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Improving decision-making performance through argumentation: An argument-based decision support system to compute with evidence

Joshua Introne [a,b,*], Luca Iandoli [c,d]

[a] The Center for Collective Intelligence, Sloan School of Management, MIT, Cambridge,MA, USA
[b] Telecommunication, Information Studies & Media, Michigan State University, East Lansing,MI, USA
[c] Dept. Of Industrial Engineering, University of Naples Federico II, Naples, Italy
[d] School of Systems and Enterprises, Stevens Institute of Technology, Hoboken,NJ, USA

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ABSTRACT

While research has shown that argument based systems (ABSs) can be used to improve aspects of individual thinking and learning, relatively few studies have shown that ABSs improve decision performance in real world tasks. In this article, we strive to improve the value-proposition of ABSs for decision makers by showing that individuals can, with minimal training, use a novel ABS called Pendo to improve their ability to predict housing market trends. Pendo helps to weight and aggregate evidence through a computational engine to support evidence-based reasoning, a well-documented deficiency in human decision-making. It also supports individuals in the creation of knowledge artifacts that can be used to solve similar problems in the same domain.
An unexpected finding and one of the major contributions of this work is that individual unaided decision-making performance was not predictive of an individual's performance with Pendo, even though the average performance of assisted individuals was higher. We infer that the skills activated when using the tool are substantially different than those enacted to solve the same problem without that tool. We discuss the implications this result has for the design and application of ABSs to decision-making, and possibly other decision support technologies.

1. Introduction

Numerous studies have characterized the ways in which people fail to make rational, consistent decisions in light of available evidence. Human decision-makers make generalizations on the basis of information that is more recent or familiar, ignore a priori probabilities, and overweight data that better fits stereotypes [48]. Cognitive limitations are often assigned blame for these difficulties; given our limited capacity to process information we tend to not carry out the proper search and assessment of evidence when making an inference and opt for easier, heuristic shortcuts [4,28].

Decision support technologies can address these difficulties by allowing people to keep track of larger amounts of information, and in some cases help people evaluate their information in a consistent and principled manner by applying mathematical decision theory. Yet these systems are not without their costs; they require training to learn [36] and, in the workplace, careful integration into existing organizational decision making routines [1,8,38]. Even once such tools are successfully integrated, they can be difficult for decision-makers to trust [22].

Argument based systems (ABSs) could address some of these problems. ABSs employ a visual formalism at the interface that embodies a handful of rhetorical primitives (e.g. claim, pro, con) that may be combined to create sophisticated decision structures. Because argumentation is a process that most people use in their daily lives, argument based interfaces may be easier to understand and more transparent than other kinds of decision support technology. There is also evidence suggesting that individuals benefit from being able to reflect upon the external representation of an argument structure [37] and experience has demonstrated that ABS can be a useful tool for storing and evaluating decision information in organizational contexts [7].

As reviews of argument system research [19,34] illustrate, most investigations have focused upon the representation of arguments and role of ABSs in the decision process rather than their impact on decision outcomes. Furthermore, in many cases where ABSs have been used to support decision-making, they have been applied to "wicked" problems that have no verifiably correct answer [8,13,26,37]. These research foci have made it difficult to determine if there are concrete payoffs to using argument-based systems to support decision-making.

In this article, we seek to address this gap by comparing the performance of individuals with and without an ABS in a complex, realistic decision task with an objective outcome—predicting housing market trends. Our findings demonstrate that the ABS employed in the study significantly improves individuals' ability to make correct housing

* Corresponding author. Tel.: +1 517 432 8003.
E-mail addresses: jintrone@msu.edu (J. Introne), luca.iandoli@unina.it, luca.iandoli@stevens.edu (L. Iandoli).

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market forecasts, and that the argument maps constructed by users to solve one set of problems outperform the users themselves on another set of problems from the same domain.

However, we also find that the decision performance of users without access to the tool is not predictive of their performance with it. ABS assisted individuals achieve performance scores that are normally distributed around a mean performance level that is significantly higher than the mean performance level for unassisted individuals, but uncorrelated with unassisted performance. Because the ABS under study has many similarities to other argument platforms and some other kinds of decision support tools, our results have interesting implications for the design of decision support tools.

In the following section we provide background on the benefits and limitations of ABS. We then motivate and describe our experimental tool. Finally, we describe a study in which subjects were required to solve a decision task with the support of the tool.

2. Argument-based systems and computational decision support

It is generally accepted that the practice of formal argumentation can improve the rationality of one's reasoning process. This has led researchers to develop argument-based systems (ABS) to support the construction of arguments using visual representations called argument maps. Early ABS platforms [43,51] were faithful to formal theories of argument, such as Toulmin's [47] theory of argumentation and Walton's presumptive reasoning [52]. However, many modern ABSs (e.g. DebateGraph,[1] Rationale[2][12]) use somewhat more simplified representations, in part to address usability concerns [43].

2.1. Benefits of argument representation

Argumentation is a natural form of rhetoric that most people are already familiar with [25]. By the age of three, children can understand and apply the basic elements of argument, and children as young as seven use argumentation in their everyday life [40,41]. An interface based on these familiar rhetorical patterns should thus be easier to use than one based on more abstract mathematical formalisms like Bayesian belief networks and decision trees.

The practice of argumentation may be considered a form of quasi-logical reasoning that encourages context sensitive, grounded decision-making, and favors coherence [45], critical thinking [49], and evidential reasoning [5,30] over mathematical reasoning [47]. When embodied in a software tool, argument representations make certain types of relationships easier to see [44,46] and have been shown (with concomitant training) to improve critical thinking [12,29,46,49] and reflective assessment [29].

In decision-support contexts, ABSs may be particularly useful because they require the decision-maker to carefully articulate her rationale, and this process is considered to be an important step in many decision analytic techniques [2,38]. There is also evidence that practicing argumentation can help individuals make rigorous assessments of available information in the absence of objective statistical data [31].

Finally, argument maps can be used to build representations of domain knowledge that are easy to access and reuse [7,13,39]. Because argument maps follow a well-structured formalism, it may be possible to use them as a basis for semi-automated reasoning systems and to apply mathematical approaches to compute the relative support for the claims that are made [10,15,23]. We expand upon this point below.

2.2. Argumentation and decision-support

Despite their apparent potential, only a handful of studies have carefully examined ABS in such decision-making contexts [14,16,18,24], and there are few examples of ABS for decision support in the wild. We identify several reasons why argumentation research has focused on decision support, and argue that this is at least partially responsible for the dearth of commercial argument based decision support platforms.

From its inception, research on argumentation as a mediating artifact has focused on the structure and use of argument representations. Buckingham Shum [55] traces the idea of graphically depicting argument to John Henry Wigmore [53], who envisioned the design of a representation to capture the logic of legal argument. The embodiment of such representations was not realistic until the advent of the personal computers with graphical user interfaces. One of the earliest implemented argument platforms was the gIBIS system [6], which was created to help represent and evaluate design rationale. Such representations were novel at the time, and research consequently focused upon their design and use.

Subsequent research on argumentation has been carried out primarily within human–computer interaction and related fields and continues to focus on representational issues; the study of ABS is more commonly referred to as argument mapping,[3] reflecting this bias. This has led to theories about the role of representations in guiding cognition [44,46], and to new approaches to training rational thought [11]. However, this work has also found that argument interfaces can be complex and difficult for users to understand, and that a significant amount of training is required if one is to reap their benefits [37]. For example, Van Gelder [12] attributes success in using argument maps to train critical thinking to a pedagogical strategy called LAMP (Lots of Argument Mapping Practice), and Conklin [7] has emphasized the importance of training, technical support, and enthusiastic advocacy for ABS within an organization.

In most of this work is that the intended effect of using of an argument representation is a more rational thought process, rather than improved decision-making. Comparatively little work has sought to attach algorithms to argument structures to make decision support explicit, although there are several viable approaches (e.g. [9,15,18]), and this is a common design pattern among commercially available decision support tools (e.g. Bayesian Networks,[4] Decision Trees,[5] the Analytical Hierarchy Process[6]).

Those studies that have sought to evaluate the efficacy of ABSs in decision-making contexts have used criteria other than decision performance. Hua and Kimbrough [14] demonstrated that a decision support system for helping people construct, evaluate, and communicate arguments can help people make correct inferential statements on abstract if-then logical statements, but never tied this improvement to decision making performance. Karacapilidis and Papadias [18] evaluated their HERMES platform for medical and engineering problem solving, but only reported that users enjoyed using the tool and that they thought it was helpful. Jarupathirun and Zahedi [16] showed how a dialectical argument system can help collaborative decision makers elicit underlying assumptions when reasoning with complex problems, but they do not extend their results to task performance.

Another reason few studies report directly on decision performance is the research community's growing interest in "wicked" problems [32], which by their very nature do not present easily evaluated outcomes [8,13,26,37]. Wicked problems are more ecologically valid than the toy decision tasks often used in controlled studies, but focusing only on problems with no objective solution makes assessment of decision support technology much harder.

[1] http://debategraph.org/.
[2] http://rationale.austhink.com/.
[3] http://en.wikipedia.org/wiki/Argument_map.
[4] http://www.hugin.com/.
[5] https://www.treeage.com/.
[6] http://makeitrational.com/analytic-hierarchy-process/ahp-software.