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A Dialogical Account of Deductive Reasoning as a Case Study for how Culture Shapes Cognition

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Abstract
In this paper, I discuss how certain social, cultural practices, namely different kinds of dialogical and argumentative practices, may influence how humans reason. I will focus particularly on deductive reasoning and address the question of whether deductive reasoning skills must be learned to be mastered, or whether they arise spontaneously in untrained reasoners. Based on a historically-informed dialogical reconceptualization of deductive reasoning, I will argue that deductive skills arise predominantly by means of specific training, schooling in particular. In a slogan, the main claim of the paper is: when it comes to deduction, we may say that ontogeny – the onset of deductive reasoning in an individual reasoner – to some extent recapitulates phylogeny – the historical emergence of the concept of deduction (in both cases, we are dealing with cultural phenomena). But I will also argue that some 'mundane' forms of dialogical interaction such as story-telling and adversarial betting may also cue untrained reasoners to perform closer to the deductive canons in experiments.

Keywords
Deductive reasoning, history of logic, dialogues, schooling

Introduction

To what extent does culture influence human cognition? At one end of the spectrum, we have the individualistic, typically internalist position according to which human cognition is not significantly shaped by the particular cultural and social context of an individual. At the other end, we have the social, externalist position according to which a person's cognitive makeup is significantly shaped by social and cultural factors. The former is (at least tacitly) held by most psychologists working on reasoning and cognition, who, purporting to study the universal core of human cognition, tend to make universal claims on the basis of experimental results with a culturally highly homogeneous group of participants: undergraduates at North-American and European universities.

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The latter is represented by, e.g., the Vygotskian school, and has received renewed attention recently in the work of Nisbett and Henrich, among others.

This remains a much-debated issue but, arguably, it requires a precise framing to be discussed fruitfully. I here propose to examine specifically how certain social practices, namely different kinds of *dialogical* and *argumentative* practices, may influence how humans reason; in other words, I will be interested specifically in the connections between argumentation (understood as a cultural practice) and reasoning. I will focus particularly on *deductive reasoning* (narrowly construed) and address the question of whether deductive reasoning skills must be learned to be mastered, or whether they arise spontaneously in untrained reasoners. Based on a historically-informed dialogical reconceptualisation of deductive reasoning, I will argue that deductive skills arise predominantly by means of specific training, and thus typically emerge, if at all, in the context of formal schooling. In a slogan, the main claim of the paper is: when it comes to deduction, we may say that ontogeny – the onset of deductive reasoning in an individual reasoner – to some extent recapitulates phylogeny – the historical emergence of the concept of deduction (to be clear, according to the present account, these are cultural phenomena). But I will also argue that some 'mundane' forms of dialogical interaction such as story-telling and adversarial betting may also cue untrained reasoners to perform closer to the deductive canons in experiments. This is so precisely in virtue of the inherent dialogical nature of deductive reasoning.

The paper proceeds as follows: I begin by presenting a philosophical reconceptualization of the concept of deduction inspired by its emergence in the context of specific dialogical practices in ancient Greece. Next, I discuss alternative accounts of the connections between culture, argumentation and reasoning, in particular Bloor's social constructivism, and point out the differences between my approach and these other proposals. I then review the experimental findings on deductive reasoning with the typical undergraduate population, which show that participants deviate considerably from the responses dictated by the deductive canons, but with a modicum of 'logical competence' emerging from the results. Next, I review the scarce experimental findings with unschooled populations, which present an even greater deviation from the deductive canons. Finally, I argue that certain forms of dialogical interaction, such as story-telling and betting, mimic two crucial features of deductive reasoning (dissociating belief in premises from the possibility to reason with them, and formulating indefeasible arguments), and can thus prompt reasoners to reason in ways that come closer to the deductive canons. I then conclude that the case of deductive reasoning offers support to the idea that culture shapes cognition in a fundamental, non-trivial way.

A Dialogical Conception of Deduction

A deductively valid piece of reasoning is traditionally conceived as one where, if the premises are true, then the conclusion must necessarily be true, no exceptions allowed: "All dogs are animals, Fido is a dog, thus Fido is an animal". As the concept developed historically, two key, mutually independent components of deductive reasoning established themselves: (1) the willingness to reason from premises regardless of one's doxastic attitude towards them; (2) the formulation of *indefeasible* arguments, where the premises *necessitate* the truth of the conclusion.

At least since Kant, deductive logic and deductive reasoning have been conceived predominantly in individualistic, internalistic terms, i.e., as pertaining to the *thought processes* of individual reasoners. This has arguably led to a number of conundrums and misconceptions concerning the nature of deductive logic (Harman, 1986). However, for most of the history of logic and philosophy, logic was often (though not unanimously) conceived in terms of discourse and dialogical (debating) practices (Dutilh Novaes, 2011; Dutilh Novaes, under review). Going back to the historical origins of the deductive method in ancient Greek logic and mathematics is instructive for the formulation of a reconceptualization of deduction that is more faithful to its historical origins and conceptual core.

Research on the historical emergence of the deductive method in ancient Greece – a unique event in human history – has shown that debating practices (for example, those of the early Academy; Castelnerac and Marion, 2009) played a crucial role in this development (Lloyd, 1996; Netz, 1999). Now, while the kinds of dialogical games discussed in the ancient dialectic tradition (as reported for example in Aristotle's *Topics*) are quite diverse, we can easily conceive a regimented kind of debate in the spirit of this tradition, which mimics precisely the two main components of deductive reasoning stated above. From this point of view, a deduction is an *argument* (a piece of discourse), not an inner mental process; more specifically, a deduction is an argument put forward by a debater in order to compel the interlocutors to accept the conclusion of the argument if they accept its premises.

Here follows a rational reconstruction of what such a dialogue might be like, loosely inspired by historical dialectical games. A deductive dialogue would involve two participants, proponent and opponent, and is adversarial in that the two participants have opposite goals: proponent seeks to establish a given thesis from certain premises, while opponent seeks to block the establishment of a conclusion by questioning individual inferential steps. (but notice that there is also a higher-order element of cooperation. Aristotle says that "it is not in the power of one participant alone to see that their common work is well

accomplished" (*Topics* VIII.11. 161a20–22), much as prosecution and defence must cooperate for the higher goal of justice to be attained at a court of law). The game begins with proponent and opponent agreeing on the starting point, the premises: proponent then puts forward statements which he claims follow 'of necessity' from what opponent has already granted. Opponent's role is to verify that this is indeed the case, and if not, to provide a counterexample, i.e., a situation where the premises are the case but the (preliminary) conclusion is not. By chaining instances of perspicuously valid individual arguments ('small' inferential steps), proponent compels opponent to accept the overall conclusion if they have granted the initial premises. The rationale behind proceeding in this step-wise way is to obtain persuasive as well as explanatory effect: opponent and the audience must also become *convinced* of the truth of the conclusion. In fact, opponent may also request that proponent spells out a particular inferential move in more detail.

Such a 'dialogue' thereby mimics precisely the argumentative structure of a deductive proof. The claim is not that such regimented dialogues actually took place in exactly this guise; this is a rational reconstruction intended to show that the very concept of a deductive argument is best understood in dialogical terms. But historical evidence for the dialogical historical origins of the concept of deduction is for instance the extensive use of dialectical vocabulary in the *Prior Analytics*, which suggests a strong relation of continuity between this text and the other clearly dialogical logical texts by Aristotle (*Topics* and *Sophistical Refutations*).

Now, granting a premise 'for the sake of the argument' is a familiar move in these debating contexts; this can be seen, for example, in Aristotle's distinction between kinds of arguments used in a debate in *Sophistical Refutations* (164a37). He distinguishes didactic, dialectical, periastic and eristic arguments, and only in the case of periastic arguments must the premises be based on the actual beliefs of the answerer. Even if, in the other cases, the premises are not necessarily unknown or false statements, the key component is the dissociation of one's doxastic attitude towards a given premise and the ability to maintain it in a disputation and to infer what follows from it. Thus, item 1 above (dissociation of belief and the willingness to reason from a premise) can be accounted for in terms of granting a premise for the purposes of debating in a multi-agent setting.

Another feature of the deductive method that is easily explained on this dialogical reconstruction is the fact that the reasoner is not allowed to help herself to external, implicit information: she must reason only on the basis of the explicitly stated premises. In dialogical, debating terms, this corresponds to the fact that proponent can only make use of premises explicitly granted by opponent, as this is the common starting point for the debate.

As for the concept of indefeasible arguments, here too it seems that a dialogical conceptualisation straightforwardly suggests itself. Indefeasible arguments such as deductively valid arguments cannot be defeated (i.e., rendered invalid) by the addition of external information. Contrary to defeasible arguments, which can be thus defeated. A classic example of a defeasible argument is: 'Birds fly, Tweedy is a bird, thus Tweedy flies'. "The truth of the premises of a good defeasible argument provides support for the conclusion, even though it is possible for the premises to be true and the conclusion false. In other words, the relationship of support between premises and conclusion is a tentative one, potentially defeated by additional information" (Koons, 2009, Introduction). As such, indefeasible arguments are *strategically attractive* for proponent, because opponent will not be able to counter them with a counterexample. This idea can also be formulated in game-theoretic terms: a deductive argument corresponds to a *winning strategy* for proponent. No matter what new information opponent introduces (i.e., no matter what countermoves she makes in the game), if she has granted the premises, she will be forced to grant the conclusion.

Cognitive scientist K. Stenning draws similar connections between logic's historical origins and the idea of indefeasibility, and points out the contrast with the majority of ordinary conversational situations, which are typically *co-operative*:

> Logic originated as a model of what we might call adversarial communication – at least in a technical sense of adversarial. What *follows* in deduction is anything that is true in *all* interpretations of the premises – that is the definition of logically valid inference. [...] Our job, as speaker or hearer of a discourse that purports to be a deduction, is to test the drawing of inferences to destruction, to ensure that what is inferred is true in *all* models of the premises, not just the intended one. It is in this technical sense that logic models adversarial discourse. We may actually be socially co-operating in testing a deduction for validity, and certainly we have to co-operate a great deal to be sure that we are assuming the same things about the range of interpretations which are intended, but there is a core of seeking out all possible assignments of things, not simply finding one intended one. This is perhaps not accidentally related to the fact that logic arose as a model of legal and political debate. (Stenning, 2002, 138)

Given the highly regimented nature of such dialogues, we may conclude that the particular form of adversarial dialogue underpinning the deductive method – agreement on possibly arbitrary premises as a starting point, and the search for counterexamples no matter how improbable and far-fetched they may be – is arguably not part of our usual repertoire of dialogical interactions. This may partially explain why, in experiments, participants' performance often deviates from the deductive canons even in highly schooled populations (see

below). Arguably, they are not familiar with the exact rules of the 'game of deduction', and instead tend to apply rules of other 'games' that they are in fact familiar with (as also argued by, e.g., Oaksford and Chater, 2002).

As we will see, the experimental results to be discussed shortly suggest that ordinary formal schooling goes a long way toward familiarising the reasoner with the practice of taking premises 'at face value', independently of one's own beliefs with respect to their contents (component 1 as presented above). But they also show that the second core component – the indefeasibility of arguments – typically remains unfamiliar even to highly schooled reasoners, which would (at least partly) explain the discrepancy between the performance of participants and the canons of deductive reasoning.

The idea that reasoners must be acquainted with the practice of deductive argumentation and reasoning to be able to reason deductively thus suggests that the very notion of the deductive canons of correctness for reasoning may be culture-relative. Now, as is well known, claims to this effect have been defended by social constructivists such as Bloor. However, the present proposal differs from Bloor's idea of logical relativism in important ways, and such differences will be discussed in the next section.

Alternative Accounts of the Relations Between Reasoning, Argumentation and Culture

Are the laws of deductive logic universally valid? Social constructivists famously reject universalist conceptions of the canons of deduction, endorsing instead the idea of *logical relativism*. The debate on logical relativism acquired momentum with the publication of Bloor's *Knowledge and Social Imagery* (1976), where he defends the so-called Strong Program in the sociology of knowledge. Here is an apt summary of Bloor's views on logic:

> In *Knowledge and Social Imagery*, David Bloor suggests that logical reasoning is radically relativistic in the sense that there are incompatible ways of reasoning logically, and no culturally transcendent rules of correct logical inference exist which could allow for adjudication of these different ways of reasoning. Bloor cites an example of reasoning used by the Azande as an illustration of such logical relativism (Triplett, 1988: 361).

Bloor takes the (presumed) patterns of reasoning of the Azande, as reported by Evans-Pritchard (1937), to indicate that these individuals do not follow the principle of non-contradiction when reasoning. For example, the Azande were reported to agree with the premises while rejecting the conclusion of the

following deductively valid argument: "At least one man in your line of descent is a witch. If any man in your line of descent is a witch, then so are his father and all of his sons. Thus, all of the men in your line of descent are witches". Bloor's conclusion is then that this principle is not universally valid, given the existence of a culture where it is not present – the (contentious) assumption being that it is indeed widely present in the so-called Western culture. Bloor's claims gave rise to a cottage industry of articles on 'Zande logic', as opposed to 'Western logic'. For our purposes, the main upshot is the thesis that the grounds for the canons of deduction might not pertain to human cognition and psychology, but rather to cultural institutions and social phenomena in general:

> The Azande have the same psychology as us but radically different institutions. If we relate logic to the psychology of reasoning we shall be inclined to say that they have the same logic; if we relate logic more closely to the institutional framework of thought then we shall incline to the view that the two cultures have different logics (Bloor, 1976: 129–130).

He then goes on to argue that, since the Azande demonstrably reason differently from 'us Westerners', logic must be related to the 'institutional framework of thought' rather than to psychology: logic is a culture-dependent phenomenon.

There are, however, several shortcomings with Bloor's formulation of the thesis of logical relativism, as discussed, for example, by Greiffenhagen and Sharrock (2006). Indeed, the presupposition that 'classical logic', and the principle of non-contradiction in particular, permeate all of 'Western culture' is clearly at odds with the experimental results in the psychology of reasoning to be discussed in section 3, which strongly suggest that participants (typically, undergraduates in 'Western' universities) do not strictly follow the canons of deduction in their reasoning. If there is something like a 'Western logic' at all, different from the patterns of reasoning in other societies, it does not appear to correspond to anything like the traditional canons of (classical) logic and deduction. As pointed out by Greiffenhagen and Sharrock (2006: 280; emphasis added),

> Even if formal logic has been developed in one culture, it is not really the whole culture which has done so. Rather, formal logic has typically been developed as part of some *highly specialized practices* . . . the practice of formal logic is [. . .] an aspect of a culturally distinctive *specialist practice*.

(they seem to be using 'formal logic' here in the sense of the traditional canons of logic and deduction). That is, the thesis of logical relativism is ultimately based on a strong empirical claim: different cultures, as a matter of fact, are each characterised by different patterns of reasoning, and thus by different logics. But the available empirical evidence fails to lend support to the claim that classical logic and the canons of deduction do in fact underpin the reasoning of those belonging to the 'Western culture'.

It is of course still possible that some other 'logic' rather than classical logic permeates reasoning in such 'Western societies', but even within one and the same culture, individual differences in reasoning are invariably observed (Stanovich, 2008). Moreover, it seems plausible that different situations may require different styles of reasoning (Stenning and van Lambalgen, 2008), and monolithic accounts according to which there is a unique way of reasoning that a given individual adopts across the board (either universally or culture-relatively) leave no room for this possibility. In other words, there seem to be intra-cultural (inter-individual) as well as intra-individual (inter-situational) variations in reasoning patterns, but Bloor's formulation of logical relativism seems to assume that only inter-cultural variations are significantly present (in contrast, by stressing the idea of different kinds of dialogues that people can engage in, the present proposal is better able to account for these different dimensions of variability).

Nevertheless, the conception of logic and deduction presented here is 'social constructivist' in a weak sense, i.e., in that it outlines the significance of practices of debating for the emergence of the deductive method in ancient Greece (Netz, 1999). As a matter of fact, this is a unique occurrence in human history: while mathematical cultures emerged independently in a number of places, Euclidean-style axiomatic deductive mathematics never appeared anywhere else, but was later 'exported' to large portions of the world. Traditional logic and the canons of deduction would have emerged within ancient Greek philosophy and mathematics, and against the background of dialectical practices.

One may thus wonder: why in ancient Greece and not elsewhere? What were the specific conditions that allowed for the unique emergence of the deductive method in this context? A comparison with other ancient intellectual and scientific traditions having attained similar levels of sophistication and complexity can be instructive, and this is precisely what Lloyd (1996) set out to do, by comparing the ancient Greek and ancient Chinese traditions.

While recognising the sophistication of Chinese mathematics, the convergence of results, and (as shown by Chemla, 2005) the existence of proofs in this tradition (provided that one does not restrict the meaning of 'proof' to Euclidean-style proofs), Lloyd remarks that there are still significant differ-

ences in argumentative style. He then hypothesises that the dissimilarities in social and political background (in particular, attitudes towards legal argumentation) may have contributed to the development of different styles of argumentation within philosophy and mathematics in Greece (naturally, this observation pertains first and foremost to democratic states such as Athens, and presumably much less so to, e.g., Sparta) and in China.

> More generally, so far from positively delighting in litigiousness, as many Greeks seem to have done, so far from developing a taste for adversarial argument in that context and becoming quite expert in its evaluation, the Chinese avoided any brush with the law as far as they possibly could (Lloyd, 1996: 307).

According to Lloyd, while the persuasion component was indeed present in Chinese reflections on oratory, persuasion was directed primarily towards the prince/ruler, rather than toward the citizen body in assembly, as in the Greek case (see also his contribution in this issue, which further develops these points). He thus concludes that these differences in practices and social background may be partially responsible for the differences between axiomatic-deductive Greek mathematics and philosophy, on the one hand, and their Chinese counterparts, on the other hand.

It all seems very plausible at first sight. However, as a matter of fact, some of the most noteworthy ancient Chinese philosophical traditions, in particular the so-called 'School of names' (Fraser, 2009) and the later Mohist tradition (Fraser, 2011) both very much emphasised debates and argumentation, being quite close in spirit to dialectic in the early Academy. So it would seem that ancient Chinese philosophy is very much like ancient Greek philosophy in the period immediately preceding the emergence of the axiomatic-deductive method (a point acknowledged by Lloyd himself in his contribution to this issue), while at the same time not giving rise to fully-fledged formulations of the concept of deduction (as the one found, for example, in the *Prior Analytics* at 24b18–20). There are of course still significant differences between the two contexts as a whole (including the social and political components), but the existence of these Chinese debating philosophical traditions at least suggests that Lloyd's narrative, though attractive, may require further elaboration. It is still not entirely clear why and how these differences in political and pragmatic backgrounds would be sufficient to explain the emergence of the axiomatic deductive method in Greece but not in China, given their similar starting points.

However, with Lloyd, and against Bloor, I maintain that the fact that specific social and cultural elements may have been crucial for the emergence of the deductive method still does not entail the thesis of logical (or

mathematical) relativism: "Mathematical truths do not vary across cultures" (Lloyd, 1996: 304).

Moreover, by emphasising the argumentative, dialogical origins of deductive reasoning, my account also bears some similarities with Mercier and Sperber's (2011) 'argumentative theory of reasoning'. But it differs from their account in two important points: my claim is restricted to *deductive* reasoning, thus not ruling out that at least some forms of human reasoning may not have dialogical, argumentative origins; and my story is a story of *cultural* evolution, whereas Mercier and Sperber are mostly interested in the biological, evolutionary emergence of reasoning as an adaptation.

We will come back to the relations between reasoning and dialogues in section 5, but first I briefly review the experimental results on reasoning of the last decades, both for schooled and unschooled populations.

Deductive Reasoning in Schooled Reasoners

What are the relations between human reasoning and (classical) logic? *Do* humans in fact follow the canons of deduction when reasoning? *Should* humans follow these canons? In the 1950s, Piaget's influential work represented a strong normative view of the centrality of classical logic to good reasoning; but significantly, his views were developed on a highly schooled group of children. Some relevant aspects of what was viewed as a 'Piagetian' conception of human cognition and rationality are described in the following passage:

> How do people reason? The view that I learned at my mother's knee was that they rely on logic. [. . .] Jean Piaget and his colleagues argued that the construction of a formal logic in the mind was the last great step in children's intellectual development, and that it occurred about the age of twelve (see, e.g., Inhelder and Piaget, 1958) (Johnson-Laird, 2008: 206)

Piaget's own ideas are certainly much more subtle than this passage suggests, but the passage is illustrative of how these psychologists conceived the starting point for their investigations, and what they saw themselves as arguing against. In other words, the predominant idea was that mature reasoning is rule-based, and that the 'abstract' rules in question were simply the rules of 'logic' as traditionally construed (syllogistic, classical logic). This is actually not true of Piaget himself, whose concept of formal operations encompasses operational schemata that have no direct relation to propositional logic. Piaget did not claim that we were *born* with these rules in our heads, ready to use as it were; the rule-based system of reasoning had to develop, and in principle education and social interactions might play a fundamental role (Piaget 1995).

However, the aspect of Piaget's notion of 'formal operations' which became most prominent is the idea of reasoning proceeding by schematic substitution with different contents – what can be described as a *schematic* conception of formality (see Dutilh Novaes (2012a) for the formal as schematic). Mental rules would be something like schematic rules ('If A then B; A, therefore B'), which could then be instantiated by different contents ('If it is night, it is dark; it is night, therefore it is dark').

The picture of human reasoning as proceeding by means of instantiations of formal rules and schematic substitution with different contents began to be challenged in the late 1960s by a series of experimental findings (such as those reported in the classic (Wason, 1966)) suggesting that humans do not really reason on the basis of the specific logical rules defining the traditional conception of (classical, deductive) logic (Dutilh Novaes, 2012b: chapter 4). The experiments focused almost exclusively on conditionals ('If this is the case, then that is the case') and syllogisms ('All humans are animals; all animals are mortal; thus, all humans are mortal') as their task materials, and participants' responses were found to deviate systematically from the responses deemed correct by classical logic. Nevertheless, classical logic remained by and large the normative system guiding both the formulation of experiments and the evaluation of the results.

Indeed, it became established that a number of non-formal factors play a significant role in how participants formulate and evaluate arguments. The notion of 'reasoning biases' was introduced in order to conceptualise the systematic deviations from the canons of deductive logic observed in the experiments (Evans, 1989, 2002), just as in the 'heuristics and biases' research program initiated by Tversky and Kahneman (1974) for probabilistic reasoning.

For example, participants are more likely to endorse deductively invalid arguments having a believable conclusion than deductively valid arguments having an unbelievable conclusion – what is known as the *belief bias effect*. The results of the Evans et al. (1983) study on belief bias, for example, are revealing (Table 1). The details of the cognitive processes involved in the phenomenon of belief bias remain somewhat controversial (Klauer et al., 2000), but the experimental results are very robust and have been replicated extensively since this early study. Participants were given fully formulated syllogistic arguments, and asked to evaluate their validity. Some arguments were valid and some were invalid (according to the traditional syllogistic canons); some had a believable conclusion and some had an unbelievable conclusion (in all four possible combinations). Typically, in such experiments the valid syllogisms (both believable and unbelievable) are of the same syllogistic mood and figure (same 'logical form'), and the same holds of the invalid syllogisms. The results were (in % of accepted arguments):

Table 1
Results of the Belief Bias Effect Study of Evans et al. (1983)

	Believable conclusion	Unbelievable conclusion
Valid	89	56
Invalid	71	10

A modicum of 'logical competence' can be identified here insofar as deductively valid arguments were more often viewed as valid than the invalid ones (89% vs. 71% for arguments with believable conclusions; 56% vs. 10% for arguments with unbelievable conclusions). However, believability of the conclusion clearly trumps deductive validity: participants endorsed invalid arguments with believable conclusions more often than valid arguments with unbelievable conclusions (71% vs. 56%). Moreover, the discrepancy in endorsement between arguments having the same 'logical forms' speaks against a naïve conception of reasoning by means of instantiations of formal schemata.

Another robust experimental finding is that human reasoning is usually *defeasible*: arguments from premises to conclusion that are taken to be valid/cogent can then be deemed invalid upon the arrival of new information (Oaksford and Chater, 2002; Stenning and van Lambalgen, 2008). This is in stark contrast with the canons of deductive logic, according to which a valid argument remains valid come what may. A deductively valid argument is *indefeasible*: it cannot be defeated by the arrival of new information.

One possible account for the component of defeasibility in the experimental results (e.g., Byrne's (1989) 'suppression task' results) is that, rather than looking for counterexamples to the argument – a situation where the premises are the case and the conclusion is not – what participants in fact do in reasoning experiments is to look for plausible situations where the premises are the case (i.e., plausible *interpretations* of the premises), and then check whether the conclusion is also the case in such situations. In other words, they engage in the defeasible-reasoning task of finding the 'intended interpretation' for the premises rather than in the indefeasible-reasoning task of checking for the absence of counterexamples (Stenning and van Lambalgen, 2008).

It is true that, in simple cases such as reasoning with a conditional and the assertion of the antecedent (*modus ponens*), participants (including those with low levels of schooling) are indeed typically able to draw the deductively correct conclusion, namely the assertion of the consequent. However, in such simple cases, the deductively correct response coincides with what participants are likely to reply also if they are reasoning defeasibly, so it becomes

difficult to differentiate defeasible from indefeasible reasoning in such cases. One element suggesting that large portions of participants are reasoning defeasibly also when doing modus ponens is the 'suppression effect' identified by Byrne (1989), when participants who previously performed a modus ponens reasoning then retract the conclusion when new information is added. Presumably, what they were doing all along was to apply the principle of defeasible modus ponens. But as soon as the task materials become more complex, for example a conditional and the denial of the consequent (*modus tollens*), deductive performance drops considerably also with highly schooled populations (around 70%, whereas the acceptance rate of *modus ponens* in this population is virtually 100%) (Oaksford and Chater, 2008). This is because, in such cases, the defeasible and the indefeasible responses come apart, and it becomes clearer which kind of reasoning participants are in fact applying. Here is roughly why the defeasible and indefeasible responses come apart in the case of modus tollens, but not of modus ponens. If the conditional 'If A then B' is given a defeasible interpretation, an assertion of A will make B a plausible conclusion; but an assertion of not-B does not make the acceptance of not-A plausible, because the defeasible interpretation of the conditional (unlike the classical, material implication interpretation) allows for exceptions. Indeed, in several non-monotonic logics (semantic networks, default logic, etc.), modus tollens does not hold but (defeasible) modus ponens does (Koons, 2009).

It has been claimed that, despite results that for the most part deviate from the canons of deduction as traditionally construed, participants do show a modicum of 'logical competence'. For example, with respect to the belief bias effect, participants still endorse valid arguments more often than invalid ones in absolute terms, despite the strong effect of the believability of the conclusion. Moreover, acceptance of *modus tollens* is still well above chance. Accounting for this apparent discrepancy in the responses was one of the original motivations for the formulation of the currently popular dual-process theories of reasoning and cognition (Evans, 2008; Frankish, 2010).

However, a serious methodological objection to this specific body of research concerns the demographics of the participants' samples. Almost invariably, research has been carried out with groups of undergraduate students at the researchers' universities, thus typically with participants with many years of formal education of a specific, homogeneous kind (what may be inaptly described as 'Western-style schooling'). Now, if these participants display a modicum of 'deductive competence', this may well be in virtue of the fact that they must have had *some* exposure to the main tenets of the deductive method throughout their school years, even if only implicitly (say, when learning physics or mathematics).

This methodological objection has been articulated in detail by Henrich et al. (2010: 111):

> Behavioral scientists routinely publish broad claims about human psychology and behavior in the world's top journals based on samples drawn entirely from Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies. [...] Overall, these empirical patterns suggest that we need to be less cavalier in addressing questions of *human* nature on the basis of data drawn from this particularly thin, and rather unusual, slice of humanity.

The general point applies to the domain of reasoning as well: given that it has been conducted almost exclusively with participants having a particular, homogeneous educational background, this body of research does not address the possible effects of education on (deductive) reasoning abilities.

In other words, the available data are equally compatible with the hypothesis that the modicum of 'logical/deductive competence' emerging from the experiments is essentially related, in some way or another, to formal schooling (the results in Evans et al. (1994) also show that even basic instruction on the notion of logical necessity prior to the experiment brings responses closer to the deductive canons). This hypothesis is further corroborated by the results reported in Morris and Sloutsky (1998), an investigation of the onset and development of the notion of logical necessity in high-school adolescents in function of different kinds of mathematical education. They undertook a diachronic study of two groups receiving unconventional math education: one with emphasis on the metalevel of deduction through an algebraic approach (in Russia), the other with emphasis on calculating and applied mathematics (in England) (plus two control groups, one in each country, receiving conventional math education). From the abstract:

> It was hypothesized that instructional emphasis on the metalevel of deduction within a knowledge domain can amplify the development of deductive reasoning both within and across this domain. [...] The results support the hypothesis, indicating that prolonged instruction with an emphasis on the metalevel of algebraic deduction contributes to the development of understanding of logical necessity in both algebraic and verbal deductive reasoning. Findings also suggest that many adolescents do not develop an understanding of logical necessity naturally. (Morris and Sloutsky, 1998: 721)

In practice, however, the psychology of reasoning has for the most part neglected the possible effects of formal education on reasoning. Elqayam and Evans (2011: 243) offer appropriate observations on this omission: "The argument encouraged by [...] numerous philosophers is essentially this: (classical)

logic provides the laws of rational thought in all contexts. People are rational. Therefore, logic must be built into people's heads in some innate and a priori manner. [But] why on earth, for example, should our notion of rationality exclude learning?" The failure to consider the learning/educational factor is a serious one, which can only be remedied by systematic experimental work on populations having received different levels and different kinds of schooling. So let us now turn to the scarce investigations with unschooled participants.

Deductive Reasoning in Unschooled Reasoners

An investigation of the effects of training and schooling on reasoning could be based on a diachronic approach following the schooling process over time (such as (Morris and Sloutsky 1998)), or on a synchronic approach with participants having different educational levels. In practice, though, there is a severe scarcity of studies with populations with low educational levels (for surveys, see Counihan (2008), chapters 1 and 3, and Harris (2000), chapter 5).

The seminal work in the genre is Luria (1976), a study conducted in the 1930s with unschooled peasants in remote parts of the then-Soviet Union. Luria espoused the ideas of Vygotsky, according to whom thinking and reasoning are deeply influenced by cultural, social and historical factors. "[Luria and Vygotsky] speculated that the radical changes in the lifestyle of the peasants, notably their increased access to education and their incorporation into Stalin's agricultural collectives, should produce dramatic cognitive changes." (Harris, 2000: 95). Luria then conducted experiments with two groups of participants: one group composed of illiterate peasants with no schooling, working in a traditional, non-technological economy, and the other group having recently received one or two years of basic education and been involved in collective farming.

The results were striking. Both groups performed close to the logical-normative responses in simple reasoning tasks whose first premise referred to contents they were familiar with, but the first group 'failed miserably' in reasoning tasks with unfamiliar content. The second group, by contrast, with only a modicum of formal education, performed much closer to the normative canons of deduction also in the second kind of task. In fact, participants in the first group often seemed not to understand what exactly was expected of them with the unfamiliar content tasks: why were they being asked to answer questions about things they could not possibly know anything about? Here is one illustrative exchange:

> Experimenter: In the Far North, where there is snow, all bears are white. Novaya Zemlya is in the Far North and there is always snow there. What color are the bears there? Subject: I don't know what color the bears are there, I never saw them. . . . E: But what do you think? S: Once I saw a bear in a museum, that's all. E: But on the basis of what I said, what color do you think the bears are there? S: Either one-colored or two-colored . . . [ponders for a long time]. To judge from the place, they should be white. You say that there is a lot of snow there, but we have never been there! (Luria, 1976: 111).

Such responses have been described as 'participant refuses to engage in the task'. In contrast, participants with just a few (recent) years of schooling had no issues reasoning from unfamiliar content; this led Luria to conclude that the results confirmed his initial hypothesis concerning the effects of schooling.

Luria's results remained unpublished until 1976, for political reasons. For the same reasons, he could not pursue his program of cross-cultural investigation of reasoning, and for decades nothing much was done in this direction. It was only in the 1970s that Michael Cole and Sylvia Scribner (Cole et al., 1971; Scribner, 1977; Scribner and Cole, 1981) re-initiated Luria's program, this time investigating unschooled populations in Africa. Their results were very similar to Luria's in most respects. On the basis of these results, Scribner (1977) hypothesised the existence of two possible 'orientations' towards a reasoning task: the empirical one and the analytic one. According to Scribner (in the words of Harris),

> In the absence of schooling, [participants] adopt an "empirical orientation": they use their own experience to supplement, to distort, or even to reject the premises supplied by the interviewer; they reason instead on the basis of their empirical experience. After two or three years of schooling, they adopt what might be called a "theoretical" or "analytic" orientation instead: they focus on the claims encapsulated in the premises of the problem even when those premises do not fit into their everyday experience and they confine their reasoning to what follows from those premises. (Harris, 2000: 98–99)

In other words, Scribner's claim was that unschooled participants tend to stay close to their own beliefs and experiences, whereas schooled participants are typically capable of putting their beliefs and experiences aside so as to reason with premises even if the premises conflict with their convictions. In the spirit of Vygotsky and Luria's original ideas, Scribner concluded that schooling has the fundamental effect of giving rise to the analytic orientation in the reasoner, who would otherwise be confined to the empirical orientation.

In recent decades, Scribner's conclusions have been further investigated by Paul Harris and collaborators. They conducted a number of experiments with

young children (Dias and Harris, 1988, 1990), as well as unschooled adults in the northeast of Brazil (Dias et al., 2005). They found that it is not only through schooling that the so-called 'analytic orientation' may emerge; by modifying the formulation of the task materials, children and unschooled adults could be prompted to take the premises as if they were true and to reason on their presumed truth, even when the premises conflicted with their beliefs or were unknown to them.

As described by Harris (2000: chapter 5), pretence play situations, for example, may prompt a (young) reasoner to put aside her factual knowledge and to focus on the pretended truth of some statements. Indeed, Harris and collaborators obtained results much closer to the deductively normative responses by formulating the reasoning task in terms of make-believe story-telling and pretence play for children. With unschooled adults, they obtained a similar effect by postulating that the premises in the experiment were about a 'different planet', which in practice prompted participants to suppress or put aside their factual beliefs about the actual world.

More recently, Counihan (2008) presented experimental results with participants with varying but low educational levels in South Africa. Her investigation explored some hitherto neglected aspects of the experimental set-up, in particular semantic and pragmatic components. How do unschooled participants interpret the task proposed to them by the experimenter? In particular, what *semantic interpretation* do they attribute to the premises? They seem for example not always to interpret the 'All' in categorical sentences ('All bears are white') as not allowing for exceptions, giving it instead a generic reading. Indeed, Counihan found that participants with low educational levels deviated more strongly from the normative responses of traditional logic in syllogistic tasks than in conditional tasks.

Another important finding in Counihan (2008) is that schooled participants who have been away from the school environment for many years, having then returned to activities such as agriculture or herding, often give typical 'unschooled' responses in experiments. This suggests that the possible effects of schooling on reasoning become less pronounced over time, once the reasoner is no longer at school.

One conclusion to be drawn from this literature is simply that unschooled participants may not be familiar with specific forms of dialogical interaction such as quizzing (answering a question to which the interlocutor already knows the answer) and answering questions on topics going beyond their immediate knowledge. Indeed, what must be acknowledged is that a reasoning experiment is *itself* a specific kind of dialogue between participant and experimenter; this may not be immediately apparent in classical, 'paper-and-pencil'

experiments, but it becomes manifest in experiments with participants with little or no schooling, which are typically conducted orally. For all she knows, the participant is engaging in a dialogical interaction with the experimenter, and naturally she will rely on her previously available repertoire of dialogical interactions to try to establish what is expected of her. If she is not used to this particular 'language game', what is she to make of the questions asked by the experimenter?

Dialogical Practices Enhancing Deductive Reasoning

Focusing on the kinds of dialogical interactions – 'language games' – present in a school environment thus allows for the formulation of a few hypotheses concerning what exactly about schooling has the effect of influencing performance in reasoning experiments (as in Luria's results).

One of the possible effects of just a few years of formal schooling is thus to introduce participants to these forms of dialogical interaction, which in turn crucially influences their performance in classical reasoning tasks. In school, students are exposed to situations where a person of authority (the teacher) poses a question merely in order to know whether the interlocutor knows the answer, rather than to obtain new information for him/herself; clearly, this should influence how a participant interprets the experimental situation in a reasoning experiment, which is quite similar. A school context also fosters the kind of dialogical interaction where one participant (the teacher) puts forward claims that the other participant (the student) must accept as true in order to reason with – e.g., the formulation of an arithmetic problem. It is thus not surprising that schooling facilitates the emergence of what Scribner described as the 'analytic orientation', which finds its pinnacle in debating practices where a debater can argue for a given thesis entirely independently of her own doxastic state towards the thesis.

Unschooled participants can also adopt such a stance, as shown by the work of Harris and collaborators, but they need specific cues to do so. This is arguably because other dialogical practices outside the school context, such as pretence play and storytelling, also tap into the reasoner's ability to grant propositions independently of her factual beliefs. These practices may be viewed as the precursors of learning to reason in a school-like setting, and in particular as precursors of one of the two core components of deductive reasoning, namely reasoning on the basis of the explicitly provided information, regardless of its truth value or believability. In other words, Scribner's analytic orientation does not arise exclusively through schooling, but outside the school context it may

require specific dialogical cues to be adopted, and remains somewhat unstable. In effect, Harris and collaborators found that even the intonation used by the experimenter has a significant impact for the participant's response (if the experimenter adopts a 'story-telling' intonation, children are more willing to reason on the basis of the provided premises).

By contrast, the second core component of deductive reasoning as defined here, namely the evaluation and formulation of *indefeasible* arguments, appears to be more closely connected specifically to formal schooling. Indeed, formulating an indefeasible, deductively valid argument such as a mathematical demonstration (a practice that some, but by no means all, high school students are exposed to) can also be seen as a specific 'language game' that must be learned to be played correctly. As shown in Morris and Sloutsky (1998), the kind of mathematical education one receives crucially influences the development of the ability to understand the notion of logical necessity and to formulate and evaluate deductive, indefeasible arguments (perhaps unsurprisingly, emphasis on the metalevel of deduction has a noticeable facilitating effect).

The experimental results obtained with schooled and unschooled reasoners discussed above suggest that ordinary formal schooling familiarises a reasoner with the practice of putting aside one's beliefs with respect to the contents of premises for the purposes of reasoning (even though schooling is not the only environment giving rise to this practice). They also show that the second core component of deductive reasoning – the indefeasibility of arguments – typically remains unfamiliar even to highly schooled reasoners, and this might at least partially explain the discrepancy between the performance of participants and the canons of deductive reasoning. This does not mean that unschooled reasoners cannot spot implausible arguments or internal incoherencies in what they are told, but here again I would claim that their reasoning patterns will be distinctively defeasible rather than indefeasible (they can distinguish good and bad defeasible arguments). But is it really the case that there are no precursors to the indefeasibility component outside circles of specialists?

Now, if we go back to the dialogical conceptualisation of deduction presented in the Introduction and bear in mind that the indefeasibility component seems to have arisen in connection with the *adversarial* nature of such dialogues (and related strategic considerations), we may look for everyday dialogical situations where the adversarial component is also present. One kind of adversarial dialogue that readily comes to mind is *betting*, which is also a notion used by philosophers to discuss the concept of rationality, e.g., the prolific industry on Dutch Book Arguments. Indeed, we may formulate the hypothesis that, if a reasoning task is presented to a participant in the form of a bet, she is more likely

to steer towards indefeasible reasoning and away from defeasible reasoning in virtue of the adversarial component. The idea would be that, in conventional presentations of reasoning tasks, participants not trained in logic do not quite understand what exactly is expected of them – namely, to establish whether the arguments in question have the property of necessary truth preservation and thus are not merely plausible. In a betting formulation, however, the participant may more readily understand that the goal is not only to establish the intended interpretation of the premises (a defeasible-reasoning task), but instead to establish that there are no counterexamples where the premises are true and the conclusion is false (an indefeasible-reasoning task).

In this spirit, in a pilot study with university undergraduates, Stenning and Achourioti (personal communication) formulated a syllogistic reasoning task in the following way. The task is introduced through a suspicious character called Harry-the-Snake who is offering bets on syllogistic conclusions. Harry proposes a pair of syllogistic premises and what he claims is a valid conclusion from them. The participant has first to decide whether to bet that Harry's conclusion is invalid. If they agree with Harry on his conclusion and so choose *not* to bet, then they pass to the next problem. But if they bet against Harry, then they are disagreeing about a logical consequence. They are then asked to justify their disagreement by constructing a 'countermodel' (explained to them as a special kind of counterexample) that makes the premises true but Harry's conclusion false.

This is a staging of the discourse of classical logic that exploits the concept of betting as a means to capture the dialogical, adversarial component which (arguably) underpins the concept of a deductive argument (both historically and conceptually). The preliminary evidence obtained shows that this staging shifts substantial numbers of undergraduate participants in a classical (indefeasible) direction, thus bringing the results closer to the deductive canons. But further work is still required before conclusions can be drawn.

That specific dialogical stage-settings may prompt reasoners to reason closer to the deductive canons is not so surprising if we take into account the idea that the two core components of deductive reasoning arose from specific features of debating practices in ancient Greek culture. Storytelling and pretense reproduce the idea of taking premises 'at face value', while betting reproduces the adversarial component of these debating practices. Presumably, other forms of competitive interaction (e.g., guessing games) may have the same effect, so the claim is not that betting alone captures the adversarial component of deductive reasoning. But at the very least, betting seems like a reasonable starting point to investigate the adversariality hypothesis. Now, even granting that ontogeny need not recapitulate phylogeny (and to be clear,

we are here speaking of *cultural*, not biological, phenomena; see below), it is worth considering the possibility that the same factors involved in the historical emergence of deductive reasoning may in turn have a facilitating cognitive effect for the individual reasoner who is learning to reason deductively.

At any rate, the arguments presented here strongly suggest that both the historical emergence of deductive reasoning and the development of deductive skills are fundamentally *cultural* phenomena. The former pertains to the historical development of logic and mathematics, while the latter is strongly, though not exclusively, associated with formal education, in particular the kinds of 'language games' that a reasoner is exposed to in school situations.

A more modest interpretation of the data might be that a modicum of schooling does not fundamentally modify the cognitive capacities of individual reasoners, contrary to Vygotsky and Luria's initial assumption. It simply teaches them to engage in specific kinds of language games, and this in turn facilitates their understanding of what is expected of them in reasoning experiments. This is certainly correct, but if one adopts a social conception of cognition and reasoning, aptly engaging in different dialogical exchanges is (at the very least) a large component of what counts as cognition anyway; so there is no real dichotomy here.

Conclusion

Thus, we may conclude that social and cultural factors, schooling in particular and, within the school context, exposure to specific kinds of dialogical interactions, may greatly influence the deductive reasoning abilities of an individual. But rather than a radical rearrangement of a person's cognitive abilities, the 'dramatic transformation' observed by Luria in participants having had a few years of schooling may be above all a matter of expanding one's repertoire of dialogical interactions. Familiarity with certain 'language games' has tangible implications for how participants engage in the experimental situation, but the effects may well go beyond the mere pragmatics of the experimental setting.

Moreover, I argued that certain kinds of dialogues outside the school context – pretence play and storytelling, betting – also mirror the key components of deductive reasoning: the dissociation between belief in the premises and being able to draw conclusions from them, and the adversarial component at the root of the notion of an indefeasible argument. These observations tie neatly with the dialogical account of the historical emergence of deduction presented at the beginning of the paper, and this is why it may be said that 'ontogeny recapitulates phylogeny' for deductive reasoning.

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