inferences differ. Thus, spontaneous inferences are not limited to the social domain. When stimuli present enough clear information and constraints, both logical and illogical inferences occur (e.g., Rader & Sloutsky 2002).

The formation of "intuitive beliefs" is more complex than the target article describes. Research on spontaneous inferences (social and otherwise) can tell us much about how intuitive beliefs are formed and what they are, before reasoning proper shapes them into persuasive arguments.

Incidentally, the argument that people can distinguish good arguments from bad, based on Petty and Cacioppo's (1979) persuasion research, is completely circular. They have no principled basis for constructing good versus poor arguments; the arguments are simply pretested to have these properties.

Query theory: Knowing what we want by arguing with ourselves

doi:10.1017/S0140525X10002797

Elke U. Weber and Eric J. Johnson

Center for Decision Sciences, Columbia University, New York, NY 10027.
euw2@columbia.edu **ejj3@columbia.edu**

Abstract: Mercier and Sperber (M&S) argue that reasoning is social and argumentative, and that this explains many apparently irrational judgment phenomena. We look at the relationship between interpersonal and intrapersonal argumentation and discuss parallels and differences from the perspective of *query theory*, a memory-based model of constructive preferences. We suggest an important goal is to integrate models across inference and preference.

Mercier and Sperber's (M&S's) provocative perspective suggests that inference has adapted to a social world where argumentation is common, and that many phenomena identified as reasoning errors are not errors but adaptive when considered as inferences embedded in a social world.

We agree that inferences are often constructed when confronting a problem, and that this construction is influenced by context rather than generated by unvarying algorithms. We suggest, however, that inference construction is affected not just by social forces but also by properties of human memory retrieval and multiple goals of decision makers.

This commentary describes parallels and differences between M&S's argumentative hypothesis and a memory-based account of preference construction: *query theory* (QT). M&S cite two applications of QT as examples of reason-based choice with resulting choice inconsistencies; namely, the endowment effect (Johnson et al. 2007) and greater discounting of time during delay than during acceleration decisions (Weber et al. 2007).

However, QT is more than another example of reason-based choice. It provides *evidence* and *process-level specification* of the implicit memory-retrieval and argument-integration processes people use to evaluate choice options and demonstrates their causal role in arriving at a decision. Just as M&S unpack intuitive inference, QT treats intuitive preferences neither as a primitive (as in economics [Becker & Stigler 1977]) nor as a mysterious black box (as in social cognition [Dijksterhuis et al. 2006a]), but instead documents the cognitive mechanisms used in constructing preferences (Weber & Johnson 2006).

These are the key process specifications of QT: (1) People query past experience for evidence supporting different choice options, (2) these queries are executed sequentially, and (3) the first query produces richer representations because of output interference. This occurs because, as evidence for the first option is generated, evidence supporting other choice options is temporarily suppressed. Finally, (4) choice follows from the resulting balance of evidence. Since the order of options consideration influences the balance of evidence, it is important to know what determines which choice option gets queried first. Characteristics of the choice environment often determine what option is considered first, such as the existence of decision defaults. Like M&S, QT suggests that framing effects occur because different frames make reasons differentially available. QT finds that framing works by influencing the order in which two options are considered and thus the balance of evidence, which mediates choice (Johnson et al. 2007; Weber et al. 2007). For example, different countries have different defaults for organ donation, which changes the order in which queries pro versus con donating are considered, producing different levels of organ donation (Johnson & Goldstein 2003). Similarly the order of consideration can be affected by different attribute labels that trigger positive versus negative emotions for different choice options (Hardisty et al. 2010).

Just like the inferential processes described by M&S, QT processes operate automatically, without awareness, and are effective (though sometimes biased) products of motivated cognition. The motivation for which option to consider first makes sense most of the time. Default options currently in place were typically selected for good reasons and have not caused injury or harm. Options that trigger desire have desirable features, and options that don't trigger disgust or contempt are typically superior to those that do. Giving such options an advantage by querying arguments for their selection first is a way of making the right decision faster and with greater confidence. Both inference and preference trade off between accuracy and efficiency and confidence, though these different goals do not always work in opposite directions. Whereas argumentative goals raise confidence in one's inferences or decisions and also shorten time to reach them, the initially favored options or opinions typically have good reason behind them, and the seemingly biased inference or preference reflects mostly reasonable Bayesian priors, with perhaps some built-in conservatism.

These parallels between M&S's hypothesis and QT suggest that the purpose of argumentation is not purely interpersonal, but that implicit argument recruitment, in some outcome-biasing fashion, is also an intrapsychic process that is part of implicit preference construction. Note that Franklin's comment about the human ability to "find or make a reason for everything one has a mind to do" (cited by M&S in support of social argumentation [sect. 4.1.4, para. 1]) was prompted by his internal struggle between vegetarian beliefs and the tempting smell of freshly caught fish on a sea voyage (Franklin 1817/2006). (He justified eating the fish by recalling the observation, while watching the fish being cleaned, that it had eaten other, smaller fish.) While this is an example of conscious inference, justification, and argumentation, M&S and QT argue that such memory retrievals and inferences occur constantly and without conscious awareness to guide our actions. Few choices offer dominating alternatives, and internal conflict between competing objectives and hence choice alternatives is the norm. Like Franklin's example, many decisions also have the potential for postdecisional regret, making it important to bolster confidence that the chosen option is in fact the best one.

Are there differences between intrapsychic and interpersonal argumentation? One difference relates to one of the most crucial components of QT's sequential argumentation; namely, the process of output interference, where the first query for evidence supporting the implicitly favored, and thus first-considered, choice option temporarily inhibits arguments for other choice options, hence reducing generation of support for it during subsequent queries. This is clearly an intrapsychic process, not an interpersonal one. It is only when I generate arguments for a given action (and not when someone else does so) that the accessibility of arguments for other actions in my mind gets inhibited. To the extent that we find similar subtle biasing of choices in line with the goals of motivated cognition in group discussion and decision settings, it must be accomplished by different processes. Smith et al. (2009) suggest that interpersonal argumentation in group decisions changes goal-specific weights and not the order by which evidence is considered and thus its recall success. M&S find similar differences in implicit inference processes when inferences are made by a single individual or by several individuals in a group setting.

In summary, preference and inference tasks seem connected, among other things, by a common argumentative nature, which may suggest shared cognitive mechanisms (Weber & Johnson 2009).

Reasoning, robots, and navigation: Dual roles for deductive and abductive reasoning

doi:10.1017/S0140525X10002955

Janet Wiles
School of Information Technology & Electrical Engineering, University of Queensland, Brisbane 4072, Australia.
wiles@itee.uq.edu.au **http://www.itee.uq.edu.au/~janetw/**

Abstract: Mercier & Sperber (M&S) argue for their argumentative theory in terms of communicative abilities. Insights can be gained by extending the discussion beyond human reasoning to rodent and robot navigation. The selection of arguments and conclusions that are mutually reinforcing can be cast as a form of abductive reasoning that I argue underlies the construction of cognitive maps in navigation tasks.

Mercier and Sperber's (M&S's) theory of the adaptive value of argumentative reasoning is intriguing from a computational perspective, since the search for arguments that support a given conclusion is computationally more difficult (viewed as a reasoning problem) than logical reasoning. The first logical solvers were developed in the 1950s (Newell & Simon 1956). Argumentative computers are yet to be developed.

Argumentative reasoning, defined broadly as the discovery of statements to support a given conclusion can be cast as a form of adbuctive reasoning, or inferring a precondition from a consequent (following Peirce 1931–35). Such reasoning is logically fallacious, but as M&S's target article details, it is typical of human behaviour to select arguments and conclusions that together are mutually reinforcing.

We accept M&S's arguments for the adaptive value of argumentative reasoning as a communicative skill. However, just as questions have been raised in other fields about the evolution of the sophisticated communicative abilities of humans, we can also ask how an argumentative ability could have evolved. Many evolutionary adaptations are thought to be exaptations; that is, new uses for existing structures. Verbal argumentative reasoning obviously draws on linguistic ability, but it need not postdate it. We consider the possibility that cognitive abilities underlying argumentative reasoning may predate the evolution of language by exapting abductive abilities from other domains.

Reasoning is not the only domain where adaptive behaviour may utilise abductive reasoning. A much more ancient evolutionary ability, which humans share with other mammals, birds, reptiles, and even insects, is the ability to navigate. Much is known about the navigational systems of mammals, including the neural representations of places (O'Keefe & Dostrovsky 1971) linked into cognitive maps (O'Keefe & Nadel 1978; Tolman 1948), grid cells (Moser et al. 2008), and head-direction cells (Taube et al. 1990). Complementing neural studies are computational models and embodied robots, and it is the fully functional robotic systems (Arleo & Gerstner 2000; Kuipers 2000; Milford & Wyeth 2003; Thrun 2003) that provide insight for this commentary.

Two approaches can be contrasted for robotic navigational systems: a logically correct approach based on Bayesian reasoning (analogous to deductive reasoning), and one based on a bio-inspired approach that exploits a form of abductive reasoning to constructive a cognitive map. In mobile robots, a key problem is to maintain an estimate of one's current location while exploring and mapping a new environment (called *simultaneous localisation and mapping* [*SLAM*]).Given information about localisation (such as a Global Positioning System [GPS]), mapping is a relatively straightforward deductive reasoning problem, and conversely, given a map, localisation is straightforward. However, when both tasks must be solved simultaneously (in the absence of GPS), the errors in each compound. Many locations do not have unique landmarks; apparently unique features of one environment may turn out to be present only transiently or to be shared by other locations. Even recognising a previously visited location at a later time can be challenging. In vision-only SLAM, one of the best-performing systems is the RatSLAM system (Milford 2008), inspired by the hippocampal mapping system of the rodent. Initially developed using place cells and head-direction cells, it was discovered early on that the robots also needed something akin to grid cells (although when the model was first developed in 2003, grid cells themselves were yet to be discovered). RatSLAM learns the paths that a robot traverses through its environment and links them into maps. It uses a unique optimisation system that maintains information that is locally consistent, while also estimating a global map.

If a location is considered a "conclusion" in a mapping task, and features of the environment are considered "arguments to support that conclusion," then systems that are effective at navigation are of necessity abductive reasoners. Maps are constructed by using locations for which there is evidence, and evidence is retained when it is useful for localisation. Maps and their evidence need to be mutually reinforcing to be useful. The hippocampus has been linked to many aspects of cognition as well as spatial memory. Argumentative reasoning may well be the latest of its exapted abilities.

Some empirical qualifications to the arguments for an argumentative theory

doi:10.1017/S0140525X10002840

Christopher R. Wolfe
Department of Psychology, Miami University, Oxford, OH 45056.
WolfeCR@muohio.edu
http://think.psy.muohio.edu/home/

Abstract: The empirical research on the psychology of argumentation suggests that people are prone to fallacies and suboptimal performance in generating, comprehending, and evaluating arguments. Reasoning and argumentation are interrelated skills that use many of the same cognitive processes. The processes we use to convince others are also used to convince ourselves. Argumentation would be ineffective if we couldn't reason for ourselves.

Mercier and Sperber (M&S) are insightful in proposing a strong link between reasoning and argumentation. Understanding the argumentative context sheds light on the processes of reasoning. However, empirical research on the psychology of argumentation contradicts several of their key claims. Contrary to their position, reasoning biases are common even in the context of argumentation, the *confirmation bias* is not a feature of argumentation and actually weakens arguments, and people cling to claims less rigidly than is tacitly assumed by the authors.

M&S's review of the literature on the psychology of argumentation is surprisingly sparse. Unfortunately, the data suggest that people are subject to fallacies and suboptimal performance in generating, comprehending, and evaluating arguments. Kuhn