrutinizing: for example, that others also disagree (see the MS11 commentary), or already hint at your own objections

5: Add a few words on that the "why" of communication is an important question, explain why this is needed to ultimately answer the RQ. It's more primitive, or primary; address this

In this thesis, I will scrutinize this position in order to ultimately answer the question of whether advanced reasoning skills in humans evolved because they facilitate more advanced communication.

6: Could do with some more explication: how will I scrutinize this position?

1 | The chicken and the egg: the evolutionary approach

{ch:evolution}

Before we are able to answer any *why*-questions about the evolution of reasoning and communication, some groundwork needs to be laid out. For what are the processes underlying evolution, and how does evolutionary causation work? What does it mean for some trait to evolve 'for the purpose of' another trait? Are we even justified in using this kind of terminology when it comes to evolution? And what intermediate questions will we need to ask ourselves in order to ultimately answer the question of why we reason and communicate?

This chapter serves to answer these and related questions. It by no means provides a comprehensive overview of the issues in evolutionary theory, since this is a vast field of research in its own right with widely diverging opinions on a number of specifics of the process of evolution¹. The purpose of this chapter is to touch on a number of issues in the field that are relevant to our endeavor, such that we have a stronger foundation for our investigation into the evolution of reasoning and communication.

1.1 Evolution: biological vs. cultural

{sec:evo-bio-culture}

Although the term 'evolution' is in everyday usage most commonly interpreted as 'Darwinian evolution', or 'natural selection', the concept of evolution can be stripped down to a very broadly construed version, which may prove to be illuminating.

In general, any process of selection can be taken to consist of three consecutive steps: (1) variation, (2) sorting², and (3) retention (Donahoe, 2003). I will first discuss how each of the steps of this process are construed in standard evolutionary theory, and then we will consider how the process of cultural evolution fits this definition of selection.

¹See Ariew et al. (2002) and Uller and Laland (2019) for an overview of topics in evolutionary theory and evolutionary causation.

²Donahoe (2003) uses the term 'selection'; I follow Heyes (2018) and Scott-Phillips et al. (2013) in using the term 'sorting', to avoid confusion with the full process of selection, which consists of the three steps outlined here.

Firstly, in standard evolutionary theory the processes introducing variation are mutation (changes in an organism's DNA) and migration (the movement of (genetic material of) organisms from one population to another) (Scott-Phillips et al., 2013). Variation by itself is undirected; it is only due to sorting that the selection process becomes directed (Donahoe, 2003). Secondly, in standard evolutionary theory the sorting process amounts to natural selection and genetic drift. Natural selection acts upon the variation introduced by mutation and migration such that the genes that enhance an organism's fitness persist over time in the population (Scott-Phillips et al., 2013). An organism's fitness corresponds to how likely they are to leave offspring in the next generation compared to organisms with a different genetic makeup. This fitness relates to both the organism's chances of survival as well as its chances of reproducing.

Do I need a citation for these definitions? Academic sources seem to either assume familiarity and forego definition, or, rigorously pull apart the term in such a way that the resulting definition is too formal for my purpose. I used "Evolution 101" type of sources for these definitions.

Genetic drift, on the other hand, is a random sorting process, resulting from a sampling error due to populations being finite in size³.

I'm not sure, but genetic drift might warrant more discussion: I included it for completeness because Scott-Phillips et al. (2013) mentions it, but biologists seem to disagree on how important genetic drift is compared to natural selection. But it sounds like it could complicate my analysis because of its randomness.

Thirdly, in standard evolutionary theory, the process responsible for retention is genetic inheritance, i.e. the transmission of characteristics from parents to their offspring through the genetic material (DNA) parents impart on their offspring.

Now, the evolution of *culture* can also be said to operate by these principles (Heyes, 2018). In this context, culture is understood at its core as *information*: more specifically, it is information "that we inherit from others through social interaction (via certain kinds of social learning)" (Heyes, 2018, p. 30). Let us now consider the cultural processes underlying each of the three steps of the selection process.

Firstly, variation in culture is introduced by error and by innovation. Secondly, sorting of behaviors and habits in culture can happen through two different routes. A behavior can be sorted (selected for) because of some property inherent to the behavior that makes it "more noticeable, learnable, or memorable than others" (Heyes, 2018, p. 34) and thus more likely to be copied. Also, a behavior or habit may be sorted in a more 'classic' evolutionary way: a habit may be selected for because it improves the fitness of the individual, such that individuals with that habit are more likely to survive and reproduce than individuals with an alternative habit. Thirdly, culture may be retained through cultural inheritance, that is, through mechanisms of social learning.

Whether or not the process of cultural evolution can be taken to be analo-

³See Millstein (2021) for discussion on the concept of genetic drift and how it compares with natural selection.

(too many brackets)

I suppose Scott-Phillips and Donahoe also use these definitions, so what you have already we should be enough.

I agree. Maybe half a sentence on sorting but that's it

I don't think I need examples in this paragraph, since I believe that the workings of biological evolution are more or less common knowledge(?)

Maybe just unpack the definition, mention it's importance is debated, keep it aside

Add example

Add example

Add example

Add example

gous to that of biological evolution, is not an uncontroversial issue; see Claidière et al. (2014) for discussion and a formal account of cultural evolution. In this thesis however, I will follow Heyes (2018) in the assumption that cultural evolution is 'Darwinian'; that is, it abides by mechanisms that are analogous to those of biological evolution. As a consequence, in discussing how reasoning and communication evolved, we may remain agnostic on the kind of evolution responsible for this evolution, since the mechanisms underlying biological and cultural evolution are assumed to be the same. Thus, for the remainder of this thesis, I will use the term 'evolution' to talk about the development of characteristics (in our case, cognitive capacities) in humans over time, remaining agnostic about whether this development is due to biological evolution or cultural evolution.

Find this reference again!

nice!

Possibly add to this section: (1) Something about gene-culture coevolution (though, can that be said to be Darwinian?) (2) Something about the hypotheses we need to form to make this theory complete, that Heyes (2018, Chapter 2) talks about: about variants and quantifiable differences between them; about routes of inheritance (vertical / oblique / horizontal); about mechanisms of inheritance.

1.2 Causation in evolution

{sec:causation-evolution}

Next, we will dip our toes into the waters of causation in evolution. As it turns out, causation in evolution is not a simple notion; let us consider for example a moth whose wings provide it with camouflage due to their coloration. The camouflage of the wings is an *effect* of their coloration; yet, it is precisely the camouflage the coloration provides that is the *cause* of the coloration being present at all (Lipton, 2009).

good example!

Evolutionary causation is a subfield of philosophy of biology that has continued to see widely diverging opinions (Baedke, 2021; Scott-Phillips et al., 2013). In this section I will restrict focus to four topics in evolutionary causation that are of interest to this thesis. First, I will discuss the distinction between proximate and ultimate causation. Then, I will briefly cover Tinbergen's (1963) questions for explaining animal behavior, which will be discussed at length in Section 1.5. Thirdly, we will have a look at niche construction and reciprocal causation. Lastly, we circle back to our research question and discuss what it entails for one trait to evolve for the purpose of another.

✓

In evolutionary causation, one may distinguish *proximate* from *ultimate* causes. Proximate causes are the immediate influences on a trait: they explain how the trait results from the internal and external factors causing it. Ultimate causes, on the other hand, provide the higher-level historical and evolutionary explanation of those traits (Mayr, 1961). In other words, these two different causes relate to two different explanatory questions: the proximate cause is related to the *how*-question (*how* did a trait come about?), whereas the ultimate cause is related to the *why*-question (*why* did a trait come about?). According to Mayr (1961), who pioneered the distinction⁴, one needs to answer both of these ex-

Add an example to illustrate

⁴See (Laland et al., 2013) for a discussion of the exact origins of the distinction.

planatory questions about a trait in order to obtain a complete understanding of it.

In a seminal proposal considered by some to be an extension of Mayr's dichotomy (Laland et al., 2013), Tinbergen (1963) outlined four questions central to the study of animal behavior. In order to fully understand a pattern of behavior, he argued, one must consider (1) the proximate causation of the behavior, (2) the lifetime development of the behavior, (3) the function⁵ of the behavior, and (4) the evolutionary history of the behavior. Since Tinbergen, other authors have grouped these four questions according to Mayr's proximate-ultimate distinction, characterizing the 'causation' and 'development' questions as proximate questions (*how*-questions) and the 'function' and 'evolution' questions as ultimate questions (*why*-questions) (Bateson and Laland, 2013; Laland et al., 2013). Tinbergen's framework has had an extensive and lasting influence on the study of animal behavior, and his questions continue to be used by biologists to this day (Bateson and Laland, 2013). Hence, I will let this framework inform the methodology for this thesis and will thus discuss it in greater detail in Section 1.5. ✓

According to standard evolutionary theory, evolution is a causally *unidirectional* affair: natural selection shapes an organism in such a way that the organism is better adapted to its environment, and as such, the causal chain starts with the environment and ends with the organism. In recent years however, biologists have been looking beyond this unidirectional view and are starting to consider the role of *reciprocal* causation in evolution. According to this concept, not only does the environment cause changes in an organism through evolutionary processes, the organism also causes changes in its environment through its actions:

To varying degrees, organisms choose habitats and resources; construct aspects of their environments, such as nests, holes, burrows, webs, pupil cases, and a chemical milieu, and destroy other components; and frequently choose, protect, and provision nursery environments for their offspring (Day et al., 2003, p. 81)

This process by which organisms influence their environment is referred to as *niche construction*. A prominent example of niche construction is the evolution of lactose tolerance in adult humans. The prevalence of lactose tolerance in a population correlates with whether that population has a history of dairy farming. This suggests that due to their adoption of dairy farming, the individuals in the population have come to rely upon their tolerance of lactose, and this reliance amounts to a selection pressure for lactose tolerance into adulthood (Scott-Phillips et al., 2013). Much discussion remains on the exact role that niche construction should play in our evolutionary theories. Proponents of *niche construction theory* maintain that niche construction is a process that operates alongside natural selection and is an evolutionary factor in its own right, whereas skeptics argue that standard evolutionary theory can account for niche ✓

⁵See Section 1.4 for a discussion of function in biology.

construction effects (Scott-Phillips et al., 2013). However, the concept of niche construction itself is uncontroversial: there is plenty of empirical evidence for the fact that organisms may partake in shaping their niche (Scott-Phillips et al., 2013).

Lastly, we briefly touch on what it means for one trait to evolve because of, or for the purpose of, another trait. In this thesis, we are interested in what evolutionary benefits one feature (reasoning) may have to another feature (communication). In order to answer this question, we should first consider what the function⁶ of communication is to humans; only then can we consider whether the function of reasoning could be to advance communication and in doing so, improve the fitness of humans.

Is this the most suitable time in this chapter to discuss this?

This last paragraph deserves more attention

Missing: concluding remarks about what I will do with these concepts

It's a good
build-up
I think.

nitpicky
(but genuine)
question
is reasoning
a feature or
the ability to
reason?

1.3 Evolutionary psychology

{sec:evol-psych}

In order to answer the question of whether reasoning evolved for the purpose of communication, we will also need to zoom out to consider the field of evolutionary psychology as a whole. What is the merit, and the validity, of adopting an evolutionary approach in our endeavor at all?

The field of evolutionary psychology concerns itself with trying to understand human behavior using evolutionary theory, by looking into the past and considering how our ancestors must have adapted to their environment in order to survive and reproduce. Researchers in the social sciences and humanities have historically been wary of using evolutionary approaches to study human behavior, because evolutionary theory has been abused for prejudiced ends in the past; see Laland and Brown (2002, pp. 19–20) for an overview. Moreover, evolutionary-psychological research has received the criticism that too much of it is "just-so" storytelling and post-hoc explanation of known phenomena, sometimes accompanied by a sensationalist spin on the story (Laland and Brown, 2002). However, if these pitfalls are avoided, looking at human psychology from the evolutionary perspective can be an illuminating endeavor. Let us now consider some of the central concepts and assumptions of evolutionary psychology.

In order to explain humans' psychological mechanisms, evolutionary psychologists look to the concept of an *environment of evolutionary adaptedness* (EEA). The EEA is the environment in which these psychological mechanisms must have come into being; usually the EEA is identified as hunting and gathering groups on the African savannah in the second half of the Pleistocene, between 1.7 million and ten thousand years ago (Laland and Brown, 2002).

⁶See Section 1.4.

This is a bit
strange question
to ask given
that your RQ
is about
evolution.
It could be
tackled in
the intro though
(since RQ needs
to be motivated).
Or maybe it's
just the matter
of how you
phrase the
question.

Are the groups the EEA or the savannah? Elaborate more on this: is it the physical environment or does it include the groups? Aren't the groups a trait that evolved? Think about this

The assumptions underlying the use of the concept of an EEA are that (1) our modern-day environment is too different from that of our ancestors for us to use it to explain why and how our psychological mechanisms evolved in the past; and (2) for our psychological mechanisms to be as complex as they are, they must have evolved slowly; because of this, they must have evolved a considerable amount of time ago without changing significantly since the Stone Age.

There are a number of issues associated with the use of the concept of the EEA (Laland and Brown, 2002). Firstly, we do not know very much about the environment of our ancestors, so the specifics of the EEA may be filled in as is seen fit for one's purpose. Secondly, we do not know enough about the process of evolution to make assumption (2); while evolution does in general operate on a large timescale, there is **empirical evidence** that the process can also be faster, operating on a timescale of thousands of years, or less than 100 generations (Laland and Brown, 2002, pp. 190–191 and references therein). Thirdly, the argument can be made that for our species to have flourished and dominated in the way that it did, we must have remained adaptive to our changing modern environments after the Stone Age. Lastly, the EEA argument does not take into account reciprocal causation or niche construction.

If relevant
for the argument?
What is this
evidence?

Elaborate on this last issue, because it seems to be important for my argument. Also, it seems like a strange point to make, because especially with humans, it seems obvious that niche construction is a thing that might play a role. Why would the EEA concept rely on assumptions of unidirectional causation?

Yes!

Despite the issues associated with the concept of the EEA, it is instrumentally valuable in reminding us to consider the state of the environment and its role in the evolutionary process. For the purposes of this thesis, we need not commit to any strong assumptions about the nature and properties of the EEA. The most important assumption I will make is that humans throughout history have been dependent on cooperation and strong social groups for survival.

In the EEA, humans lived together in groups and relied on hunting game and gathering plants for their nutrition. In this lifestyle, cooperation is a "necessary element of human life" (Apicella and Silk, 2019, p. R448) in a number of ways. Firstly, hunting is a 'high risk, high reward' endeavor: the returns are variable, but often when hunting does succeed the yield is large; sometimes even too large for the hunter and his relatives. In this case, food sharing within or between groups is **beneficial**. Another way that early humans counterbalanced the variable returns of hunting was to also rely on gathering plant foods, which yielded more predictable returns. In this case cooperation through shared labor was also beneficial, since some foods required complex foraging techniques to acquire it, or required complex processing (through e.g. cooking) before consumption. Lastly, cooperation in early humans manifested itself in 'cooperative breeding', where the responsibilities of childcare are spread among multiple caregivers. Moreover, mothers and children relied on

✓

only under
assumption
of future
reciprocity
no?

the efforts of others for their food (Apicella and Silk, 2019).

The following paragraph warrants a larger discussion about domain-specificity; define it and give examples (outside of psychology: maybe vision?), maybe with Cosmides/Tooby conception of Wason selection task as cheater detection? Find some literature on domain-specificity, because it turns out to be a bit of a hairy subject. Find definition; because opinions may vary on what features are and aren't domain-specific

you can define it and give an example, admitting lack of consensus.

Another topic of discussion in evolutionary psychology that is of importance to our investigation is that of domain-specificity of the psychological mechanisms. The argument has been made that these adaptive mechanisms are necessarily problem- or domain-specific, because the evolutionary process would not favor general solutions to specific problems (Buss, 2015, p. 50). However, as with the EEA, issues with this stance have been raised: the push to domain-specificity can be said to rely on overly strong assumptions about the modularity of the brain; and moreover, there is also a push to domain-generality of cognitive skills because domain-general skills are neurologically more cost-efficient than domain-specific skills (Laland and Brown, 2002).

1.4 Teleological notions in evolutionary theory

{sec:teleology}

This section needs quite some work: see notes from discussion with Karolina

important?

Next, it is ~~useful~~ to scrutinize the terminology that I will be using throughout this thesis. Biological literature frequently makes use of *teleological* terminology, that is, terminology that implies goal-directedness of the processes it describes. Such terminology includes concepts like the *design* of a trait, and *function*, *purpose*, or *utility* of a trait. At first glance, the usage of these terms in discussing evolution would seem to be inappropriate; for evolution is a process of nature, not purposefully performed by an agent, and it is thus without any intentionality or goals. And indeed, this teleological terminology has its roots in pre-Darwinian conceptions of nature: it originates from Aristotle's views on causation, and it was subsequently adopted by creationist Muslim and Christian scholars (Johnson, 2005).

I'd say just: on nature, his metaphysics.

Maybe reformulate this sentence again: still too convoluted?

In general, teleological explanations in biology are quite controversial: not only is the usage of the specific terminology itself debated (Ayala, 1999, p. 27 and references therein), the concept has been criticized for its apparent lack of formalization and insufficient argumentative persuasiveness (Baedke, 2021, p. 83).

Address the controversy around teleological explanations. Talk about instrumentalism, usefulness of the concepts. Lack of formalization is not such a big problem for the purpose here maybe, but the other thing is more of a problem. Address why they won't be a problem for you. Can mention that MS assume it as well, this teleological explanation is at the heart of their thesis (quote it?), so it's their problem to defend this. I work using the same assumptions as them.

However, explanations in terms of goals and function have considerable instrumental value in describing evolutionary processes. Throughout this thesis, I will be adhering to the conception of teleological explanations of Ayala (1999),

which is as follows:

Teleological explanations account for the existence of a certain feature in a system by demonstrating the feature's contribution to a specific property or state of the system, in such a way that this contribution is *the reason why the feature or behaviour exists at all*. (p. 13)

In this respect, the evolutionary process of adaptation merits a teleological explanation: the function of a trait (its 'contribution to a specific property or state of the system') is the reason that the trait exists, because it exists as a consequence of natural selection.

Is this view compatible with reciprocal causation and niche construction? I think so; they're a complication for the whole picture, not necessarily for using this definition.

Add example here

Is this view compatible with cultural learning? From the quote, it doesn't necessarily follow that it's about biology necessarily. Think about this, and after writing a section on culture, state to what extent and in what way we'll adhere to Ayala (1999)

The distinction between proximate and ultimate causes we saw in Section 1.2 can be applied to teleological explanation as well, yielding the distinction between proximate and ultimate *ends* of features. The proximate end is then the 'immediate' function the feature serves, and the ultimate end is the reproductive success of the organism.

Add example

A footnote to this account is that not all features of organisms can be explained teleologically; only if the feature has arisen and persisted as a direct result of natural selection, a teleological explanation is in place.

This "direct result of natural selection" is very vague/slippery; acknowledge this, and elaborate more on it if it turns out to be important for my thesis. A way to do this would be to contrast it with an indirect result. Talk about side effects?

1.5 Adopting and adapting Tinbergen's four questions

{sec:tinbergen}

As mentioned in Section 1.2, Tinbergen (1963) proposed an influential framework of problems⁷ that should be addressed if one intends to give a complete account of a behavior an animal exhibits. Let us dive more deeply into Tinbergen's framework here, as it will turn out to form a desirable foundation for the investigation this thesis concerns itself with.

current investigations?

As mentioned before, the four problems that Tinbergen argued to be central to the study of behavior are causation, survival value, ontogeny, and evolution. Although these problems were originally raised in regards to animal behavior, the framework has since been adopted for analyzing the characteristics of organisms in general, and can even be used to gain understanding of nonliving systems, such as traffic lights (Bateson and Laland, 2013).

⁷In the literature (e.g. Bateson and Laland (2013)), the terms 'problems' and 'questions' are used interchangeably. I will take 'problems to address' and 'questions to answer' to be synonymous, and will use these terms interchangeably.

I will now discuss each of these problems in more detail, such that we can ultimately come to a set of methodological questions to guide us in investigating human communication and reasoning.

1.5.1 Causation

The first Tinbergen problem is that of the mechanistic causation of the behavior; in other words, the proximate causation of the behavior. In our case, addressing this problem would entail a detailed investigation of the neurological processes underlying communicative and reasoning behaviors. This problem, however interesting, will not be addressed in this thesis. The reason for this is that more empirical and conceptual research would be necessary in order to give a satisfactory account of the exact neurological processes underlying communicative and reasoning behavior. Although it has been emphasized that we can only gain a full understanding of a behavior if the four problems are addressed simultaneously (Bateson and Laland, 2013; Tinbergen, 1963), I believe I am justified in considering the proximate-causation problem out of scope for this thesis.

leaving

for future research,

1.5.2 Survival value

The second problem that Tinbergen outlines relates to the value a behavior provides to an animal's survival: how does the behavior contribute to the chances of the animal surviving?

This survival value is, in teleological terms, the function of the behavior. However, the use of the term 'function' may obscure the fact that a **characteristic's** function can change over time: the *current* utility that a characteristic has, may not be the same as the *original* utility it had (Bateson and Laland, 2013). For example, feathers originally evolved for temperature regulation in the evolutionary predecessors of birds, and were later adapted for flight (Bateson and Laland, 2013; Benton et al., 2019). We will see in Chapter 2 and ?? what can be construed as the original and current utilities or functions of the cognitive capacities we are dealing with.

feature
= characteristic?

We will discuss?

As we saw in Section 1.1, an organism's fitness is not only determined by their chances of *survival*, but also their chances of *reproducing*. As a consequence of this, the survival value a trait brings to an organism is not the only reason that the trait may persist throughout evolution. A trait is also more likely to appear in future generations if it improves an organism's chances of reproducing.

Possibly change this comment after Chapter 2 and 3 are more or less finished

✓

In the methodological framework proposed here I will amend Tinbergen's question on survival value by broadly speaking of the *utility* of a characteristic, which denotes the way the characteristic contributes to the fitness of the organism. This leads us to the following formulation of Tinbergen's question for our purposes:

- (1) a. What was the original utility of communication to humans? And what is the current utility of communication to humans?

- b. What was the original utility of reasoning to humans? And what is the current utility of reasoning to humans?

This distinction between original and current utility might turn out to be too much to cover in Chapter 2 and 3; in that case, I'd add here that a consideration of both original and current utility is out of scope for this thesis

1.5.3 Ontogeny

The third question that is essential for gaining understanding about a behavior is the question of how the behavior emerges and changes throughout the development (ontogeny) of the animal.

This section is very short, but I don't feel like anything can/needs to be added?

So this leads us to the following question:

- (2) a. How does the capacity for communication develop throughout childhood?
- b. How does the capacity for reasoning develop throughout childhood?

1.5.4 Evolution

The fourth and last problem considered by Tinbergen is that of the evolutionary history of the behavior: in order to provide a complete explanation of a behavior, one must look at how it evolved throughout history. To form hypotheses about this, one must look to whether and how the behavior presents itself in the close evolutionary relatives of the animal.

Bateson and Laland (2013) maintain that for traits related to human cognition, this question about evolutionary history should be split up into two questions. They argue that due to the influence of not only biological evolution but also culture on the development of the trait, one should distinguish two kinds of evolutionary history, leading to the questions "Which historical processes were responsible for the **character**?" and "How can its trajectory be explained?" (Bateson and Laland, 2013, p. 714). However, as I concluded in Section 1.1, we are justified in remaining agnostic about these historical processes, so we will only take up the latter of these two questions.

This leads us to the following formulation of Tinbergen's evolutionary question:

- (3) a. What is the evolutionary history of human communication? How can its evolutionary trajectory from our nearest evolutionary relatives to us be explained?
- b. What is the evolutionary history of human reasoning? How can its evolutionary trajectory from our nearest evolutionary relatives to us be explained?

of ?

1.5.5 A fifth Tinbergen problem: observation and description

A problem that is mentioned by Tinbergen in his original paper 1963, but not included as one of the core problems of his framework, and more or less never included by authors discussing his framework (Allen and Bekoff, 1995; Laland and Brown, 2002; Laland et al., 2013), is the problem of *describing* the observed behavior. In the case of describing reasoning and communication, this issue is akin to the problem of defining and delineating what we take to be reasoning and what we take to be communication. This is by no means a trivial issue, which is what warrants its inclusion in the set of questions we will ask ourselves in thesis:

- (4) a. What is human communication?
- b. What is human reasoning?

1.6 Conclusion

{sec:evo-conclusion}

Throughout this chapter, it has become apparent that for none of the topics in evolutionary theory discussed here consensus has been reached among its practitioners. Since the purpose of this thesis will not be to provide a complete causal framework for the evolution of reasoning and communication, we will be able to cast aside some of the issues plaguing the frameworks discussed in this chapter. We will proceed cautiously, using the concepts outlined without needing to account in detail for their shortcomings. Let us conclude this chapter by first gathering four key assumptions that will inform this thesis, and then restating the methodological questions that will guide its investigations.

The first one is the assumption that we are justified in wanting to explore human reasoning and communication from the perspective of evolution. Despite some of the issues raised against evolutionary psychology as a field of study (Laland and Brown, 2002), it cannot be denied that reasoning and communication are cognitive capacities that must have emerged somewhere on our evolutionary journey, through processes of selection (i.e. as a result of variation, sorting and retention).

The second assumption is that in order to answer the question of whether reasoning evolved for communication, we must consider not only reasoning but also communication in detail. This is because for reasoning to have evolved for the purpose of communication, the latter must have been evolutionarily advantageous in its own right, such that advancements in reasoning could have advanced communication to such an extent that it made communication more evolutionarily advantageous. Moreover, as we will see, a thorough investigation of communication will illuminate the role reasoning plays in communication.

The third assumption is that throughout our evolutionary trajectory, we have been dependent on fellow humans for our survival, relying on cooperation and strong social groups. This assumption is especially important in the analysis of human communication.

The fourth and last assumption is that in our analysis we may remain agnostic about whether biological or cultural evolution is responsible for the emergence of reasoning and communication, since both kinds of evolution have the same underlying mechanisms of selection.

Lastly, regarding the questions we will ask ourselves in the following two chapters: the discussion in Section 1.5 has yielded four questions reformulated and adapted from Tinbergen's (1963) framework. Here, I restate these questions in a general manner and in an order that will be most useful to the investigations in Chapter 2 and ??.

Definition	How can this cognitive capacity be defined and delineated?
Development	How does this cognitive capacity develop throughout childhood?
Evolution	What is the evolutionary history of this cognitive capacity; how can its evolutionary trajectory from our nearest evolutionary relatives to us be explained?
Utility	What are the original and current utilities of this cognitive capacity to humans?

Now that we have gathered the assumptions and questions, it is time to consider the cognitive capacity that is primary in the context of our research question: communication.

2 | Why do we communicate?

{ch:communication}

7: In general: this chapter is very dense, you can go at a bit of a slower pace most of the time. But pace will also be better once elaborations and examples are added.

In order to answer the question of how advanced reasoning may have evolved to further communication, we will first need to examine communication in its own right: why do we communicate? In order to answer this question, we will discuss each of the methodological questions raised in ?? as they pertain to communication. But before we can take a look at the evolutionary history, the developmental origins and the functions of communication, we must first fix a definition of communication, since this determines the frame of our research question.

10: This whole introduction could be clearer: why do we look at communication now? Can use a bit more words.

8: Terminology: probably drop "advanced" here. Possibly get back to this after writing Chapter 3

9: Refer to the numbers or codes of the Tinbergen questions

2.1 Conceptions of communication

{sec:comm:definition}

11: Missing from this section: what Mercier (& Sperber) define as, and/or have to say about, communication

There are many different ways organisms may communicate with each other, and indeed many different ways in which one may define communication. In any case, communication is an process necessarily involving a signaler (a sender) and at least one receiver (a listener).

Some authors regard communication to inherently be a tool of persuasion, which then translates to their very definition of communication: for example, on the manipulative model of communication, communication can be taken to occur "when an animal, the actor, does something which appears to be the result of selection to influence the sense organs of another animal, the reactor, so that the reactor's behavior changes to the advantage of the actor" (Dawkins and Krebs, 1978, p. 283).

13: Say something about this quote in your own words: comment on it, this also justifies you using the quote. Point the reader to why you use it.

One may also notice that this definition has a teleological explanation embedded in it as well (see Section 1.4). I mention this definition only for com-

12: Rewrite this so that the quote is actually typeset as a quote, for emphasis

14: Elaborate on this: make it more explicit

pleteness' sake , because I believe this definition to be insufficiently parsimonious in its assumptions about the function of communication.

15: Maybe not necessary to mention this

16: Elaborate on this: what are the assumptions they make, in what sense are they strong, and why are they too strong for my liking (i.e. what's wrong with them)?

In their discussion of communication as it relates to social cognition, Freeberg et al. (2019) define communication as follows:

Communication involves an action or characteristic of one individual that influences the behaviour, behavioural tendency or physiology of at least one other individual in a fashion typically adaptive to both (p. 281)

17: Explain this in own words; and explain the difference with the definition of Dawkins and Krebs (1978). The difference lies in "to the advantage of"

This is a very broad conception of communication; on this definition, all organisms, from bacteria to fungi to plants to animals, communicate.

Provide examples for each of these kingdoms here, nice illustration

Scott-Phillips (2015, 2018) contrasts two different models of communication with each other: the classical *code model* of communication, and the *ostensive-inferential* model of communication. In the former model, communication involves processes of coding and decoding messages. The coding, on the side of the sender, involves a mapping between the state of the world and a behavior (namely the signal they send). The decoding, on the side of the receiver, involves a mapping between two behaviors: the signal sent, and a subsequent response of the receiver. If the mappings are properly calibrated to each other, communication between sender and receiver can be said to have occurred.

18: This paragraph could do with a lot more philosophical discussion: Quine should definitely be mentioned, even if it's just in a footnote, because it's like this milestone philosophy thing that would be a glaring omission to philosophers reading this. Also, the usage of "meaning" and "content" here is a big philosophical no-no, either explicate what you mean by them or change your terminology. You could also just acknowledge or specify that you use the intuitive, colloquial meaning, not the technical one. Read also the Putnam paper on the ants and Winston Churchill?

However, in order to capture human communication, the code model is too simplistic, because it fails to account for the *underdeterminacy of meaning*: in merely looking at the content of the message, one cannot account for the meaning that the message conveys to the sender (Scott-Phillips, 2018). Therefore, a move away from the code model of communication towards the *ostensive-inferential* model of communication would be in order. This model takes into account the intentionality inherent in human communication.

Add example

19: This paragraph also needs a lot more work: (1) mention Sperber & Wilson and relevance theory (credit where credit's due!), and that their theory is neo-Gricean, because most philosophers will be familiar with Grice. (2) Add an example, this needs to be way clearer and elaborated more if this will be my definition of human communication. (3) Define ostensive behavior, also with an example. It's apparent right now that I don't fully understand this model myself. (4) Add a comment on how the underdeterminacy is captured better by the ostensive-inferential model

In the ostensive-inferential model, one may speak of a sender's *informative intention*, which is their intending for the receiver to believe something. The sender's *communicative intention* is then their intending for the receiver to believe

that they have an informative intention. The sender may then express or convey this communicative intention to their receiver with an *ostensive* behavior. If their receiver receives their communicative intention, then ostensive-inferential communication has occurred.

Currently, there is no evidence that any species other than humans communicate ostensively (Scott-Phillips, 2018). As a result, not only may one distinguish between the code model and the ostensive-inferential model to define what communication entails, one may also conceptualize these two models as two different types of communication. The code model then captures the way that non-human animals communicate, and the ostensive-inferential model then captures the way that humans communicate with each other.

It is this ostensive-inferential model that I will consider to form the definition of *human communication* throughout this thesis. When I speak of communication broadly construed, I will adhere to the definition of communication by Freeberg et al. (2019). This definition is compatible with the code model outlined by Scott-Phillips (2018);

20: This is a weird comment, because it implicates maybe that the ostensive-inferential model is not compatible with the Freeberg definition. Make this implicature explicit, say something about how the Freeberg definition compares to the two models we have.

the code model, however, provides a level of detail that will not be necessary for our discussions of non-human animal communication.

21: Explicate the relation between the two models/definitions, because now it's very unclear why and how I'm using two different definitions at the same time

22: Actually, this section could do with a lot more work on intentional and non-intentional communication: read up on this, and make things explicit here. Could choose to define communication and non-intentional communication, or intentional communication and communication. Need to make a choice in this, explain it, and then be clear and *consistent!* about using this terminology.

23: Gricean objection: talking to the self is also communicating, albeit to an imaginary audience, or you yourself are the addressee. The point I make about using language without communicating is a bit slippery, philosophically controversial, and is maybe not relevant. Communicating without language *is* relevant, but maybe this is not the place to point that out; it can also become implicitly or explicitly clear throughout or at the end of the chapter.

As a last side note: while we would often equate human communication with linguistic communication, humans can easily communicate without language – for example, using glances or gestures¹, see also Section 2.3 – and can use language without communicating – for example, when one is talking to oneself. Therefore, although language will come up now and then throughout this chapter, it is not our object of focus at the present moment.

¹One might even speculate that any human behavior can be used to communicate.

2.2 Communication in non-human animals

24: This section deserves a mention of Chomsky's work on animal communication: something about humans having language, and NHA only having stimulus-dependent responses? Also, this section could do with more references to experimental evidence.

Now we turn to the first methodological question and we look at the communication of other animals, especially those that we are evolutionarily closely related to. As already mentioned, one fundamental difference between the communication of non-human animals and humans is by which model their communication is best described: the code model and the ostensive-inferential model, respectively (Scott-Phillips, 2015, 2018).

Communication is used by non-human animals for a wide range of purposes, and it can be elicited by a number of stimuli. Moreover, communicative behaviors can manifest themselves in different modalities: not only can animals communicate through vocalizations, they may also communicate through gestures or glances.

27: Write more on gestural communication in apes (is mentioned in Tomasello (2008))

One can broadly distinguish between communication in aggressive and cooperative interactions (Seyfarth and Cheney, 2003). In aggressive interactions, primates may for example use communication in order to intimidate, by using it to signal their size and willingness to fight. This minimizes the chances of a physical altercation or fight actually happening, which minimizes the chance of injury for both the dominant and the subordinate animal. In cooperative interactions on the other hand, where the interests of the signaler and the receiver overlap, communication can be used to alert others of predators, to coordinate foraging activities and to facilitate social interactions:

[information acquired by listeners] may include, but is not limited to, information about predators or the urgency of a predator's approach, group movements, intergroup interactions, or the identities of individuals involved in social events (Seyfarth and Cheney, 2003, p. 168)

In animals in general, vocalizations are most often elicited not by just one stimulus, but rather a complex combination of them. Moreover, the "history of interactions between the individuals involved" (Seyfarth and Cheney, 2003, p. 151) can also play a role in eliciting vocalizations. As for the 'immediate' stimuli eliciting vocalizations, we may distinguish between sensory stimuli on the one hand and mental stimuli on the other. Sensory stimuli then refer to stimuli received through the external senses, such as visual, auditory and olfactory senses. For example, if I stop petting my dog (sensory stimulus), she will direct her gaze at me (communicative behavior) to indicate that she would like me to continue. Mental stimuli on the other hand can be viewed as the mental states an animal attributes to another animal.

25: Are they numbered?

26: The model that best describes them is a consequence of the difference between the two: so the difference is that which makes one model work better for NHA and the other better for humans. Reformulate

28: About?

Take a different example: this is too much anecdotal, and with domesticated animals there's issues of evolutionary tractability as well as anthropomorphization. Get a reference on this

29: Glaring omission: the large controversy surrounding theory of mind. You can make assumptions that are controversial, so long as you acknowledge the controversy and give good reasons for making the assumption. Show that you're aware of the debates. Consider taking the consensus in the field from Kristin Andrews' textbook "Animal minds"

For example, . This type of stimulus elicits the majority of vocalizations in human conversation, but there is no evidence that the attribution of mental states to others causes vocalizations in other animals, except for possibly chimpanzees (Seyfarth and Cheney, 2003).

Add example from the literature

2.3 Communication in children's development

{sec:comm:ontogeny}

30: This section tries to fit a lot of information in little space: it is too dense. Also, the structure is weird and unclear. It could do with a whole overhaul.

Now that we have seen how communication works in non-human animals, let us turn to how children start communicating throughout their development. Around their first birthdays, children start communicating ostensibly by pointing (Tomasello, 2008).

31: Check the exact timing of this: Tomasello (1999) talks about the "nine-month revolution", and the difference between 9 and 12 months is very big in human children. Possibly directly cite experimental sources.

Although at first glance pointing may seem like a simple behavior, it may be used in a number of communicative contexts to convey a fairly wide range of messages and intentions. For example, infants may point at a cup to indicate that they want to drink from it (i.e., pointing to request), but they may also point to a hidden object that their parent is searching for (i.e. pointing to inform).

32: Why do we focus on pointing? Elaborate more on why pointing constitutes communication, and other earlier stuff doesn't. For example, raising arms to parent: a behavior that we inherited from our ape ancestors (instinct to climb on parent). Is that communication? What distinguishes these earlier from the later interactions? And consider for example the communicative function of crying, is this mentioned by Tomasello or by other authors? How is that different from vocalizations in animals? Simple stimulus-response? This basically all comes down/back to the definition of communication I adhere to, and intentionality in it.

33: This paragraph is way too dense: she doesn't understand this upon reading. It's a matter of unpacking the notions.

On the classic account, pointing can serve either of two communicative motives: an imperative motive, in which the pointer requests things from someone, and a declarative motive, in which the pointer shares their experiences and emotions with someone. This account can be extended upon by distinguishing between declaratives as expressives (sharing attitudes and emotions) and declaratives as informatives (providing information), and by furthermore conceiving of imperatives as a continuum, with the underlying motive ranging on a scale from individualistic – e.g. forcing someone to do something – to cooperative, e.g. indirectly making a request to someone by informing them of some desire (Tomasello, 2008).

The fact that pointing is a fairly complex communicative act is underscored

by the fact that non-human animals are not able to understand pointing in the same way humans are. The hypothesis is that in order to communicate intentionally,

34: Add reference for this

35: On the current definition, isn't all communication intentional? Should really settle on this, and then change the wording here as applicable. Read up also on Putnam's Brain in a Vat article, this might be illuminating philosophically. Grice also has some readings on natural and non-natural meaning, distinguishing between different types of communication. Something about intentionality? Make the distinction between intentional and non-intentional stuff very explicit, because it's one of the most important things in this chapter.

like children begin doing around their first birthday, first the skills and motivations for *shared intentionality* need to be present in the infant; that without skills of shared intentionality, infants could only communicate intentionally, but not cooperatively.

36: Elaborate more on intentional vs. cooperative communication: does Tomasello (1999) have something on this? Something to do with joint attention.

Shared intentionality is the "ability to participate with others in interactions involving joint goals, intentions, and attention" (Tomasello, 2008, p. 139). Communicative pointing behaviors in infants emerge around the same time as skills and motivations of shared intentionality do, which according to Tomasello confirms this hypothesis of dependency between them.

37: Disentangle communication and shared intentionality, because up until this point, they seem to be the same thing. Go a bit slower in this section.

38: Reconsider the usage of the terminology "skills and motivation", and make explicit exactly what you mean by them. Would abilities be a better word? Why does Tomasello (2008) use skills? Why are motivations included? What are motivations?

Tomasello further investigates what he calls *pantomiming* or *iconic gestures*, which are symbolic or representational gestures. He presents empirical evidence

Give example

39: Discuss this empirical evidence

that these kinds of gestures rely heavily on convention for their meaning, and that the acquisition and usage of these conventions bears a strong resemblance to the acquisition and usage of language.

40: This trajectory should also be more clear throughout the section

In short, infants first acquire the skills and motivations needed for shared intentionality; then they acquire the skills and motivations for communicative pointing; and then they acquire the ability to use iconic gestures and language around the same time.

2.4 What is the function of communication?

{sec:comm:function}

41: Make a terminological choice between aggressive and competitive, and be consistent in your usage of them (so also back in the phylogeny section). Maybe even define them.

Finally, let us have a look at different conceptions of what the function of communication might be. We have already seen that we can broadly distinguish between competitive and cooperative functions of communication (Seyfarth and Cheney, 2003). For competitive, or aggressive, motives, one might use communication for attempting to intimidate a rival in the competition for food or for a mate. It would be evolutionarily beneficial to the communicator to intimidate verbally rather than physically because of a reduced risk of injury. According to the theory of human self-domestication, a number of human traits can be explained by a process of 'self-domestication', in which females select sexually for less aggressive males. It has been proposed that because of this reduction in physical aggression, interactions between individuals became longer and more frequent throughout evolutionary history, which allowed for our language and communication to become more complex (Benítez-Burraco et al., 2021).

As for the cooperative functions of communication, Tomasello (2008) proposes three different motives underlying communication: sharing (of emotions and attitudes), informing, and requesting (help to achieve goals).

43: Explicate and elaborate more on this argument, because now it's not convincing. Cite some literature also on it, maybe Heyes 2018 or Tomasello 2009 talks about it

It is apparent that communication crucially enables individuals to cooperate and collaborate. In addition, more sophisticated communication would make more sophisticated forms of cooperation and collaboration possible, from coordinated hunting activities to the social institutions we depend on nowadays.

44: To what extent do animals participate in coordinated hunting activities? I remember reading about it, about monkeys launching a coordinated attack, was that in Tomasello (2009)? Find this reference

But in order for us to complete the causal chain, we need to have a look at what makes cooperation and collaboration something evolution has selected for at all.

In cooperative behaviors, one can distinguish between altruistic behavior (sacrificing something in some way for the benefit of another individual) and collaborative behavior (working together with another individual for mutual benefit) (Tomasello, 2009). In the case of the latter, the evolutionary causation is straight-forward: the mutual benefit of the outcome constitutes the evolutionary pressure that has selected for it. In the case of the former though, it is not immediately obvious that helping another person without benefit to the self would be evolutionarily advantageous. (Tomasello, 2009) hypothesizes that altruism can be best explained in the broader picture of the social group, considering the norms that are enforced and being conformed to within the group and the shared intentionality inherent in the group. Moreover, he emphasizes the role of both human biology and human culture in shaping humans' cooperative tendencies; see also Chapter 1.

42: Change around the way you reference it: maybe find multiple references for this theory, and then only the last finding is specifically from the 2021 paper. See notes

45: Change the presentation of this last point around: if you want to mention it, then mention his arguments, the evidence he presents, because it's a bit devoid of content as it stands. Why is this relevant?

Bibliography

- Allen, C. and M. Bekoff (1995). "Biological function, adaptation, and natural design". In: *Philosophy of Science* 62.4, pp. 609–622.
- Apicella, C. L. and J. B. Silk (2019). "The evolution of human cooperation". In: *Current Biology* 29.11, R447–R450.
- Ariew, A., R. Cummins, and M. Perlman (2002). *Functions: New essays in the philosophy of psychology and biology*. Oxford University Press, USA.
- Ayala, F. J. (1999). "Adaptation and novelty: teleological explanations in evolutionary biology". In: *History and philosophy of the life sciences*, pp. 3–33.
- Baedke, J. (2021). "What's wrong with evolutionary causation?" In: *Acta Biotheoretica* 69.1, pp. 79–89.
- Bateson, P. and K. N. Laland (2013). "Tinbergen's four questions: an appreciation and an update". In: *Trends in Ecology & Evolution* 28.12, pp. 712–718.
- Benítez-Burraco, A., F. Ferretti, and L. Progovac (2021). "Human self-domestication and the evolution of pragmatics". In: *Cognitive Science* 45.6, e12987.
- Benton, M. J., D. Dhouailly, B. Jiang, and M. McNamara (2019). "The Early Origin of Feathers". In: *Trends in Ecology & Evolution* 34.9, pp. 856–869. doi: 10.1016/j.tree.2019.04.018.
- Buss, D. M. (2015). *Evolutionary psychology: The new science of the mind*. Fifth. Routledge.
- Cheney, D. L. and R. M. Seyfarth (1997). "Why animals don't have language". In: *Tanner lectures on human values*. Ed. by G. B. Peterson. Vol. 19. University of Utah Press, pp. 175–209.
- Claidière, N., T. C. Scott-Phillips, and D. Sperber (2014). "How Darwinian is cultural evolution?" In: *Philosophical Transactions of the Royal Society B: Biological Sciences* 369.1642, p. 20130368. doi: 10.1098/rstb.2013.0368.
- Dawkins, R. and J. R. Krebs (1978). "Animal Signals: Information or Manipulation?" In: *Behavioural Ecology: An Evolutionary Approach*. Ed. by J. R. Krebs and N. B. Davies, pp. 282–309.
- Day, R. L., K. N. Laland, and F. J. Odling-Smee (2003). "Rethinking adaptation: the niche-construction perspective". In: *Perspectives in biology and medicine* 46.1, pp. 80–95.
- Donahoe, J. W. (2003). "Selectionism". In: *Behavior theory and philosophy*. Ed. by K. A. Lattal and P. N. Chase. Springer, pp. 103–128. doi: 10.1007/978-1-4757-4590-0_6.

- Freeberg, T. M., K. E. Gentry, K. E. Sieving, and J. R. Lucas (2019). "On understanding the nature and evolution of social cognition: a need for the study of communication". In: *Animal Behaviour* 155, pp. 279–286.
- Heyes, C. M. (2018). *Cognitive gadgets: The cultural evolution of thinking*. Harvard University Press. doi: 10.4159/9780674985155.
- Johnson, M. R. (2005). "Historical Background to the Interpretation of Aristotle's Teleology". In: *Aristotle on Teleology*. Oxford University Press, pp. 15–39. doi: 10.1093/0199285306.003.0002.
- Laland, K. N. and G. R. Brown (2002). *Sense and nonsense: Evolutionary perspectives on human behaviour*. Oxford University Press, USA.
- Laland, K. N., J. Odling-Smee, W. Hoppitt, and T. Uller (2013). "More on how and why: cause and effect in biology revisited". In: *Biology & Philosophy* 28, pp. 719–745.
- Lipton, P. (2009). "Causation and Explanation". In: *The Oxford Handbook of Causation*. Ed. by H. Beebe, C. Hitchcock, and P. Menzies. Oxford University Press. doi: 10.1093/oxfordhb/9780199279739.003.0030.
- Mayr, E. (1961). "Cause and effect in biology". In: *Science* 134.3489, pp. 1501–1506.
- Mercier, H. and D. Sperber (2011). "Why do humans reason? Arguments for an argumentative theory". In: *Behavioral and Brain Sciences* 34.2, pp. 57–74.
- Millstein, R. L. (2021). "Genetic Drift". In: *The Stanford Encyclopedia of Philosophy*. Ed. by E. N. Zalta. Spring 2021. Metaphysics Research Lab, Stanford University.
- Scott-Phillips, T. C. (2015). "Nonhuman primate communication, pragmatics, and the origins of language". In: *Current Anthropology* 56.1, pp. 56–80.
- (2018). "Cognition and communication". In: *The International Encyclopedia of Anthropology*. Ed. by H. Callan and S. Coleman. John Wiley & Sons.
- Scott-Phillips, T. C., K. N. Laland, D. M. Shuker, T. E. Dickins, and S. A. West (2013). "The niche construction perspective: a critical appraisal". In: *Evolution* 68.5, pp. 1231–1243.
- Seyfarth, R. M. and D. L. Cheney (2003). "Signalers and receivers in animal communication". In: *Annual review of psychology* 54.1, pp. 145–173.
- Tinbergen, N. (1963). "On aims and methods of ethology". In: *Zeitschrift für Tierpsychologie* 20.4, pp. 410–433.
- Tomasello, M. (2008). *Origins of human communication*. MIT Press. doi: 10.7551/mitpress/7551.001.0001.
- (2009). *Why we cooperate*. MIT Press.
- Uller, T. and K. N. Laland (2019). *Evolutionary causation: biological and philosophical reflections*. Vol. 23. MIT Press.