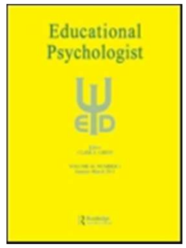

Natural born arguers: Teaching how to make the best of our reasoning abilities

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Abstract

We summarize the argumentative theory of reasoning, which claims that the main function of reasoning is to argue. In this theory, argumentation is seen as being essentially cooperative (people have to listen to others' arguments and be ready to change their mind), but with an adversarial dimension (their goal as argument producers is to convince). Consistent with this theory, the experimental literature shows that solitary reasoning is biased and lazy, while reasoning in group discussion produces good results, provided some conditions are met. We formulate recommendations for improving reasoning performance, mainly, to make people argue more and better by creating felicitous conditions for group discussion. We also make some suggestions for improving solitary reasoning, in particular to maximize students' exposure to arguments challenging their positions. Teaching people about the value of argumentation is likely to improve not only immediate reasoning performance, but also long-term solitary reasoning skills.

Natural born arguers: Teaching how to make the best of our reasoning abilities

Cognitive science provides an increasingly detailed understanding of the mind, from low-level perceptual processes to high-level reasoning. Evolutionary psychology builds on cognitive science and stresses the usefulness of understanding the function of cognitive mechanisms. The goal of this article is to apply some recent developments in cognitive science and evolutionary psychology—a new theory of reasoning—to education.

We start by briefly outlining some ways in which cognitive science and evolutionary psychology can inform education research, namely, by identifying specific cognitive mechanisms, describing how they are triggered, how they work, and what their function is. We suggest that although reasoning is but one of the many cognitive mechanisms that is targeted in education, it is an important one—in particular for critical thinking courses, but much more generally as well, and at all ages and levels of education. We then present a theory of what reasoning is and what reasoning is for, and briefly review experimental data supporting this theory. This theory, the argumentative theory of reasoning, posits that the main function of reasoning is to exchange arguments in dialogic contexts in order to improve communication.

The evidential support for this theory largely stems from well-known results: the robust failures of individual reasoning, and robust successes of reasoning in the context of group discussion. Although these results should be familiar to education researchers, in particular the success of collaborative learning, the theory exposed here offers a new understanding of these phenomena. This new understanding could help researchers to more intuitively understand the failures and successes of students that they grapple with in their work.

On the basis of the argumentative theory of reasoning, we formulate some suggestions regarding the best ways to improve reasoning performance. Broadly, we advocate shifting the focus away from trying to transform students' reasoning abilities, towards helping students make the best possible use of the abilities they have. We suggest students should be taught how to create felicitous contexts for group discussion, thereby allowing them both to reap the benefits of their argumentative skills, and to improve on their solitary reasoning skills.

Cognitive Science and Education

Cognitive science is the study of the computational mechanisms that process representations—chiefly, but not only, those of the human mind. Other approaches, such as behaviorism, focus on the inputs (stimuli) and the output (behavior). By contrast, cognitive science posits the existence of a number of intermediate steps, each carried out by a different mechanism, from low-level perceptual or motor processes, to higher-level inferences (see a full definition of *inference* in Table 1).

Except for the lowest-level perceptual and motor processes, each of these cognitive mechanisms takes a representation as input, processes it, and produces another representation as output. The goal of cognitive science is to understand how this myriad of mechanisms works, and thus to explain extraordinarily complex behavior in terms of increasingly simple mechanisms. This understanding can inform education research, for instance in the following ways: 1) by identifying what are the most relevant cognitive mechanisms to accomplish a given task, learn a given concept, etc.; 2) by understanding the best way to trigger these mechanisms (and to avoid triggering other mechanisms that could produce less felicitous results); and, 3) by finding ways to use these mechanisms in the most felicitous way possible.

The teaching of each school topic relies on a great many cognitive mechanisms. For instance mathematics taps into cognitive mechanisms dedicated to the processing of exact small quantities, of approximate large quantities, of spatial relations (Dehaene, 1999), but also memory and reasoning, as well as low level perceptual, motor, and linguistic mechanisms. Here our focus is on the cognitive mechanism of reasoning (see below, and *reasoning* in Table 1).

Reasoning likely plays a crucial role for the study of most school topics. However, if there is one course that focuses on improving reasoning performance, it is critical thinking. Like other school topics, critical thinking relies on a variety of cognitive mechanisms (as suggested in the multiple definitions of the field, see, e.g., Ennis, 2000; Paul & Elder, 2013; Scriven & Paul, 2004), but it seems clear that reasoning plays a prominent role. Since our focus is on reasoning, we will often have recourse to examples from critical thinking teaching. However, our conclusions apply to improving reasoning performance more broadly. For cognitive science to best help improve reasoning performance, we must start by defining reasoning: what cognitive mechanism are we dealing with?

What Is Reasoning?

Reasoning has been defined in many different ways. Some have defined reasoning as “the process of drawing inferences (*conclusions*) from some initial information (*premises*)” (Holyoak & Morrison, 2005, p. 2). One advantage of such a definition is that it draws attention to the sophistication of even unconscious, automatic inferential mechanisms. However, it seems to us counter-intuitive to treat as “reasoning” such inferences as, for instance, the assessment of the trustworthiness of an individual based on facial traits; an inference that takes place in milliseconds has seemingly low reliability, and many people would likely disavow if they were made aware of it (see, e.g., Olivola, Funk, & Todorov, 2014). By calling all inferences “reasoning,” we deprive ourselves of the specificity of the term, which we believe is more helpfully used to refer to a much more restricted set of cognitive mechanisms.

A common way of restricting the meaning of reasoning is to use it to refer to so-called ‘system 2 processes’ in dual-process models (Evans, 2003; Kahneman, 2003; Stanovich, 2004). Reasoning would then be a set of cognitive processes that share the following traits: slow, serial, controlled, effortful, rule-governed, flexible, neutral (Kahneman, 2003, p. 698). In this model, reasoning is opposed to intuitions, which are the negative of reasoning: fast, parallel, automatic, effortless, associative, slow-learning, emotional (ibid.). In spite of their popularity, we believe there are serious issues with these definitions of reasoning (see Mercier & Sperber, 2011b). In particular, following such definitions, the same cognitive processes can sometimes be defined as reasoning and sometimes as intuitions. As an example of a typically intuitive mechanism that sometimes fits with the definitions of reasoning, consider face recognition. When you scan a crowd (e.g., looking for a friend at the train station), the process is slow (it takes time to scan the crowd), serial (you look at each face in turn), controlled and flexible (the search is under conscious control, you can proceed in various ways), effortful (you need to focus), and neutral (no emotions need be involved).

By contrast, as an example of a mechanism that (we suggest) is a form of reasoning but mostly has intuitive traits, consider the following problem (known as the 'Bat and Ball'): A bat and a ball cost $1.10 together. The bat costs $1 more than the ball. How much does the ball cost? When faced with this problem, most people answer 10c (Frederick, 2005). Yet the correct answer is 5c: then, the bat costs $1.05, and the two $1.10 as stipulated. When participants are given this argument for the correct answer, many of them understand it immediately, a reaction that is fast, automatic (they did not make a conscious decision to recognize the strength of the argument), effortless, and that can even be emotional (Gopnik, 1998). As a result, understanding this argument mostly has System 1 traits. Yet, if understanding this argument is not reasoning, then we do not know what is. Therefore, even though dual-process models are a step in the right direction, in that they attempt to restrict reasoning to a specific set of processes, we believe that they do not select a consistent set of processes. Instead, they select for processes on the basis of temporary, and possibly superficial, features (a criticism which has led recent dual process models to look for a single criterion, see, e.g., Evans & Stanovich, 2013).

Over the past years, Sperber and Mercier (2011b) have developed an alternative theory of reasoning. In this theory, reasoning is defined as a mechanism (or set of mechanisms) that deals with the relation between reasons and their conclusions (see *reasons* in Table 1). For instance, when someone finds the correct answer to the Bat and Ball, or when she understands the argument for the correct answer, she is typically reasoning. In the first case because she had to realize that there was a good reason to answer 5c instead of the more intuitive 10c answer. In the second, because she had to realize that the argument above was a good reason to accept 5c as the correct answer.

To better understand why paying attention to reasons makes reasoning special, we must go back to an important insight of cognitive science: most inferences are drawn without any attention being paid to reasons. When someone infers that an individual is trustworthy because he has round features, she does not represent the reasons for her inference, not even on an unconscious level. There is simply no representation of reasons to be found anywhere in the mind. When an infant infers that an object is going to fall because it does not rest on anything, she does not know the reasons for her inference. When a Vervet monkey infers there is a leopard because she heard the leopard alarm call, she does not know the reasons for her inference. All those inferences are intuitive. This does not mean that they are not sound, or that they are not based on representations that can be thought of as reasons by individuals with the capacity to represent reasons. But the ability to recognize that a given representation is, or is not, a good reason to accept a given conclusion requires a set of cognitive mechanisms that are distinct from other inferential mechanisms. In the remainder of the article, we will use ‘reasoning’ to refer to this set of cognitive mechanisms.

We believe this definition of reasoning is the most helpful for the present endeavor. If reasoning is defined as any inferential process, then one can hardly see how it could be a reasonable educational target. Following the argument above, focusing on reasoning defined as 'system 2 processes' would also be problematic. Yet for the definition of reasoning defended here to be genuinely helpful, it must be complemented with a better understanding of how reasoning works—an understanding best reached if we first ask: what is reasoning for?

What is reasoning for?

Individualist Theories

If we accept that reasoning is a cognitive mechanism that deals with reasons, and that by contrast most other inferences are drawn without any attention being paid to reasons, the question arises of the function of reasoning. If the whole of non-human cognition, and most of human cognition, goes on efficiently without reasoning, why do we reason at all? The standard answer to this question is that reasoning can improve on other inferential processes (Evans, 2003; Kahneman, 2003; Stanovich, 2004). In particular, through ratiocination—solitary reasoning—one should be able to tell whether the product of one's inferences is cogent or not: whether one's beliefs and decisions can be properly justified. If the grounding for our beliefs and decision is found wanting, reasoning should help us find better-grounded alternatives.

The Bat and Ball problem seems to illustrate well individualist theories of reasoning. Faced with this problem, a solitary thinker can discard her misguided intuition and, thanks to reasoning, find the correct answer. The problem is that most people do not do so. Even though the correct answer should be accessible to all—it requires no expert skill or special knowledge—only a tiny minority of participants (around 15%) find it. Such a failure is not limited to this problem: it is the standard outcome when a problem elicits a strong but misguided intuition, even for simple mathematical (Frederick, 2005), statistical (Tversky & Kahneman, 1982), probabilistic (Tversky & Kahneman, 1983), or logical (Wason, 1966) problems. In all of these problems, most participants fail to recognize that their initial, misguided intuition is problematic, and that a better answer is available.

These recurrent, robust failures of reasoning have been often interpreted in terms of cognitive limitations such as those on working memory (Evans, 2003; Johnson-Laird & Bara, 1984). This explanation, however, does not capture what participants are doing when facing such problems. If they do not discard their misguided intuition, it is not because their reasoning attempts to solve the problem fail, it is because their reasoning seeks to identify reasons that support their intuition (Ball, Lucas, Miles, & Gale, 2003; Evans, 1996; see also Kunda, 1990). This tendency of reasoning to provide reasons that support the reasoner's prior beliefs or decisions is typically referred to as a confirmation bias (Kunda, 1990; Nickerson, 1998), although it is more properly called a myside bias since it is not a tendency to confirm everything, even things we disagree with, but a tendency to find reasons that support one's position (Mercier, in pressa).

However, a myside bias on its own would not be sufficient to explain the failure to solve simple logical or mathematical problems. In these problems, all the arguments for the wrong answer are necessarily flawed in some way. For instance, the most common argument for the 10c answer to the Bat and Ball problem is that 10c and $1 make $1.10. This argument is flawed: even though the premise is correct, the conclusion does not follow (since the bat should cost $1.10, and not $1, if the ball cost 10c). Even a participant with a myside bias, who would first consider such arguments, could reason her way to the correct answer if only she was sufficiently exigent towards her own arguments. Thus, the failure of reasoning to discard misguided intuitions reflects not only a myside bias, but also 'laziness' (Kahneman, 2011): instead of critically examining their own reasons, solitary reasoners are content with generic, superficial reasons (Kuhn, 1991; Perkins, Farady, & Bushey, 1991).

Finding reasons for one's side, and not being critical of one's own reasons, is a recipe for disaster. Not only do reasoners generally fail to correct their own mistaken intuitions, but this piling up of poorly examined reasons can even lead to overconfidence (Koriat, Lichtenstein, & Fischhoff, 1980) and polarization (Tesser, 1978). Reasoning's failures are all the more remarkable since the intuitions that reasoning is supposed to correct function, arguably, very well (see, e.g. Gigerenzer, 2007).

If reasoning served the function hypothesized by individualist theories—that of improving on one's beliefs and decisions—it should have the opposite traits. Instead of a myside bias, it should objectively consider reasons pros and cons. Instead of laziness, it should be exigent towards one's own reasons. Moreover, these traits—myside bias and laziness—seem to be very difficult to correct. Smart, educated, open-minded participants all have a myside bias (Stanovich & West, 2007, 2008). Incentives—such as monetary rewards for correct answers—make no difference (e.g. Camerer & Hogarth, 1999). Teaching participants about the existence of biases can backfire, as participants easily spot others' biases while blissfully ignoring their own (Pronin, Gilovich, & Ross, 2004). Any improvement observed has been short-lived (Lilienfeld, Ammirati, & Landfield, 2009). These failures contrast with the successes that can be achieved in the correction of much more specific failures, such as misguided intuitions about the law of small numbers (Fong, Krantz, & Nisbett, 1986) or about sunk costs (Simonson & Nye, 1992).

From this quick overview of the empirical research on reasoning, one could conclude that teaching aimed at improving reasoning—such as teaching critical thinking—is both direly needed and nearly impossible to achieve. We believe, by contrast, that individualist theories of reasoning are misguided, that they have misinterpreted the empirical results, and that, fortunately, this pessimistic conclusion does not follow.

The Argumentative Theory

Individualist theories of reasoning fail to explain what the function of reasoning is. One might be tempted to dismiss this failure as inconsequential, given that what matters is how reasoning works, not what it is for. Indeed, hypotheses about the function of cognitive mechanisms are often dismissed as so many empirically untestable just so stories. Before presenting a theory of the function of reasoning, we must thus briefly defend the importance of knowing what reasoning is for, what is its function.

For Ernst Mayr, one of the foremost historians of biology,

> [t]he adaptationist question, "What is the function of a given structure or organ?" has been for centuries the basis for every advance in physiology. If it had not been for the adaptationist program, we probably would still not yet know the functions of thymus, spleen, pituitary, and pineal. Harvey's question "Why are there valves in the veins?" was a major stepping stone in his discovery of the circulation of blood. (Mayr, 1983, p. 328)

That this insight also applies to mental mechanisms was recognized early on in cognitive science. For instance, in the influential framework of vision researcher David Marr, the question of the function of a mental mechanism (the "computational level") constitutes a crucial starting point of any inquiry (Marr, 1982; see also Tooby & Cosmides, 1992).

In many cases, researchers can rely on educated guesses about the function of a mechanism—that the function of the visual system is to form an accurate and useful representation of our environment, for instance. In some cases, however, intuitions about the function of evolved mechanisms can be non-existent, or even misguided (Cosmides & Tooby, 1994). The function of stotting—when a gazelle jumps around a predator instead of fleeing from it—is not immediately apparent.

When intuitions fall short, there are two main ways forward. One is to attempt to gain a better understanding of how a mechanism works, in the hope that this might ease the task of reverse engineering—that is, inferring the function from the functioning of a mechanism. Another is to start from specific theories in evolutionary biology. For instance, the theory of the evolution of communication can help understand why stotting might be adaptive. To illustrate, it is now well understood that for communication to be evolutionarily stable, it must be beneficial for both senders and receivers: if senders do not benefit, they evolve to stop sending; if receivers do not benefit, they evolve to stop receiving (Maynard Smith & Harper, 2003; Scott-Phillips, 2008). However, the interests of senders and receivers often diverge, so that senders have an incentive to send messages that are detrimental to receivers, threatening the stability of communication. Stotting might be one of the solutions stumbled on by natural selection to solve this problem. Counter-intuitively, gazelles and their predators have one common interest: to not engage in an exhausting and pointless chase if the gazelle is going to outrun the predator anyway. It would thus be beneficial both for gazelles and for their predators if fit gazelles, those that would outrun the predators, could simply send them a signal. It is immediately apparent, however, that most signals would be abused: all gazelles, fit or unfit, would send it, and predators would not pay any attention to it. Stotting solves this problem by providing gazelles with an opportunity to display their stamina in such a way that they cannot lie: only a fit gazelle can stot energetically enough to 'convince' its predator to not bother chasing it (Maynard Smith & Harper, 2003).

Sperber and Mercier (2011b) have argued that reasoning solves a problem similar to the one solved by stotting. Human communication faces the same threats to its stability as other communication systems. In humans, what stops senders from abusing receivers is a set of cognitive mechanisms, on the receiver's part, whose function is to evaluate communicated information in order to reject harmful information and accept beneficial information. This set of mechanisms has been dubbed epistemic vigilance (Sperber et al., 2010). Two of the most important mechanisms of epistemic vigilance are plausibility checking and trust calibration. Plausibility checking compares a piece of communicated information with the receiver's prior beliefs, and tends to reject information that is inconsistent with the receiver's prior beliefs. Trust calibration keeps track of senders' records as providers of reliable information. These mechanisms, however, tend to err on the conservative side of rejecting too much information rather than too little. As a result, many messages that would be beneficial cannot be transmitted.

According to the argumentative theory of reasoning (Mercier & Sperber, 2011b), reasoning would have evolved largely by solving this problem (for other social views of the function of reasoning see, e.g. Billig, 1996; Doise & Mugny, 1984; Gibbard, 1990; Vygotsky, 1978). Thanks to reasoning, senders can provide arguments to support their messages, arguments that can be evaluated by receivers so they can decide whether to accept the message or not. By discussing and evaluating each other's arguments, people may end up accepting a point of view that they initially deemed implausible or unpalatable (Lombardi, Nussbaum, & Sinatra, 2015). To take an extreme example, revolutionary scientific theories are nearly always counter-intuitive, and they are often defended by scientists who are not yet well recognized. If revolutionary scientific theories spread, it is because scientists who defend them can put forward arguments for their new theories, and because other scientists can evaluate these arguments and recognize their strength (Claidière, Trouche, & Mercier, n.d.; Kitcher, 1993; Mercier & Heintz, 2014).

The argumentative theory of reasoning suggests that the main function of reasoning—to find and evaluate reasons in dialogic settings— is relatively narrow, at least compared to standard individualist theories, for which reasoning is seen as a cognitive panacea. However, it should be stressed that this ability to exchange arguments can, in turn, be put to a variety of uses, from finding a better solution to a problem to showing off one's smarts (on the variety of uses of argumentation broadly, see Walton, 1998; for educational settings in particular, see, Nussbaum, 2011) (see *argumentation* in Table 1). Still, on average, if the theory is correct, reasoning and argumentation should generally be used in a way that benefits both parties. Thanks to argumentation, good ideas should spread, making both those who initially defend them and those who accept them better off.

Contrary to a common misunderstanding, a theory such as this need not be a just so story (Confer et al., 2010). It can be tested empirically. Contrary to another common misunderstanding, testing such a theory does not require knowing anything about either the genetic bases of reasoning or how our ancestors reasoned. To test a functional theory, one can test for function-structure matches: Do the structure and functioning of a mechanism fit with its hypothesized function? (Cosmides, 1989; Williams, 1966). How this is done is obvious in the case of artifacts. One could venture and test hypotheses about the function of, say, a saw, without having any idea of who made it or when it was made. Is the function of the saw to cut objects or to nail objects? Compared to a range of other tools, saws are good at cutting, and bad at nailing. Moreover, a saw has design features—such as sharp teeth—that make sense if its function is to cut and not to nail, and it lacks design features—such as a flat, heavy end—that would make sense if its function were to nail and not to cut.

The example of the saw might seem trivial, but it serves well to illustrate how one can test hypotheses about the function of an artifact. The same applies to biological structures, including cognitive mechanisms. What follows is a brief primer of what experimental psychology has revealed about how reasoning works and how well it performs various tasks (for a more complete overview, see Mercier, in pressb; Mercier & Sperber, n.d.). These results will serve to bolster the argument we sketched above that the functioning and the effects of reasoning do not fit the predictions of the individualist theories, and to show that, by contrast, the functioning and the effects of reasoning fit well the predictions of the argumentative theory.

How Reasoning Works

We discussed above the main features of solitary reasoning. When people reason on their own, they mostly find reasons that support their preexisting beliefs (myside bias), and they are not critical towards these reasons (laziness). As a result, they are unlikely to revise their own beliefs, whether these beliefs are accurate or not. This is the exact opposite, both in terms of effects and functioning, of what individualist theories would expect of reasoning.

By contrast, when we adopt the perspective of the argumentative theory, reasoning's apparent flaws—myside bias and laziness—become, in communicative contexts, potentially adaptive features. If reasoning's function, when producing arguments, is to convince others, then it should have a myside bias: persuasion is not easily achieved by providing one's interlocutors with arguments for their opinion or against one's own opinion. Less obviously, laziness also makes sense if reasoning evolved to function in dialogic contexts. Finding good arguments entails anticipating counter-arguments, a difficult and effortful task. In dialogic contexts, this task becomes largely unnecessary: instead of anticipating the interlocutor's counter-arguments, one can simply let the interlocutor provide them. There is usually little cost in starting a discussion with relatively weak and generic arguments. If those prove sufficient to convince one's interlocutor, then more effort would have been wasted; if they do not convince the interlocutor, then the interlocutor will typically provide counter-arguments to explain why she was not convinced. It is then comparatively easy to address these counter-arguments or to try another line of argument (Mercier, Bonnier, & Trouche, 2016).

Note that the adaptive value of the myside bias and of reasoning's laziness in communicative contexts does not imply that these are commendable features from an educational perspective: claiming otherwise would be to conflate evolutionary and normative considerations, a mistake that Boudry, Vlerick, and McKay (2015) have termed an adaptive "locus shift." Moreover, the myside bias and laziness are mostly adaptive in the context of informal discussions. When a lawyer prepares a plea, a politician a speech, or a scientist a talk, they have strong incentives to anticipate counter-arguments and to hone their own arguments. The difficulty of these tasks in spite of the strong incentives is a testimony to the strength of the obstacles that need to be overcome (for some ways to reduce the myside bias in written argumentation, see, e.g., Wolfe, Britt, & Butler, 2009).

Both the myside bias and laziness should only affect argument production. For argumentation to be adaptive, people have to be able to reject weak arguments—argument evaluation should not be lazy—and to accept strong arguments—argument evaluation should not be biased (Trouche, Johansson, Hall, & Mercier, in press). Note that this does not mean that people should ignore their prior beliefs when deciding whether to accept an argument's conclusion—one should be less inclined, *ceteris paribus*, to accept a conclusion deemed implausible. But the a priori estimation of the plausibility of the conclusion should not affect how people evaluate the strength of the argument itself: the more independent argument evaluation is, the more informative it is (for a more refined formulation of this prediction, see Trouche, Shao, & Mercier, n.d.).

There is substantial evidence that people are good at evaluating arguments, at least when they care about the arguments' conclusion: they give more weight to strong than to weak arguments. This has been demonstrated using different methodologies and normative benchmarks. Using Bayesian models of arguments, Hahn and her colleagues have demonstrated that participants react appropriately to various features of arguments and sensibly reject fallacious arguments (for review, see, Hahn & Oaksford, 2007). Using argument schemes, Hoeken and his colleagues have shown that participants are sensitive to the appropriate properties of arguments (e.g. whether the expert, in an argument from expertise, is unbiased and an expert in the relevant area) (Hoeken, Šorm, & Schellens, 2014; Hoeken, Timmers, & Schellens, 2012; see also, Hornikx & Hahn, 2012). Using commonsensical definitions of argument quality, a vast literature on persuasion and attitude change has consistently found that participants were more persuaded by strong than by weak arguments, at least when they cared somewhat about the arguments' conclusion (for review, see Petty & Wegener, 1998). Strikingly, studies of very young children suggest that even preschoolers (including 3-year-olds) are more likely to be swayed by stronger arguments (Castelain, Bernard, Van der Henst, & Mercier, in press; Koenig, 2012; Mercier, Bernard, & Clément, 2014; see also, Mercier, 2011b).

However, some evidence also suggests that people tend to evaluate very critically arguments whose conclusion they disagree with (e.g. Edwards & Smith, 1996), sometimes to the point that such arguments would reinforce instead of weaken pre-existing attitudes (e.g. Nyhan & Reifler, 2010; Trevors, Muis, Pekrun, Sinatra, & Winne, in press). If this were true, argumentation would often be moot, as it would be unlikely to change people's minds. We claim that this evidence of bias in argument evaluation stems from a methodological confound, a failure to distinguish between an initial evaluation of argument (argument evaluation proper) and a final rating of arguments (which would be mostly guided by the production of counter-arguments) (see *argument evaluation* in Table 1).

The arguments used in studies purporting to demonstrate biased argument evaluation are never conclusive. Take the following argument:

> Sentencing a person to death ensures that he/she will never commit another crime. Therefore, the death penalty should not be abolished. (Edwards & Smith, 1996, p. 9)

Edwards and Smith (1996) found that participants who opposed the death penalty rated this argument as being weaker than participants who supported the death penalty, suggesting biased argument evaluation. However, when a participant who opposes the death penalty reads such an argument, she is unlikely to be completely swayed by her initial evaluation of the argument, an evaluation that takes place immediately as she reads it (and which constitutes argument evaluation proper). This is true even if she is able to appropriately recognize the strength of the argument. She should then proceed to what would be the normal step in a discussion: finding counter-arguments to justify her rejection of the argument. The counter-arguments that she should easily find are then likely to affect her final rating of the argument—the rating that will appear in the questions asked by the experimenters—making it appear biased (see, e.g., Edwards & Smith, 1996; Greenwald, 1968).

The difference between initial argument evaluation and the final ratings provided should be much reduced when conclusive arguments are used—arguments for which no counter-arguments can be easily found. Indeed, when people are given arguments such as the argument for the correct answer to the Bat and Ball problem, argument evaluation seems to be unbiased—which suggests that it is not argument evaluation proper that is biased, but the production of arguments that takes place after this initial evaluation (Trouche et al, n.d).

The distinction between initial argument evaluation and the final ratings provided might seem pedantic. Isn't what matters how people evaluate the argument everything considered? Undoubtedly, the results regarding biases in final ratings are important—they must be carefully taken into account when designing, for example, public health messages. However, the question of bias in initial argument evaluations is also critical. If initial argument evaluation were as strongly biased as the final ratings, then there would be little room for argumentation to change people's minds. People would reject arguments that challenge their views as soon as they are heard or read. By contrast, if initial argument evaluation is largely unbiased, then people might at least see the potential strength in arguments that challenge their views. To the extent that people are not fully convinced, they should then generate counter-arguments, but if these counter-arguments are properly addressed, then people should end up changing their mind. Thus, if initial argument evaluation is not overly biased, group discussion should have more dramatic effects than the mere exposition to arguments in the absence of a back and forth of counter-arguments.

The most persuasive evidence that people are good at evaluating arguments—in the sense of initial argument evaluation—is thus indirect: it comes from the study of group discussion. When people solve problems together, cogent argument evaluation—paired with the ability to produce arguments to defend one's side—should lead to good outcomes: the best arguments should carry the day and discussion should allow an improvement in the members' answers. The exchange of arguments and counter-arguments should help people realize the strength of arguments, even when these arguments challenge their views.

A wealth of data shows that this is generally the case. When people are asked to discuss tasks such as the Bat and Ball problem, their performance improves dramatically (Claidière et al., n.d.; Laughlin, 2011; Moshman & Geil, 1998; Trouche, Sander, & Mercier, 2014;). For more complex tasks with less definitive arguments, discussion also allows groups to converge on the better-supported answer, sometimes generating a solution superior to that of any individual member (e.g. Mellers et al., 2014; for reviews, see Laughlin, 2011; Mercier, 2011d). Of particular relevance, psychologists and education researchers have found that the argumentation that takes place when engaging in collaborative (or cooperative) learning can greatly improve on students' performance and deepen their conceptual understanding (Doise & Mugny, 1984; Johnson & Johnson, 2009; Nussbaum, 2008; Slavin, 1995). Discussion can even change minds on issues for which people are often thought to be very slow to change their minds, such as politics (see, e.g. Fishkin, 2009; Mercier & Landemore, 2012; Minozzi, Neblo, Esterling, & Lazer, 2015) or disliked health procedures (e.g. Chanel, Luchini, Massoni, & Vergnaud, 2011).

This does not mean that group discussion is a panacea. For group discussion to improve reasoning performance, there must be some disagreement: people must have different opinions, they must be able to voice these opinions, and to criticize each other's opinions. If these conditions are not met, group discussion is likely to produce disappointing results. Group brainstorming often fails to yield better results than individual brainstorming because group members are discouraged from criticizing each other (Nemeth, Personnaz, Personnaz, & Goncalo, 2004). In discussions when people agree with each other, or are afraid to voice their disagreement, what follows is polarization (Isenberg, 1986) and groupthink (Janis, 1982). The literature in collaborative learning reached similar conclusions, showing that for students' discussions to be most effective, the students should be exposed to alternative perspectives, and should feel free both to voice their opinions, and to change their mind when warranted (see, e.g., Andriessen, Baker, & Suthers, 2003).

The dependency of performance improvements on genuine debate—which requires a measure of disagreement—is expected by the argumentative theory of reasoning. When people agree with each other, they are not very critical of each other's arguments, and they do not offer arguments that challenge the consensus. The flaws of individual reasoning are only exacerbated by the addition of more reasoners.

The evidence briefly reviewed here supports the evolutionary hypothesis that reasoning evolved chiefly to serve argumentation. This evidence has been more extensively reviewed in Mercier and Sperber (2011b). Evidence from other fields also support the argumentative theory: cross-cultural psychology (Castelain, Girotto, Jamet, & Mercier, in press; Mercier, 2011a), developmental psychology (Mercier, 2011b), political psychology (Mercier & Landemore, 2012), and moral psychology (Mercier, 2011c). The theory has also been criticized (see many of the comments on Mercier &

Sperber, 2011b; as well as Darmstadter, 2013; Santibáñez Yáñez, 2012; for replies, see Mercier & Sperber, 2011a; Mercier, 2012, 2013). An overview of this work and of these debates can be found in Mercier (in pressb) and Mercier and Sperber (n.d.).

Crucially, even if human reasoning is partly an evolved mechanism, this does not mean that no improvement in reasoning is possible. Humans evolved, among many other things, to walk long distances and to talk—yet people can improve on both skills. Moreover, like so much of human-specific cognition, reasoning is also a learning mechanism; in particular, reasoning can learn which arguments work and which do not. In the remainder of this article, we offer some advice regarding how people can make the best of their reasoning abilities, and improve on them. Compared to these first sections, which rely on a wealth of convergent empirical findings, these last sections will remain more speculative.

How To Make The Best Of Reasoning?

How To Make People Reason Better In Argumentative Contexts?

Based on this brief overview of the main features of reasoning, we claim that there are two main reasons why discussion groups perform better than individuals on a wide range of tasks. The first is that in a discussion, people are exposed to arguments defending points of view different from their own. If the arguments are good enough, people can change their mind to adopt better beliefs. The second is that the back-and-forth of a conversation allows people to address counter-arguments and thus, to refine their arguments, making it more likely that the best argument carries the day.

On this basis, some simple advice can be offered regarding how to make the best of reasoning in discussion: group members should feel free to voice their points of view, and they should feel as free as possible to revise their opinions. To allow group members to freely express their position and arguments supporting their position, they should be asked to refrain from personal attacks, sticking instead to the content of each others' positions and arguments (see next section on the importance of reputational factors). To make the back-and-forth of conversation as easy as possible, group members should have the opportunity to discuss the arguments at length, and the groups should not comprise more than four or five members (in larger groups, the normal rhythm of a conversation breaks down, and smaller groups have less diverse points of views) (R. I. Dunbar, 1993). Although this advice might be trivial, we believe it is important to keep in mind, in particular when diagnosing dysfunctional groups. For instance, phenomena such as groupthink (Janis, 1982) or group polarization (Isenberg, 1986) do not reflect dysfunctional reasoning, but inappropriate group structure that results in lack of genuine dissent or lack of perceived liberty to voice dissent. As a result, interventions on the group structure should be attempted before trying to 'fix' the supposed failures of reasoning.

One facet of argumentation that might need to be improved even when the right group structure is obtained is the way people use evidence. In particular, participants have been found to rely very little on evidence not only when asked to support their positions on a range of issues (Kuhn, 1991), but also when asked to argue with each other (Jimenez-Aleixandre, Rodriguez, & Duschl, 2000). Instead of relying on evidence, participants rely on causal explanations, anecdotes, or even partly circular arguments (Kuhn, 1991). This is surprising given that arguments that rely on evidence ought to be and in some cases at least are, more convincing than other types of arguments (e.g. Brem & Rips, 2000). Following Brem and Rips, we suggest that an important factor explaining the limited use of evidence is simply its unavailability (another one being lack of trust, see below). For instance, few people would be able to cite evidence, off the top of their head, supporting their position on what makes students fail in school. When the evidence is available, people seem to be more likely to use it (Brem & Rips, 2000).

Given that many people have immediate and constant access to an immense store of evidence on their smartphones, there is hope that they will increasingly use evidence in their arguments. Indeed, if people do not already use this type of evidence, it might not be because of a failure of reasoning, but because of a failure to agree on what constitutes a trustworthy source. For evidence to carry any argumentative weight, its source must be trusted. If a speaker's interlocutor does not trust the source of the evidence the speaker might use, then the speaker is better off using other types of arguments, such as causal explanations.

A study by Kahan *et al*. (2010) illustrates the role of trust in how people take evidence into account. Participants were exposed to arguments for and against HPV vaccination, arguments that heavily relied on evidence (e.g. "Studies show that nearly 50% of sexually active Americans now contract HPV"). The arguments were either unattributed, attributed to a source who shares the political views of the participant, or to a source who does not share the political views of the participant. The weight attached to the arguments by the participants was strongly moderated by their source, such that the conclusions of arguments coming from trustworthy sources (i.e. those that shared the participant's political views) had more impact than those of arguments coming from untrustworthy sources (i.e. those that did not share the participant's political views). This effect could be explained by participants' acceptance of the evidence presented in the arguments as a function of the trustworthiness of their source (for a similar argument regarding evidence about the benefits of vaccination, see, Miton & Mercier, in press; for climate change, see, Bråten, Strømsø, & Britt, 2009; Bråten, Strømsø, & Salmerón, 2011).

The issue of trust is made particularly salient by recent technological innovations. Consider Wikipedia: although it has proven to be quite reliable (e.g., Giles, 2005), the reasons for its reliability are much less intuitive than in the case of a traditional encyclopedia (Goodwin, 2010). People fail to appreciate how the collective and to some extent uncoordinated actions of many individuals, each of them fallible and possessing limited knowledge, can produce a reliable encyclopedia. The initial distrust of Wikipedia is not unreasonable, and people will have to learn to overcome it, as they learn from experience that Wikipedia is more reliable than intuition would tell us (Flanagin & Metzger, 2011). Until there is a widespread agreement as to what online source of evidence is trustworthy, the use of such evidence in argument is bound to be restricted. This restriction might not stem from a failure of reasoning to consider potentially strong arguments, but because reasoning discounts arguments that would carry little weight if their premises cannot be accepted on trust.

How To Make People Reason Better On Their Own?

If our overview of the features of reasoning is broadly correct, the main issue with solitary reasoning is that it is biased and lazy. People are able to find arguments that they deem good enough for most of their beliefs, whether these beliefs are correct or not. By contrast, people can usually give a fair assessment of others' arguments, at least before they start reasoning on their own about these arguments' conclusion, and reintroduce bias and laziness. We presently review one of the most common methods that aims at improving solitary reasoning—namely, teaching about fallacies of argumentation—and argue that it is unlikely to be very efficient, before discussing two more promising remedies.

Teaching fallacies is not the answer. Teaching about fallacies of argumentation—the *ad hominem*, the *ad populum*, etc.—is an old tradition (for a critical review, see, Hamblin, 1970) that is still popular in argumentation and critical thinking education (Carroll, 2012; Copi, Cohen, & McMahon, 2010; Dicarlo, 2011). This teaching method could aim at improving solitary reasoning in two ways. First, it is supposed to reduce students' reliance on these fallacies in their own reasoning. Second, it could make students better at spotting these fallacies in others' arguments, and thus help them reject misleading arguments. We believe that both goals are problematic, first of all because the very concept of fallacy is problematic. Fallacies are traditionally defined in terms of semi-formal argumentation schemes. Any argument that exemplifies this scheme is deemed fallacious. For instance, "if you start eating chocolate, you will end up dying of diabetes" is deemed to be fallacious because it fits into the slippery slope scheme. Similarly, the argument "this pill works, because I took it yesterday and now I feel better" is seen as an instance of the *post hoc ergo propter hoc* fallacy.

The problem with this approach is that many so-called "fallacies" are close neighbors to forms or reasoning that are perfectly acceptable, depending on the particular context. Boudry, Paglieri and Pigliucci (in press) have developed a destructive dilemma for fallacy theory, dubbed the Fallacy Fork, which goes as follows. The first half of the fork is that when fallacies are defined in such a way that we can all agree they are wrong, then we find that they rarely occur in real life, and that even if they do, they are even more rarely effective tools of persuasion. People just do not fall for them. The second part of the fork is that when we make the definition of fallacies more flexible, to encompass more realistic arguments, then we find that we lose grip on the normative question: now there is nothing wrong anymore with the 'fallacious' arguments. For instance, the following slippery slope seems quite reasonable: "If we accept voluntary ID cards in the UK, we will end up with compulsory ID cards in the future" (from Corner *et al*. 2011). And the inference that a pill has worked may or may not be plausible, depending on your background knowledge (what is the active substance?) the plausibility of a causal link (does the pill usually help for your condition?), and the prior probability of the effect (how likely was it for me to feel better?). None of these nuances and complications are captured by the fallacy schemes as defined and treated in textbooks on critical thinking. In other words, the Fallacy Fork shows that there is no way to define a fallacy in such a way that being a fallacy could be equated with being a poor argument, while still being in touch with reality (indeed, issues with simplistic views of fallacies have long been noted by argumentation scholars, see van Eemeren & Grootendorst, 1993; Walton, 1995).

Even if argument schemes were to offer a cogent method for recognizing genuinely fallacious arguments, it is far from clear that people would be able to consistently apply this method to scrutinize their own reasons. Having the ability to recognize the flaws in an argument does not mean that this ability will be used on one's own arguments: people routinely produce arguments that they would reject as too weak if they had been produced by others (Trouche et al., in press). We do not know of evidence suggesting that the teaching of fallacies would translate into a general improvement in individual reasoning competence.

Still, one could hope that teaching fallacies of argumentation would at least allow students to reject others' misleading arguments. However, in the perspective defended here, focusing on this goal might be to some extent unnecessary, since people already seem to be quite good at spotting weak arguments when they are indeed weak, and at evaluating their strength properly (see evidence reviewed above) (Corner & Hahn, 2009; Hahn & Hornikx, 2012; Hahn & Oaksford, 2007). We cannot exclude that teaching students about more sensible approaches to argument evaluation, such as Walton's argument schemes, might produce some benefits (see, Nussbaum & Edwards, 2011). However, we suggest that the main features of reasoning that one should aim at are those of argument production, not of argument evaluation: how to overcome the myside bias and think of arguments for the other side, and of potential counter-arguments to our own arguments? We now argue that there are two main ways of facilitating the search for arguments against our position: increasing the motivation to look for such arguments, and increasing their availability.

Increasing the motivation to look for arguments that challenge our position. A natural source of motivation to look for counter-arguments to our own position is social: to avoid the reputational costs of putting forward arguments that are too easily shot down. These reputational costs vary a lot from context to context, for instance, from a philosophy seminar to an informal conversation among friends. When people realize, often through bitter experience, that some of their arguments can be easily shot down, they will be more inclined to put in the extra effort necessary to anticipate counter-arguments. This effort should result in an increase in the quality of the arguments offered. However, there is also likely to be a drawback to these reputational concerns: they might place such a high threshold on the arguments people dare to utter that many interesting arguments never see the light of day. Sufficiently heightened, such concerns might even stop people from putting forward arguments altogether.

This fear of criticism is one of the factors that make accountability a double-edged sword (see *accountability* in Table 1). Experiments have confronted participants with a variety of reasoning and decision making problems while varying the participants' degree of accountability: whether or not they are accountable, who they are accountable to, etc. (for review, see, Lerner & Tetlock, 1999).[1] These experiments have revealed that accountability can improve reasoning performance by forcing people to make sure they

[1] Note that this definition is broader than that of accountable talk (see Michaels, O'Connor, & Resnick, 2008). In particular, it does not carry the same positive connotation (for instance, accountable talk, but not accountability more generally, implies "accountability to knowledge, talk that is based explicitly on facts, written texts, or other public information", *ibid*, p.283).

have good reasons for their decisions. These experiments have also revealed that accountability can decrease performance, as accountability forces people to forgo correct choices for fear of not being able to justify them properly (see, e.g., Lerner & Tetlock, 1999).

The most problematic drawback of increased reputational costs is that they might affect some groups disproportionately. For instance, in some contexts women and minorities might be more likely to feel (rightly or wrongly) that their reputation would suffer significantly if they offered weak arguments. An increase in reputational costs could then have the effect of silencing whole groups, depriving them of a voice, and depriving the community of their perspective.

The strategy of increasing reputational costs to raise argument quality could be relatively easily implemented in educational settings; for instance, by making students read out in front of the whole class the arguments for their answers. However, the above considerations suggest that this might backfire, and that other strategies should be used: ideally small group discussion when possible, but also, if solitary reasoning is required, increasing the availability of arguments that challenge the student's position.

Besides reputational concerns, it is possible that other factors might increase students' motivation to look for arguments against their positions and to examine more thoroughly their own arguments. Honing arguments in this way can be intrinsically rewarding—this is presumably one of the reasons some people like to take part in debate teams (although the reputational concerns are also salient in this case). It should be possible to boost this type of motivation, perhaps through various pedagogical tools widely used in other contexts, such as stressing mastery goals by contrast with performance goals (see, e.g., Darnon, Butera, & Harackiewicz, 2007). More work should be done testing the efficacy of these pedagogical tools for the specific purpose of reducing reasoning's laziness and myside bias.

Increasing the availability of arguments that challenge our position.

Fortunately, there is a relatively easy way to increase the availability of arguments that challenge our position: being exposed to many such arguments. Once one has been exposed to counter-arguments, it becomes much easier to anticipate them. This should improve performance in argumentative contexts by allowing one to focus on more persuasive counter-arguments and be prepared for them. It might also improve individual reasoning performance by making one think of counter-arguments even in the absence of an immediate threat that they would be raised.

One can learn about very specific counter-arguments: for instance, being exposed to the argument in favor of neglecting sunk costs (see, Simonson & Nye, 1992). One can also learn about broader categories of counter-arguments. For example, when the results of a junior scientist's experiment are disappointing, she is likely to rationalize the failure away by invoking deficient equipment, an assistant's mistake, etc. This would allow her, on her own, to dismiss the failure of her experiment. However, most of these rationalizations get shot down with counter-arguments during lab meetings, forcing the junior scientist to reconsider her position. Senior scientists are more likely to anticipate the counter-arguments to their rationalizations and to realize on their own what the disappointing results really mean (K. Dunbar, 1995). Besides this observational evidence, several experiments have shown that students learn to argue better about a given topic—which means anticipating more counter-arguments—when they have discussed it with their peers (Kuhn, Shaw, & Felton, 1997; on similar effects obtained with dual-positional texts, see, Nussbaum & Kardash, 2005). This improvement is much stronger than that obtained through individual essay writing.

Some studies suggest that the improvement in the ability to anticipate counter-arguments and to improve on one's arguments can transfer to topics beyond those that have been discussed. For instance, Kuhn and Crowell (2011) compared two lengthy (3-years) interventions aimed at improving the quality of the arguments generated by young students in academically challenging environments. One intervention consisted mostly of standard philosophy classes on various social issues, while the other intervention was somewhat similar to having debate teams: students had to develop arguments for one side of an issue in small groups, and they then had to debate students defending the other side. The debate intervention also involved structured feedback on performance during the debates. The final assessment took the form of an essay on euthanasia, a topic that had not been specifically targeted during the interventions. Compared to the standard philosophy classes, the debate intervention allowed students to generate many more two-sided and integrative arguments. This suggests that group discussion is not only a strong way to improve on immediate reasoning performance, but also on long-term solitary reasoning performance (see also Resnick, Asterhan, & Clarke, 2013).

These two ways of improving individual reasoning—increased motivation to look for counter-arguments, and increased availability of counter-arguments—are, to some extent, mutually exclusive. In particular, when the increased motivation to look for counter-arguments is effected through an increase in reputational costs, many arguments that would otherwise have been produced will never be uttered. Sometimes it will be because the reasoner has been able to find on her own an obvious counter-argument, in which case she just saved herself some reputational costs. In other cases, however, a reasoner might forgo putting forward an argument not because she has found a counter-argument, but because she is not sure enough of its strength. Each such argument that is not uttered represents a failed opportunity to discover how people would have reacted. On the one hand, the argument might have been more effective than the reasoner thought. On the other hand, it might have been easily dismissed as feared, but if so, then at least the reasoner would have learned about the counter-arguments used to dismiss the argument. Reputational concerns might therefore reduce the availability of counter-arguments in the long run, stopping people from learning how to reason better. These reputational concerns would then become a self-fulfilling prophecy: people would be afraid to put forward arguments because they are afraid to put forward bad arguments… and because they are afraid to put forward bad arguments, they end up being unable to learn how to generate better arguments!

Still, we should not discount the possibility that an increased motivation to look for counter-arguments might arise for reasons other than reputational concerns, for instance if people realize that the anticipatory search for counter-arguments helps them achieve their epistemic or practical goals. Such a motivation would not have the downsides of the reputational concerns. More research is needed to establish the underpinnings of the improved ability to anticipate counter-arguments that has been observed to follow from argumentative practice.

Conclusion: How To Make People Reason Better?

One of the ways through which cognitive science can contribute to education research is through a better characterization of relevant cognitive mechanisms: what they are, how they function, in what environment they work best. For education in general, and critical thinking education in particular, an important cognitive mechanism to consider is reasoning. Reasoning has been defined in many ways, some very general (any inferential mechanism) and others more specific (such as the definitions offered by dual-process models). Here we defend a definition of reasoning that is narrower but, we argue, more principled than most: reasoning is a mechanism that deals with the relation between reasons and their conclusions. While not being involved in the vast majority of cognitive operations, reasoning as so defined would play a crucial role in critical thinking, enabling thinkers to provide reasons for their beliefs, to gauge the quality of these reasons, and to evaluate others' reasons.

A review of the experimental psychology literature suggests that individual reasoning has several puzzling features: it is biased in that people mostly find reasons that support their point of view; it is lazy in that people do not examine these reasons critically; and it is inefficient in that reasoning typically fails to correct mistaken beliefs. It is difficult to reconcile such features with the view that reasoning serves to improve individual cognition. By contrast, these features make sense if the function of reasoning is to argue, as suggested by the argumentative theory of reasoning. According to this theory, solitary reasoning would mostly correspond to the production of arguments aimed at convincing others, rather than the critical examination of our own beliefs. The argumentative theory of reasoning also explains why groups tend to have better reasoning performance than individuals in a wide range of tasks (provided some conditions are met): in group discussion, the biased production of arguments is held in check both by the fact that different group members are biased in different directions, and by the fact that the group members evaluate each others' arguments, accepting only strong enough ones.

On the basis of this theory, we formulate some recommendations for improving reasoning performance. Our main recommendation is simply to make people use argumentation more, in particular by creating felicitous conditions for group discussion, such as exposure to diverse points of view, ability to speak freely, etc. Given that group discussion is not always a convenient option, we also make some suggestions for improving solitary reasoning. Our first recommendation is a negative one, as we claim that teaching fallacies—a common element of critical thinking courses—might not be a great tool for this purpose. We also point out that another strategy, that of increasing the reputational costs associated with the production of poor arguments, might backfire and, by stopping some people from fully engaging in debates, do more harm than good. Our final suggestion is to expose people to arguments that challenge their position. Once they have been exposed to such arguments, people should find it easier to anticipate them when they reason on their own. They also might be more motivated to do so thereby improving solitary reasoning performance.

To sum up, our conclusion is that to learn how to reason better, people should be taught to make the best of group discussion. Although we claim that people are 'natural born arguers,' that they already possess essential argumentation skills, specific strategies can be learned to make group discussion as efficient as possible, ranging from general rules of politeness to topic-specific rules such as how to deal with scientific evidence. Group discussion not only improves performance on the problem being discussed but also subsequent solitary reasoning, through the exposition to arguments that challenge one's perspective.

The arguments presented here should resonate with, and help better understand several strands of research in education. Developmental psychology has always put on a strong emphasis on the social dimension of reasoning (e.g. Piaget, 1928; Vygotsky, 1978). Studies of cooperative or collaborative learning have shown that making students talk with each other can produce large learning gains (Resnick et al., 2013; Slavin, 1995). Moreover, the role of the confrontation of points of view and of argumentation in these gains is increasingly recognized (Henderson, MacPherson, Osborne, & Wild, 2015; Johnson & Johnson, 2009; Nussbaum, 2008; Resnick et al., 2013). Although the theory presented here is distinct from those previously advanced in the fields of development and education—in terms of how it characterizes reasoning and its function—it is consistent with this long tradition (see, Mercier, 2011b).

The numerous empirical results, from developmental psychology, education, and many other fields, showing the benefits of argumentation are all the more important because the efficacy of argumentation does not seem to be intuitively obvious to individuals. In a series of experiments, participants were given a reasoning task to complete, and then asked to estimate how many people would be able to solve this task on their own and in small discussion groups (Mercier, Trouche, Yama, Heintz, & Girotto, in press; see also, Mannes, 2009). Participants from diverse backgrounds—different cultures, different levels of experience with group decision making—thought that group discussion would yield only a small increase in performance. In reality group performance is five times superior to individual performance on this task (Mercier et al., in press). Even psychologists of reasoning, who were all very familiar with the task in hand, underestimated the improvement yielded by group discussion. The participants (experts included) thought that the chances of someone with the correct answer convincing someone with an incorrect answer lay somewhere between 50% and 75%, when the correct answer is close to 100%.

In light of these results, one of the most important messages of a course that focuses on reasoning might be the efficacy of argumentation. Fortunately, this efficacy can be easily demonstrated with simple experiments, for instance, by asking students to solve the Bat and Ball problem described above first on their own and then with their peers (for a demonstration of this experiment with college students, see Claidière et al., n.d.; for problems aimed at younger participants, see Trouche et al., 2014). There is a large amount of evidence showing that argumentation can be effective not only in simple reasoning tasks, but also in a wide variety of contexts (for references, see Mercier, in pressb). Argumentation works remarkably well. Thinking otherwise is only likely to make people frown on argumentation, making them not only poorer arguers, but also poorer reasoners more generally.

Although the potential of argumentation is well demonstrated, further research could strengthen the present claims. Different means of teaching the efficacy of argumentation could be compared: explicit teaching through the use of evidence and examples, or more hands-on teaching in which participants have to solve problems on their own and then in groups, as suggested above (and various mixes of both methods). Finally, experiments could further evaluate the effects of increasing the amount of argumentation students engage in: Do the benefits extend to completely unrelated task? How long lasting are they?

Humans are natural born arguers. Argumentation shapes the way we reason, not only when we argue, but also when we reason on our own. Substantial efforts have been devoted to reforming reason, making it more like the Cartesian ideal of the solitary reasoner. We think these efforts are unlikely to prove very efficient. Instead, we should teach people how to make the best of the abilities they have: by discussing with others who disagree. In doing so, they might even become better solitary reasoners.

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Inference. An inference is a cognitive process that takes a representation as input, transforms it—usually in an epistemically cogent manner—and produces another representation as output. For instance, an inference can take the visual representation of some physical objects as input, and produce as output predictions regarding the behavior of these objects—that an object that appears unsupported will fall, say. The vast majority of inferences are performed without any attention being paid to the reasons for which they are performed.

Reason. A reason is a representation that is presented as being logically or evidentially supportive of a conclusion. For instance, “it’s cold outside” can be presented as a reason for “you should take your warm coat.”

Reasoning. A specific type of inference that allows us to find and evaluate reasons. Reasoning bears on the quality of a reason in relation with the conclusion the reason purports to support. For instance, when someone looks for a reason that could lead someone to accept “you should take your warm coat,” or when someone evaluates the quality of “it’s cold outside” as a reason for accepting “you should take your warm coat,” they are reasoning. As a type of inference, reasoning is a cognitive mechanism taking place within the mind of the reasoner.

Argumentation. Argumentation is the public exchange of reasons meant to convince. It is enabled by the cognitive mechanism of reasoning, which allows reasoners to find and

evaluate the reasons they publicly exchange. Crucially, here argumentation does not have the negative connotation that 'argue' and 'argument' can carry of acrimonious shouting matches. The term is neutral and encompasses more or less adversarial settings, as long as the participants pay attention to each other's arguments.
Counter-argument. Here we use a very broad conception of counter-argument. A counter-argument is any type of argument that is offered as a response to a previous argument. These counter-arguments can target either the conclusion of the previous argument, its premises, or its logic. They thus encompass counter-arguments in a narrow sense and rebuttals.
Argumentative theory of reasoning. A theory positing that the main function of reasoning is to serve argumentation. Reasoning should then be geared towards two main tasks: to produce arguments in order to convince others, and to evaluate others' arguments in order to determine whether we should be convinced or not. On the whole, reasoning should serve the interests of those who send arguments, as well as those who receive them. This entails that, thanks to argumentation, people should, on average, change their mind for the best.
Accountability. To have to justify either the outcome of one's decisions, or the process behind one's decisions. Accountability has been shown to influence decisions in various ways, typically by making people take more, and different, reasons into account in their decisions.
Argument evaluation. Argument evaluation is often measured by the explicit ratings provided by people when they reflect on an argument's quality. By contrast, we use argument evaluation to refer to the immediate evaluation that takes place as one hears or reads an argument, just as the argument is being understood. We argue that explicit,

final ratings are strongly influenced not only by the initial evaluation of the argument, but also by the subsequent production of counter-arguments.

Table 1. Glossary.