2015

Changing Philosophy through Technology: Complexity and Computer-Supported Collaborative Argument Mapping (pre-print)

Michael H.G. Hoffmann, *Georgia Institute of Technology - Main Campus*

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NOTE: This is a pre-print version of:

Hoffmann, M. H. G. (2015). Changing Philosophy through Technology: Complexity and Computer-Supported Collaborative Argument Mapping. Philosophy & Technology, 28(2), 167-188. doi: 10.1007/s13347-013-0143-6

Please quote only the published version.

Abstract
Technology is not only an object of philosophical reflection but also something that can change this reflection. This paper discusses the potential of computer-supported argument visualization tools for coping with the complexity of philosophical arguments. I will show, in particular, how the interactive and web-based argument mapping software "AGORA-net" can change the practice of philosophical reflection, communication, and collaboration. AGORA-net allows the graphical representation of complex argumentations in logical form and the synchronous and asynchronous collaboration on those "argument maps" on the internet. Web-based argument mapping can overcome limits of space, time, and access, and it can empower users from all over the world to clarify their reasoning and to participate in deliberation and debate. Collaborative and web-based argument mapping tools such as AGORA-net can change the practice of arguing in two dimensions. First, arguing on web-based argument maps in both collaborative and adversarial form can lead to a fundamental shift in the way arguments are produced and debated. It can provide an alternative to the traditional four-step process of writing, publishing, debating, and responding in new writing with its clear distinction between individual and social activities by a process in which these four steps happen virtually simultaneously, and individual and social activities become more closely intertwined. Second, by replacing the linear form of arguments through graphical representations of networks of inferential relations which can grow over time in an infinite space, these tools do not only allow a clear visualization of structures and relations, but also forms of collaboration in which, for example, participants work on different "construction zones" of larger argument maps, or debates are performed at specific points of disagreement on those maps. I introduce the term *synergetic logosymphysis* (defined as a process in which an argumentative structure grows in a collaborative effort) to describe a practice that combines these two dimensions of collaborative- and web-based argument mapping.

Modern technology can be complex, but complexity by itself is neither good nor bad: it is confusion that is bad. Forget the complaints against complexity; instead, complain about confusion. We should complain about anything that makes us feel helpless, powerless in the face of mysterious forces that take away control and understanding.

Donald A. Norman, Living with Complexity (2011)

1. Introduction

The technologies on which the following considerations focus are computer-supported argument visualization (CSAV) tools and, as a subgroup of those, computer-supported *collaborative* argument visualization (CSCAV) tools. The idea to visualize logical relations in graphical form has a long tradition, going back at least to the ancient commentaries on Aristotle's logic in which geometrical figures were used to represent syllogisms. A later systematic approach to diagramming logical relations was developed by Leibniz, although his approach of using circles became known only through Leonard Euler's independently developed work (Euler 1768; Bochenski 1970 <1956> 24.34, 36.13-14). John Venn developed his graphical illustrations of universal, particular, affirmative, and negative propositions based on a detailed criticism of Euler's approach. After Venn, it was Charles Peirce who enlarged and revolutionized the study of diagrammatic representations of logical relations, first in his system of "Entitative Graphs," then with his "Existential Graphs" (Peirce 1909; Roberts 1973; Shin 2002). Today, other well-known examples in this tradition—among many others—include the work of the group around Jon Barwise and John Etchemendy (Allwein and Barwise 1996; Barwise and Etchemendy 1994; Shin and Lemon 2008) and John Sowa's work on knowledge representation (Sowa 2000). A more detailed history of "graphical" or "diagrammatic" representations of logical relations has recently been provided by Moktefi and Shin 2012).

While this tradition focuses on diagramming the valid inferences of classical logic on a level of abstract formality that is equivalent to that of algebraic logic, most of today's argument "mapping," "diagramming," or "visualization" tools use the term "argument" much more broadly to refer to "reasoning" or "deliberating" in general. What distinguishes them from the formal systems mentioned above is the fact that they use—besides some intuitive graphical means such as lines and arrows—exclusively ordinary language. There is no need to learn the meaning of specific symbols or icons. (To use Peirce's Existential Graphs, for example, one has to know that a circle around a statement represents a negation of this statement.) "Typically," as Tim van Gelder—one of the pioneers of "argument mapping"—writes in an encyclopedia entry on this topic, "an argument map is a 'box and arrow' diagram with boxes corresponding to propositions and arrows corresponding to relationships such as evidential support" (van Gelder 2013). Apart from this smallest common denominator, however, there are huge differences.

These differences can best be described by comparing the ontologies of argument visualization systems. Since the purpose of a CSAV tool is to *represent* "arguments" (whatever the meaning of this term might be), each of these tools can be described as a representational system. Each system, again, can be specified by a certain ontology—determining the entities and relations that can be represented by the system—and a certain set of rules which are either implemented in the software so that only specific operations are possible, or that are independently provided to the user. The rule, for example, to use only complete sentences that claim or recommend something (descriptive and normative statements)—not concepts, phrases, or questions—is typically not enforced by the software but must be learned and realized by the user.

Everything that is implemented in a software is both enabling and constraining the operations a user can perform. This means that an analysis of the rules and the ontology that is realized in a certain argument visualization tool can show fairly precisely what the underlying understanding of "argument" in each system is.[1] Argument mapping tools such as Dialog Mapping, Compendium, ClaiMapper, and Cohere,[2] for example, are based on the "Issue Based Information Systems" (IBIS) that Horst Rittel developed in the 1970s (see the history of CSAV tools in Buckingham Shum (2003) and the overview in Scheuer et al. (2010)). As this name already suggests, the main focus here is on clarifying "issues" by mapping knowledge domains or problem spaces, rather than to visualize "arguments" in the classical philosophical sense of "providing reasons for a claim" (Hoffmann 2007). Starting from an "issue," there are "positions" to this issue, and then often "pros" and "cons" to these positions. In many systems, it is also possible to add things such as "ideas," "questions," and "tasks."

IBIS-based software applications can be used very effectively, for instance, to structure oral debates of even larger groups right when they are happening. An experienced "dialog mapper" can structure an ongoing debate on a screen visible to all participants so that they can react immediately to an emerging issue map by providing corrections or further ideas.[3] This helps to keep focus on the essential points at stake without drifting away into more marginal controversies, and it facilitates the structuring of complex or controversial issues. The main focus of IBIS-based software applications, however, is the organization and management of knowledge. The UK Open University's Knowledge Media Institute, for

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[1] Unless the software does not pose any constraints on the user as in most "mind mapping" software. The concept mapping software cmap, for instance, allows the construction of differently shaped and colored text boxes that can be connected by a variety of different lines (http://cmap.ihmc.us/). The only constraint is that every line has to be named so that the user is prompted to specify what kind of relationship she wants to establish. Other than that, everything is possible so that the software's ontology does not provide any hints to the kind of "arguments" that can be represented.

[2] See Conklin 2006, Kirschner et al. 2003, Okada et al. 2008.

[3] A nice online tool for this and other purposes, http://www.bcisiveonline.com/, has been developed by Tim van Gelder's team. It belongs to a software family composed of ReasonAble!, Rationale, and bCisive (http://austhink.com/).

example, recently published the “Evidence Hub” software which is designed “to help the members of your community of practice … pool their collective intelligence” in order to promote “evidence-based decisions” (http://evidence-hub.net/; De Liddo et al. 2012). Evidence Hub is a web-based tool that allows the forming of communities across the globe and online collaboration. Its overall ontology distinguishes “key challenges, issues, potential solutions, research claims, evidence, resources, organizations, projects and people.”

By contrast to issue or knowledge presentation software, CSAV in a narrower sense starts typically with *positions* that can be formulated as either descriptive or normative statements. But even within this smaller group, there is a broad spectrum of representational expressivity. One important line of division is that between CSAV tools that allow the representation of co-dependent (or “linked”) reasons for the same claim—in contrast to independent arguments for this claim—and those that do not. Toulmin’s famous “model of argument,” for example, whose ontology includes (besides lines and arrows) exactly six entities—claim, data, warrant, backing, qualifier, and rebuttal—does not provide a means to represent co-dependent reasons (Toulmin 2003 <1958>).[4] This is crucial. Although it is always possible to combine co-dependent reasons simply in form of a conjunction that can be put into a single reason box (Peter’s tomatoes will grow because “he waters them regularly *and* they get enough light”), it is, in most cases, virtually impossible to justify such a combined reason by further arguments, because any reason provided would need to address both components of the conclusion. At the very least, it would be more “natural” and structurally easier to understand, to justify each of the reasons independently. For a graphical system, this means that co-dependent reasons should be represented separately, even though they are linked.

Another dividing line concerns the provision of templates for certain argument schemes such as “argument from expert opinion” or various “practical reasoning schemes” (the currently most comprehensive overview of 60 argument schemes has been provided by Walton et al. (2008, ch. 9), many with subforms). Argument schemes can be used in Rationale (http://austhink.com/), a commercial CSAV tool, and in Araucaria and OVA (the latter is a somewhat limited online version of the former; see http://www.arg.dundee.ac.uk/). A special case in this regard is “AGORA-net,” the CSCAV tool that we developed at the Georgia Institute of Technology. AGORA-net currently seems to be the only software tool that, on the one hand, does not allow construction of arguments without using an argument scheme and, on the other, provides only deductively valid argument schemes from propositional logic such as *modus ponens* and disjunctive syllogism. I do not plan to defend this design decision here; the interested reader might have a look at Hoffmann (2013) and the considerations developed by Cloy (2010), especially in the section “Argument Reconstruction and Proof” of his article (see also Musgrave 2012). For the

[4] The same is the case with the CSAV tools “Argumentative” (http://argumentative.sourceforge.net/) and “Argunaut” (http://www.argunaut.org/), for example.

purpose of this paper, it will be sufficient to show the differences in the example discussed below.

The last important distinction to mention here is that between computer-supported argument visualization tools, which are stand-alone applications (currently the majority), and those tools that allow collaboration on one and the same argument map from all over the globe over the internet. At the moment, these are not many. If we leave aside those tools that—like the IBIS-based systems discussed above—are built on a broader understanding of "argument" and focus more on the clarification of problems, then AGORA-net and Learning to Argue: Generalized Support Across Domains (LASAD) seem to be the only ones.[5] LASAD is designed as a tool for educational settings in which an instructor selects one of the "classical" argumentation systems (e.g. Belvedere, LARGO, Toulmin schemes), which can all be emulated by the software, and customizes it for specific disciplinary purposes such as science, law, or ethics.[6]

AGORA-net, by contrast, is designed as a CSCAV tool. It is a web-based software application that supports what I call *synergetic logosymphysis*. "Symphyestai" is Greek and means "growing together into a unity." "Logo-symphysis" is intended to refer to the growing of structures that are composed of arguments, counterarguments, counter-counterarguments, and so on. "Synergetic" means "working together" and is, thus, equivalent to the Latin "collaborative." Synergetic logosymphysis is a concept that I introduce here to describe a new practice of doing philosophy: doing philosophy in a collaborative or adversarial effort to construct a growing argumentative structure. In AGORA-net, this argumentative structure is an argument map that is stored online and shared by all who participate in the argument mapping process or have access to the map. It can grow both in synchronous and asynchronous collaboration, where "collaboration" includes also adversarial settings.

My goal in this paper is twofold: first, to show how computer-supported collaborative argument visualization—or synergetic logosymphysis—can change the practice of doing philosophy; and second, to argue—based on the cognitive effects that corresponding software tools seem to have—that this new practice should be adopted more broadly, especially in dealing with the complexity of philosophical arguments. In the next section, I will specify my understanding of the problem of complexity in some more detail. After that, I will discuss, as an example of a complex argument, Immanuel Kant's argument for the

[5] OVA, the "Online Visualization of Argument" created by http://www.arg.dundee.ac.uk, allows—according to its "user guide"—the construction of arguments online, but not collaboration of different users on the same argument map. Collaboration on "arguments" in a broader sense of the term is possible, for example, with bCisive online (http://www.bcisiveonline.com/, created by www.austhink.com), Compendium (http://compendium.open.ac.uk/applications.html, created by the Open University, UK), Debategraph (http://debategraph.org/), and in the commercial SEAS software (http://www.ai.sri.com/~seas/).

[6] LASAD is a project conducted by researchers at Saarland and Clausthal University in Germany (http://cscwlab.in.tu-clausthal.de/lasad/).

existence of an external world, focusing on three different representational systems in which the argument can be reconstructed: first, a system of numbered premises that lead, in structured textual form, to the conclusion; second, a computer-supported argument visualization tool (Rationale); and third, a computer-supported *collaborative* argument visualization software (AGORA-net).

In the Section 4 of this paper, I will compare these three representational systems with regard to their cognitive potential for coping with complexity and for creativity. The result of this analysis will be an argument for CSCAV tools.

2. Complexity

Much research on complexity refers to complex systems (e.g., Hooker 2011; Edmonds 2009; McAllister 2003). In this context, complexity is often related to computability or algorithmic complexity. Whether something is complex or simple depends on the "algorithmic information content" that is necessary to compute a certain piece of information (Gell-Mann 1994). This understanding of complexity seems to be in competition with our everyday sense of complexity according to which we contrast things that are uncomplicated and easy to understand with those that are not. The former are "simple" while the latter are "complex." These two senses of complexity—computability versus understandability—seem to conflict sometimes. As Phillip Hoffmann reminds us,

> The pioneers of artificial intelligence research at MIT were struck by the fact that tasks that appear to be difficult and complex, such as solving calculus problems, turned out to be relatively easy to do from a computational point of view, whereas things we would regard as simple and requiring little intelligence, such as tying shoelaces, still thwart even the most advanced robots. And fairly simple systems, like the handful of rules and axioms that comprise arithmetic, can generate very difficult problems like Goldbach's Conjecture (which states that every even number greater than two is the sum of two primes). (Hoffmann 2002)

However, even tying shoelaces is not always "simple" for humans, as children or people with certain disabilities can attest. Based on these examples, it might be more convincing to conceive "complexity" as a relational term. Things are not "as such" simple or complex, but only in relation to certain means or abilities to cope with them. Tying your shoelaces is "simple" when you have a device at your disposal, such as your hands, that is able to do the job, but "complex" if you have to design such a device; calculating 40,327 x 27 is simple when you have a calculator, but complex if you are not sure how to do it on a piece of paper. With such a relational conceptualization of complexity, the tension between our everyday understanding of complexity and the understanding that characterizes complex systems theory disappears. Whether something is simple or complex depends on the means you have at your disposal.

Obviously, if the degree of complexity depends on the means available to cope with it, complexity can always be decreased by improving the means. We know this from the experience of learning. Tasks that looked insurmountable when we were children become less complex when we develop the capacities necessary to solve them or the ability to find and use the most appropriate tools.

In the following, I will use the assumption of means dependence of complexity to reflect on the capacities of CSAV tools to reduce the complexity that we experience when trying to understand the inferential structure of argumentative texts.[7] Arguments can be structured in a multitude of different ways—which in itself is a problem that, although crucial for applying logic, is too seldom explicitly taught (Cloy 2010). Finding the most convincing structure is especially difficult when texts are so convoluted with additional considerations that the underlying argument is hard to identify. This is one of the biggest challenges for learners as they read:

> Unlike experts, inexperienced readers are less apt to chunk complex material into discrete parts with describable functions. They do not say to themselves, for example, "This part is giving evidence for a new reason," "This part maps out an upcoming section," or "This part summarizes an opposing view." Their often indiscriminate, almost random use of the yellow highlighter suggests that they are not representing the text in their minds as a hierarchical structure. To use a metaphor popular among composition instructors, these students are taking an ant's-eye view of the text—crawling through it word by word—rather than a bird's-eye view, seeing the overall structure by attending to mapping statements, section headings, paragraph topic sentences, and so forth. (Bean 2011)

This example of young readers underlines again that complexity is not necessarily an attribute that can be objectified, but rather a phenomenon that a certain agent or a group experiences. A text or problem might be complex for one person but not for another.

3. An example for the complexity of texts: Kant's argument for the existence of an external world

Kant considered it to be a "scandal of philosophy and general human reasoning" that the "existence of things outside of ourselves" can only be assumed "based on faith." If somebody came up with the idea of doubting the existence of an external world, philosophy would not be able to provide a "satisfactory proof" to the contrary, as he writes in the Preface of his *Critique of Pure Reason* (Kant *KrV*, B XL, my translation).

The missing proof was a serious concern for Kant because such skepticism shakes the foundations of his "transcendental philosophy." As is well-known, Kant's "Copernican

[7] In Hoffmann and Borenstein (2013), we showed how AGORA-net can also be used to cope with another form of complexity: complexity that results from what Rittel and Webber (1973) described as the multiperspectivity of "wicked problems." These problems appear to be wicked or ill-structured because the way they are perceived and addressed is often determined by conflicting values and interests. This results from the fact that in pluralist societies, in which a multitude of world views and values compete, the determination and formulation of a problem as well as the assessment of its "solution" can be controversial and open to discussion.

revolution" dissolves Hume's argument against the possibility of empirical knowledge by providing what has been called a "transcendental argument" (Stern 1999; Walker 2005; Pereboom 2009; Tetens 2004). This transcendental argument is based on a switch of perspective on the problem that is indeed "revolutionary" in the literal sense of the term. Instead of getting his teeth into Hume's argument that no empirical approach to the justification of knowledge can ever be able to solve the problem of induction—as required for the possibility of empirical knowledge—Kant simply turns the problem "on its head," so to speak: The point is not, according to him, to deduce knowledge by induction from the externally given world, but to deduce the existence of certain principles that are active when we experience something from the assumption that we would simply not be able to structure our experience—as we obviously are—if those principles would not be available to us "independently from all experience," that is: *a priori*. Since we can, for instance, explain the fact that we perceive events all the time as related by causality *only* based on the assumption that we have an *a priori* concept of causality at our disposal before any experience (this exclusive "only if" is justified by Hume's argument), we can deduce that the concept of "causality" is one of those principles that we must have available as *a priori* knowledge. This transcendental argument infers, thus, the existence of principles, on the one hand, from the uncontroversial premise that we are obviously able to experience things like causality and, on the other, from the thesis that without these principles this experience would not be possible; the principles are, thus, proven as "the conditions of the possibility of experience" (Kant CPR B 80, B 125).[8]

This transcendental approach, however, confronts Kant with a serious problem. If all experience is dependent on *a priori* principles, how can we know that these principles allow cognition and "experience, and not merely imagination of outer things" (CPR B 275)? How can we know that there is actually something out there if all experience is "constructed" or structured based on *a priori* principles? Hilary Putnam discussed the same problem about 200 years later with his famous thought experiment of a "brain in a vat" (Putnam 1981). How can we exclude the possibility that just our brain exists, and what we conceive as experiences and sensual impressions from an external world is actually produced by a sophisticated computer that perfectly simulates everything coming from the outside? The movie *The Matrix* builds an entire story around this idea. To this day, there is no final agreement whether the arguments that have been proposed against this skeptical position and for the existence of an external world are convincing or not. The debate is still going on (Hickey 2005).

[8] See for reconstructions of Hume's argument and several versions of Kant's transcendental argument the AGORA-maps "Hume's argument that empirical knowledge is impossible," "Kant's transcendental argument about causality I" and "II," "Kant's argument about Euclidean space," "… about triangles," and "… its general structure." You can find these arguments after entering the AGORA-net at http://agora.gatech.edu/ in the folder "Philosophy/Epistemology."

Kant develops his argument for the existence of things outside of us in a new section that he added to the second edition of the *Critique of Pure Reason,* titled "Refutation of Idealism." Like the demonstrations of Euclid, it starts with a "theorem" (*Lehrsatz*):

> The mere, but empirically determined, consciousness of my own existence proves the existence of objects in space outside me.

Then follows the "Proof" which is again accompanied by three "Notes," each roughly the same length as the proof. The proof (in the translation of Paul Guyer and Allen W. Wood, with some interjections from the German source) is this:

> I am conscious of my existence as determined in time. All time determination presupposes something **persistent** in perception (etwas Beharrliches in der Wahrnehmung). This persistent thing, however, cannot be an intuition in me. For all grounds of determination of my existence that can be encountered in me are representations (Vorstellungen), and as such require something persistent that is distinct even from them, in relation to which their change, thus my existence in the time in which they change, can be determined. Thus the perception of this persistent thing is possible only through a **thing** outside me and not through the mere **representation** of a thing outside me. Consequently, the determination of my existence in time is possible only by means of the existence of actual things that I perceive outside myself. Now consciousness in time is necessarily combined with the consciousness of the possibility of this time-determination: Therefore it is also necessarily combined with the existence of the things outside me, as the condition of time-determination; i.e., the consciousness of my own existence is at the same time an immediate consciousness of the existence of other things outside me.[9]

This proof remains hotly debated to this day. It is far from clear how exactly Kant's proof of "the existence of objects in space outside me" should be structured, let alone whether it is convincing. This is not the place to discuss this debate in detail.[10] For the purpose of the current considerations it is enough to quote the reconstruction of Kant's argument that has been developed by Dicker 2008 (see also Pereboom 2009):

1. I am conscious of my own existence in time, i.e., I am aware that I have experiences that occur in a specific temporal order.

[9] Kant CPR B 275-276. Note: The second and third sentence in this quote replace, according to Kant's own instructions in the Preface to the Second Edition (B XXXIX), the following sentence: "This persistent thing, however, cannot be something in me, since my own existence in time can first be determined only through this persistent thing."

[10] See the section "The Refutation of Idealism" in Pereboom (2009) for a short overview.

2. I can be aware of having experiences that occur in a specific temporal order only if there is some persisting element by reference to which I can determine their temporal order.

3. No conscious state of my own can serve as this persisting frame of reference.

4. Time itself cannot serve as this persisting frame of reference.

5. If (2) and (3) and (4), then I can be aware of having experiences that occur in a specific temporal order only if I perceive persisting objects in space outside me by reference to which I can determine the temporal order of my experiences.

Therefore, (6) I perceive persisting objects in space outside me by reference to which I can determine the temporal order of my experiences. (Dicker 2008, p. 82)

It is obvious that this representation of Kant's argument is much easier to understand than the form that Kant himself chose. What helps is the identification of clearly separable premises and the hint in (5) that some of the premises need to be combined to infer the conclusion.

Even though Dicker's structured reconstructions of Kant's argument by a set of numbered premises and a clearly identified conclusion is obviously much better structured than Kant's own text, another huge step forward regarding clarity of structure can be seen in the two-dimensional representation that is possible in the CSAV tool Rationale (Fig. 1).

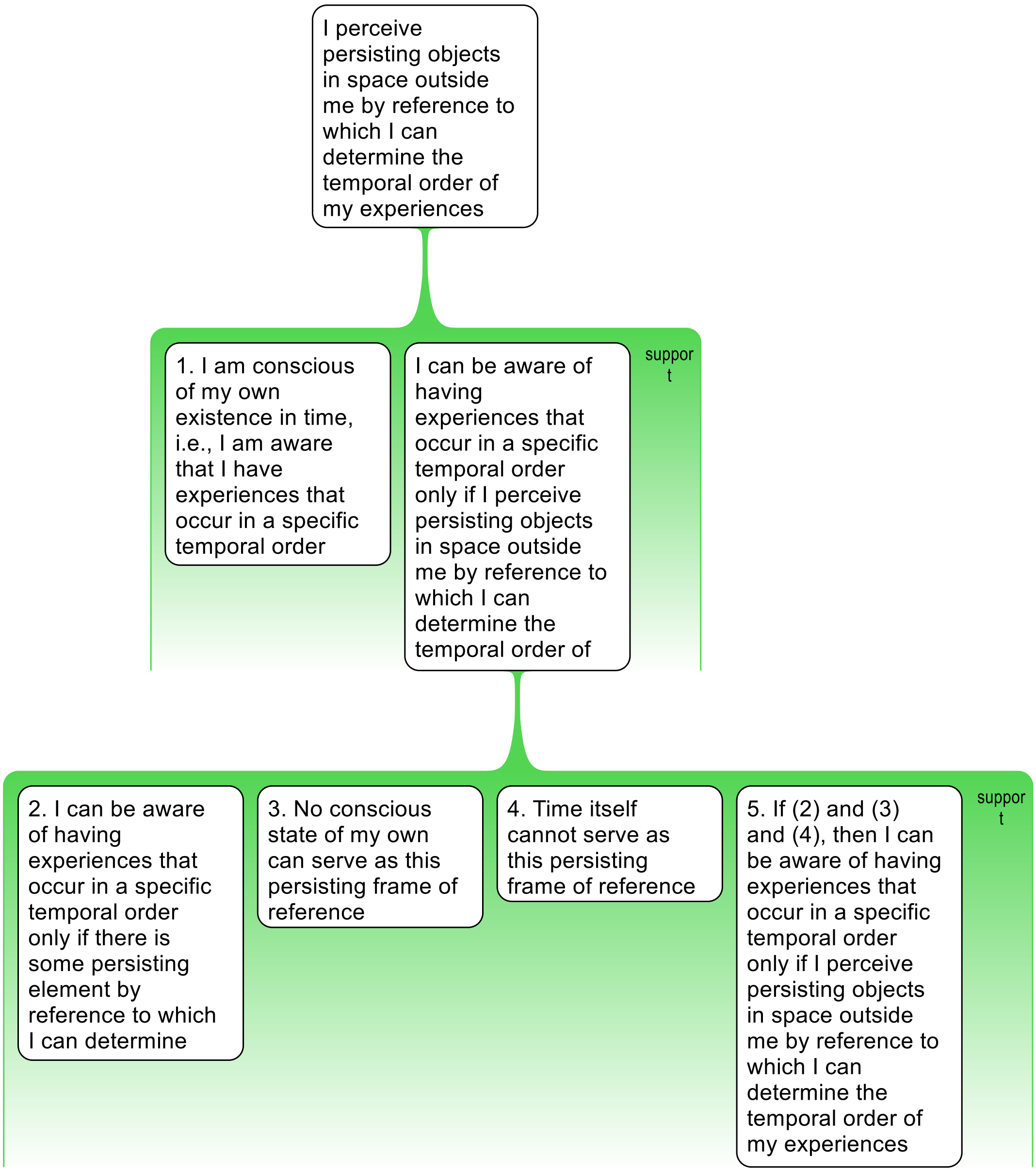

***Fig. 1**: A two-dimensional visualization of Dicker's reconstruction of Kant's "Proof" by means of the CSAV tool Rationale. The conclusion on top is justified by two co-dependent reasons in what can be called the "main argument." A second argument justifies the unnumbered premise of the main argument by four co-dependent reasons at the bottom.*

In this Rationale version of the proof, the formulations in the text boxes are the same that Dicker used in his reconstruction. The difference is that these statements are graphically arranged so that not only the overall structure of the proof becomes immediately clear, but also the relevant relations among these statements are more precisely specified. Since everything needs to be connected, there is no way that a relation could remain unspecified. For example, the user needs to make an explicit decision whether the reasons provided are co-dependent or not (the green surroundings indicate co-dependent reasons in Fig. 1).

In contrast to Dicker's reconstruction, the Rationale representation highlights three important points. First, the consequent in Dicker's conditional statement (5) can be explicitly stated as a premise of what becomes visible in Fig. 1 as the "main argument" on top (comprised of the first three text boxes). Separating this consequent out of (5) so that it becomes, at the same time, the conclusion of the argument on the bottom and a reason of the main argument on top has, secondly, the advantage that it becomes clear that just the two co-dependent reasons of the main argument are sufficient to justify the conclusion. As we can see now, this is really the main argument. And lastly, this new structure allows us to see that the four premises on the second level of reasons are sufficient to justify the unnumbered reason of the main argument. All this is not directly visible in the linear form of Dicker's reconstruction.

Now, let us compare the Rationale visualization with another one created with AGORA-net (Figs. 2 and 3). As already mentioned, AGORA-net substantially constrains the user's freedom by providing *only* logical argument schemes. This means that the user is confronted with a serious difficulty because he or she has to come up, first of all, with some creative ideas on how to translate a given argument into logical form. As we know from Robert Bjork's research about "desirable difficulties" in cognitive psychology, difficulties are actually important for learning (Bjork 2013). They engage the learner in a way that measurably improves the ability to memorize the things that are to be learned. In our case, however, the point is not memory but the stimulation of creativity. Something has to be done to cope with the difficulties posed by the software.

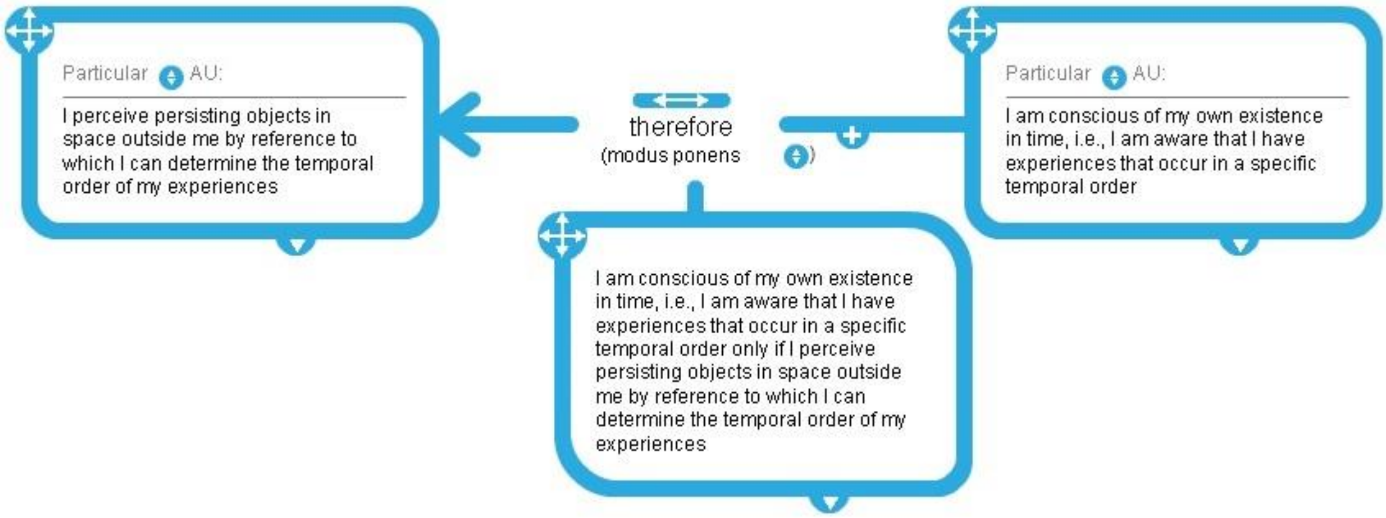

***Fig. 2**: A visualization of Kant's "main argument" on top of Fig. 1 in AGORA-net. The "enabler," that is the premise underneath the "therefore," has been automatically created by the software based on user input of the claim on the left and the reason on the right, and the selection of* modus ponens *as argument scheme and "only if" as language form. For that reason, this enabler does not have exactly the form of the consequent in Dicker's premise (5). The reason on the right is Dicker's premise (1.), and the conclusion is also formulated as suggested by him. This map can be found in AGORA-net by searching for map ID 7000.*

The fact that conclusion and premises of Kant's main argument in the Rationale reconstruction in Fig. 1 and in the AGORA reconstruction in Fig. 2 are logically equivalent shows that already the Rationale visualization of Kant's "main argument" in Fig. 1 was a logically valid *modus ponens*—implicitly, because there is no way to express this fact explicitly in Rationale. (In AGORA-net, the chosen argument scheme is always shown underneath the "therefore.") The same is the case for the second argument in Fig. 1 which is visualized in its AGORA form in Fig. 3. (Figs. 2 and 3 are of course connected as in the Rationale reconstruction. The conclusion in Fig. 3 is the enabler in Fig. 2).

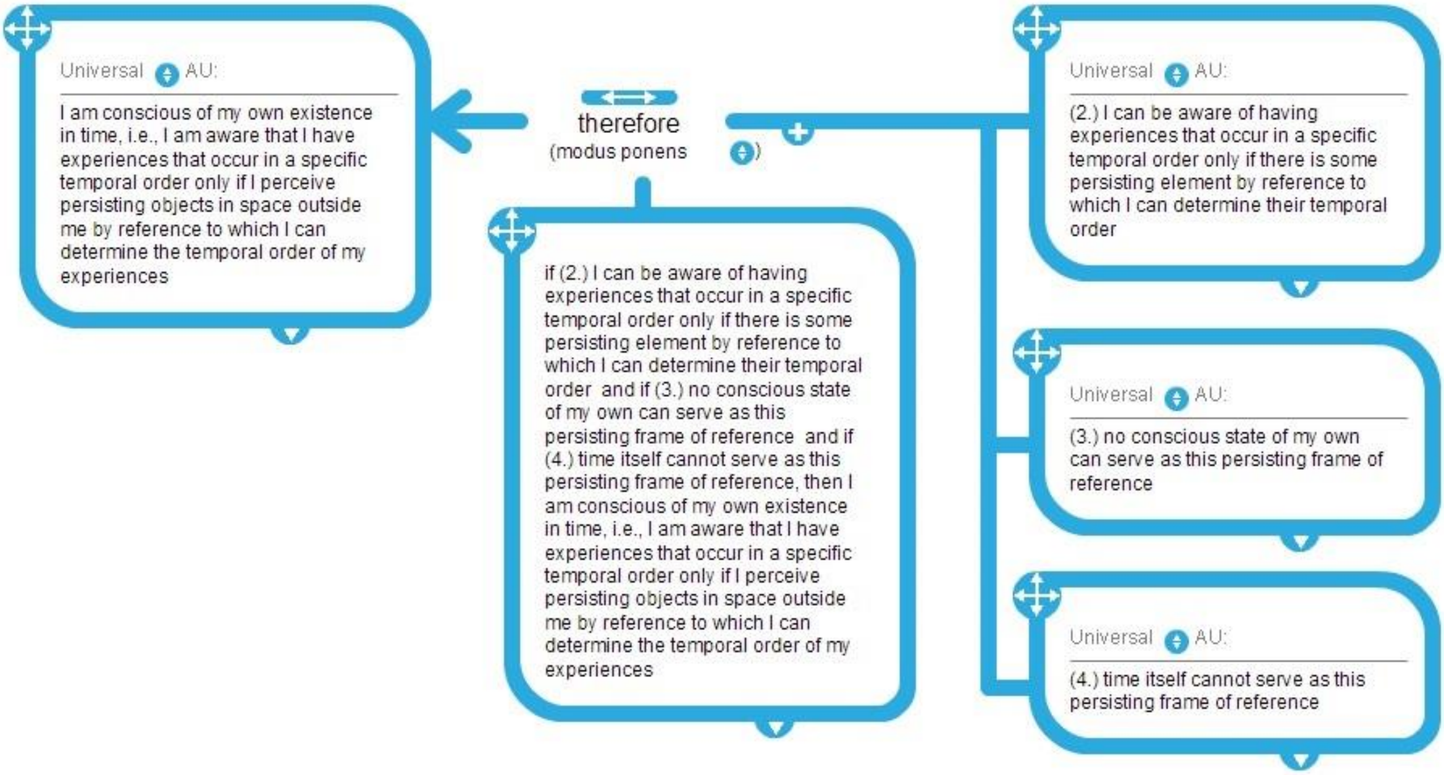

***Fig. 3**: The conclusion on the left is the enabler of the main argument in Fig. 2 which is here justified by another* modus ponens *argument. The enabler in this argument corresponds to Dicker's premise (5). (AGORA map ID 7001)*

Overall, it should be important that Kant's original argument gains substantially when we see in the AGORA reconstructions that it can be presented as a series of two connected deductions. Its logical validity is less visible in the Rationale reconstruction, and even less in Dicker's textual form.

One reason for providing only deductively valid argument schemes in AGORA-net is the hope that such a constraint on the user's freedom stimulates creativity—both in the reconstruction of given arguments and the construction of new ones. Since in a logically valid argument it is impossible that the conclusion is false if all the premises are true, the truth of all the premises needs to be carefully considered. The hope is that such a critical reflection is stimulated and guided when—as in AGORA-net—the "enabler"[11] is automatically constructed by the software based on user input. In this situation, the user should feel challenged to reflect critically on the question whether this enabler is really true and acceptable.[12]

However, the software itself does not teach the user how to build a good, convincing, and well-supported argument. And experience shows indeed that learners have serious difficulties to identify weaknesses in the arguments they construct. For this reason, the collaborative design of AGORA-net might be more important than its use of logical argument schemes. Every AGORA map can be published—either for everybody to see on the internet or in protected "projects"[13]—and everybody can add objections and counterarguments to any premise on a published argument map.[14] This collaborative—or, in this case—adversarial

[11] The "enabler"—the premise that is always located directly underneath the "therefore"—is so named because it "enables" the reason(s) provided to guarantee the truth of the conclusion, if these reasons are true and the enabler is true as well.

[12] If *modus ponens* is used, the enabler—representing a material implication—is of course true also in cases where its antecedent is false. However, since in *modus ponens* the truth of the antecedent is always affirmed in the second premise, this case is not relevant in situations where only *modus ponens* is used. More importantly—and this refers to the well-known paradoxes of the material implication—it is assumed that claiming the "truth of the enabler" is equivalent to the arguer's conviction that there is a universal, law-like relation between the components of the enabler in the sense that the reason(s) is (are) sufficient to justify the claim. "Truth," thus, remains in the eye of the beholder. But in a context in which an arguer wants to convince a possible opponent that her reason(s) justifies her claim, the conviction that all the premises are true in the sense of being acceptable is crucial. This makes it highly unlikely that somebody would claim things such as "if grass is green, then 2+2=4. See also footnote 14.

[13] Anybody can create a "project" and add the user names of others as "members." Only members have access to the maps in a project.

[14] AGORA-net realizes "defeasible deductive reasoning," that is, it is not assumed that the premises of an argument are necessarily true (see footnote 12). In the literature on "defeasible logic" (Prakken and Vreeswijk 2001), defeasibility is often indicated by inserting a qualifier such as "usually" or "as a rule" into the conclusion, or there is an additional premise such as "It is not the case that there is an exception to the rule that if P, then Q" (Walton et al. 2008, p. 366). However, the same effect can be achieved by establishing the convention that every statement is only "believed to be true" by someone whose name is connected to this statement (that is the reason why all the user-created text boxes in AGORA-net indicate the author, "AU," of statements). This convention can be justified within a pragmatist framework according to which all empirical knowledge is fallible. Whether a statement used in an argument is indeed true is less important than the question whether we can provide a justification for it, and whether our justification gets accepted. As long as nobody cares to defeat the

structure of the software allows the kind of social interaction from which we seem to learn the most. Being challenged by a real person—whose user name is always indicated in any entry on a map—works apparently better for stimulating a self-critical attitude than the fact that the software shows me which premises need to be true to get a convincing argument. If someone demonstrates to me with a counterargument why one of my premises can be criticized or defeated, I am really in trouble. Now I should ask myself whether I can reformulate either my reasons or my conclusion, or change the overall structure of my argument, to render the argument more convincing.

In this situation, the logical form of AGORA arguments is advantageous for another reason. Since in a logically valid argument the relation between reason and conclusion is made explicit in what is called the "enabler" in AGORA-net, there is always something on a map to which a counterargument or objection can be attached. Those interjections need a location to be specific, a place to connect, and such a location is always given in a logically valid argument, because in such an argument everything that is needed to necessitate the conclusion is explicitly stated.

For example, a critical reflection on Dicker's reconstruction of Kant's main argument as it is represented in Fig. 2 might lead to an observation that something is fundamentally wrong with his interpretation. An opponent could add a "comment" to the conclusion as shown in Fig. 4. (Note that an "objection"—which would appear in orange on an AGORA map—can only be added to premises that are not justified by further arguments. The reason for this design decision is that the conclusion of a logically valid argument is always true if the premises are true so that it makes only sense to object to those premises.)

reasons for claims, they can be accepted as being true. This is the essence of a dialogical and pragmatist approach to argumentation that is realized in AGORA-net (see also Pinto 2001).

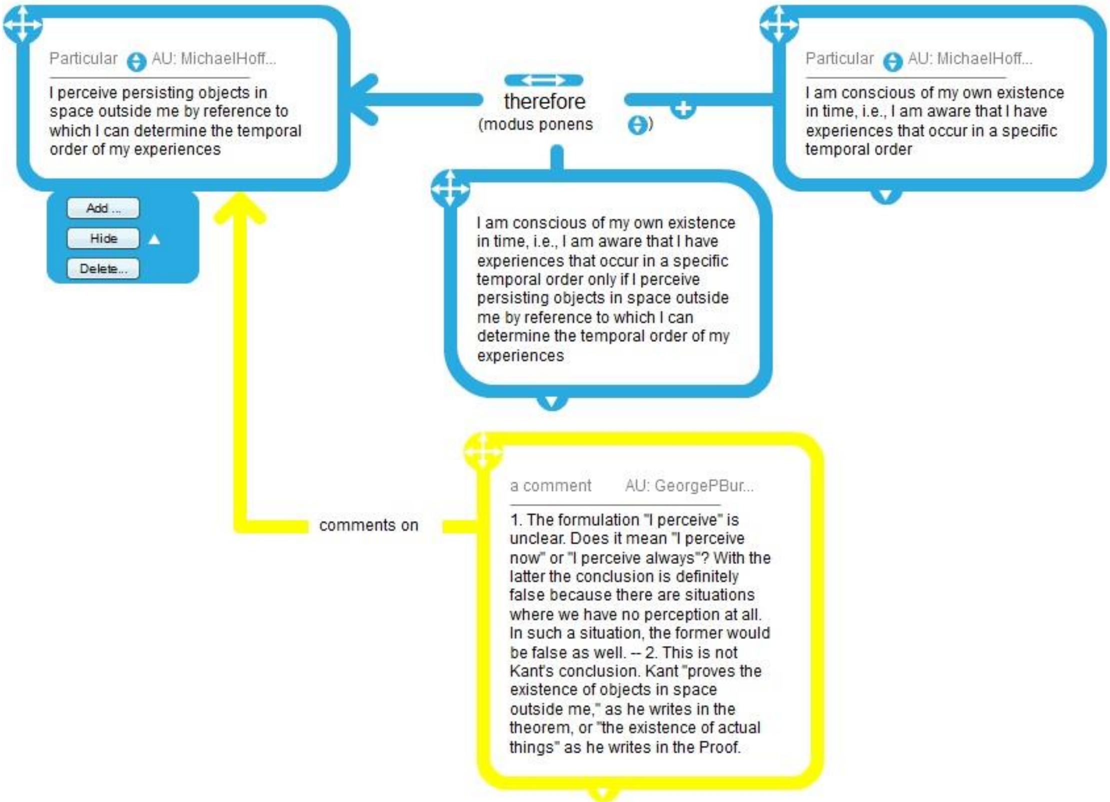

Fig. 4: *A critical comment on Dicker's reconstruction of Kant's conclusion.*

The problem in Dicker's form of the argument is that the "only if" statement that is provided in the enabler of the AGORA maps makes perfectly sense but the conclusion does not. Based on this consideration, I would represent Kant's argument differently, both with regard to its overall structure and to particular formulations (Figs. 5 and 6).

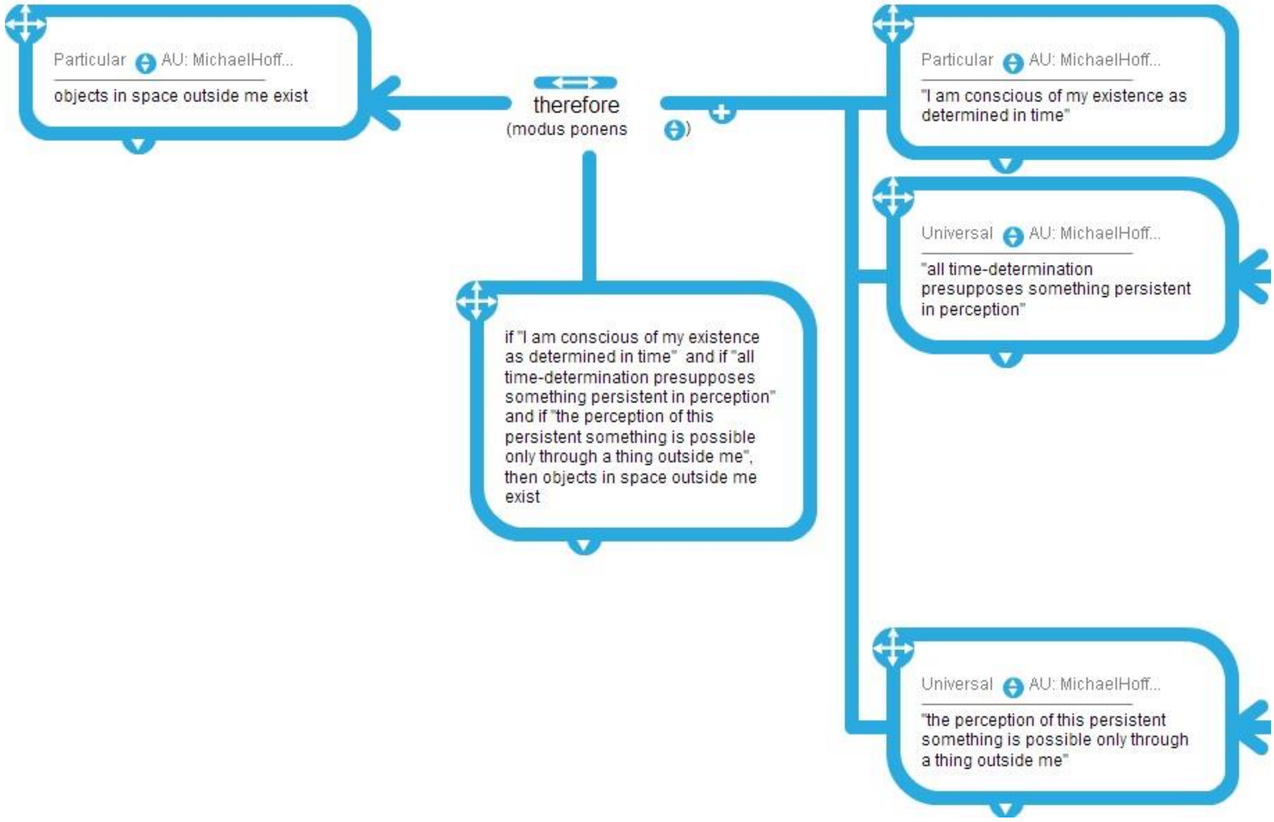

Fig. 5*: My reconstruction of Kant's main argument in AGORA-net. According to this interpretation, three co-dependent reasons are necessary to infer the conclusion (not counting the enabler). The second and third reason on the right are justified by the arguments shown in Fig. 6. Quotes are from Kant, translations of Kant's text are mine. All AGORA-maps reproduced here are also available via http://agora.gatech.edu/ (in Philosophy / Epistemology; this one and the next one are part of the map with ID 2246).*

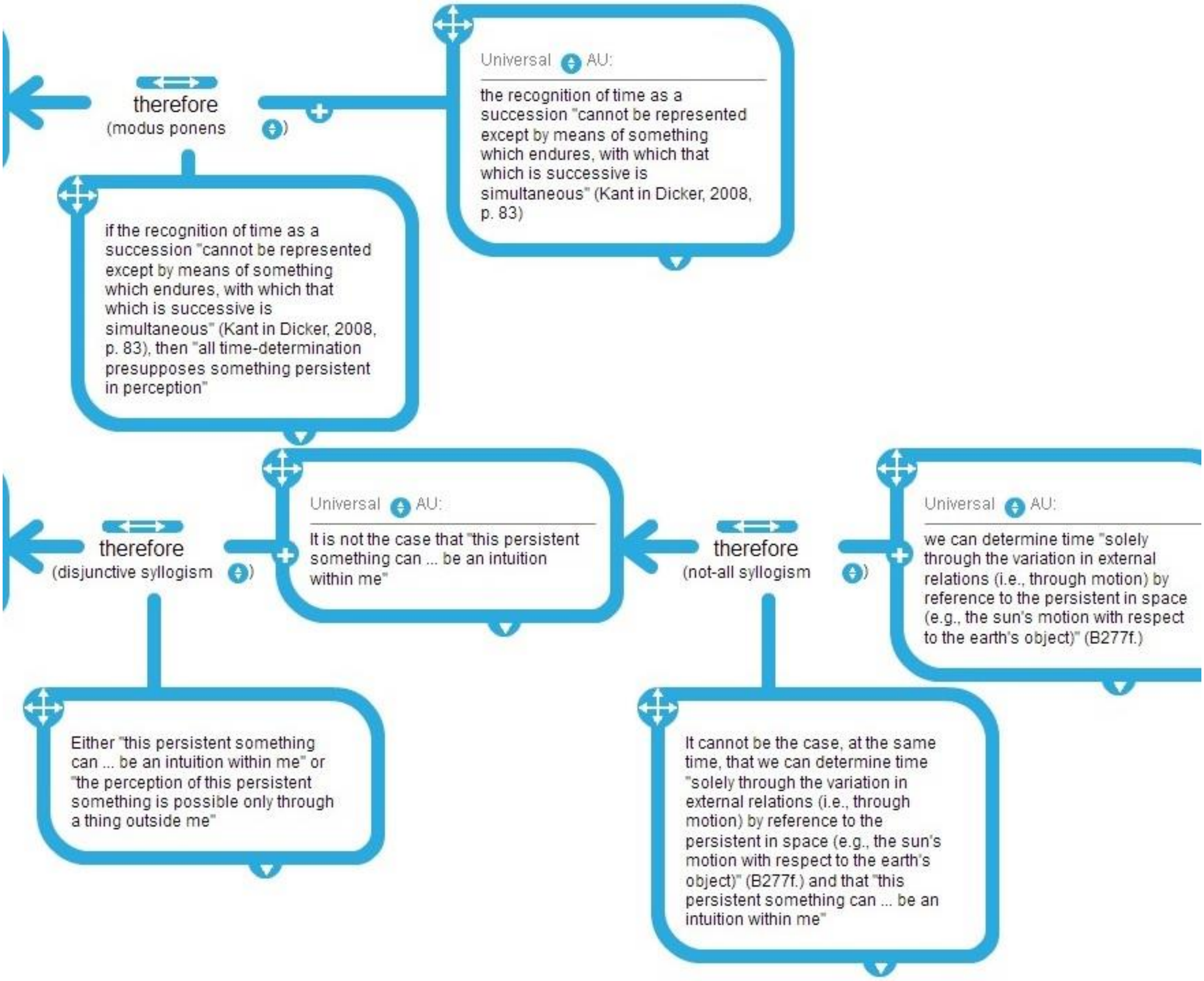

Fig. 6: *The argument on top justifies the second premise in Figure 5. The reason that I quote here from Dicker (2008) comes from a "Reflexion" in Kant's "Handschriftlicher Nachlass," 1902. The argument on the bottom justifies the third premise in Figure 5. The reason provided here stems from Kant's "Note 2" to the Proof. Text in parentheses is quoted from Kant. Translations and the selection of argument schemes are mine throughout.*

4. The cognitive potential of different representational systems

What can we learn from this distinction of three different ways to represent Kant's argument? Are there any differences that might be relevant with regard to cognitive effects of certain representational systems on our ability to cope with complexity, on creativity, critical self-reflection, or anything else? All three representational systems—the structured textual form and the computer-supported argument visualization tools Rationale und AGORA-net—aim at clarifying the structure of complex arguments by clearly separating the conclusion, the premises, and their arrangement. The graphical tools, obviously, make it easier to see the overall structure at a glance. But is this really relevant?

It seems to be relevant when we take so-called "cognitive load theory" into account. The core thesis of cognitive load theory is that the human working memory is limited: "We are unable to hold more than seven items of novel information in working memory (Miller 1956) and can probably process no more than four items (Cowan 2001)" (Sweller 2010, p. 37). These limitations are countered by a large long-term memory, for which no limitations are known, and a seemingly unlimited ability to process the content of the long-term memory without, or with only marginal, involvement of the working memory. It is assumed that information is stored in long-term memory in the form of cognitive schemas and that there are automated routines to process these schemas (Ericsson and Kintsch 1995). This means problem solving can be done unconsciously, easily, and rapidly without much burden on working memory if cognitive schemas and routines that are necessary for processing are stored and automated in long-term memory (Sweller 2010).

If we compare Dicker's reconstruction of Kant's argument in form of a structured text with the two graphical representations within the context of cognitive load theory, it seems to be obvious that the cognitive load which the linear presentation of a more complex argument poses is higher than that required to process the graphical representations (van Bruggen et al. 2003; van Bruggen et al. 2002). This can be assumed based on the fact that in linear representations relations between parts can only be represented by indices which need to be represented by symbols whose meaning must be cognitively present to understand the argument, whereas in graphical representations features such as spatial arrangement and lines can be used which should be easier to process. We are so familiar with arrangements in space and lines as representations for relations that it should be reasonable to assume that relations in the two CSAV tools can be processed by means of routines that are stored in long-term memory and do not use much working memory. Dicker, by contrast, uses indices that are represented by numbers as symbols. Of course, we are familiar with the meaning of these symbols, but to what exactly these symbols in their indexical function refer must be kept in working memory when we try to understand the structure of the argument, since the statements which the numbers represent are different in each argument.

It is already cognitively demanding to "see" the structure in Dicker's argument which distinguishes only six propositions. But this is not even a complete reconstruction of Kant's argument because some of the premises should be justified by further arguments. The reconstruction that I divide above in Figs. 5 and 6 distinguishes eleven independent propositions. In a graphical representation which distinguishes clearly between main and sub-arguments, these eleven propositions do not need to be kept simultaneously in working memory. Since each individual argument is easily identifiable by the lines that connect its components, we can simply go from one argument to the next and check it independently from the others. Obviously, the more complex an argumentation (defined here as a set of connected arguments, including counterarguments), the more significant will be the difference between representational systems with regard to cognitive load.

The first argument that we can generate, thus, from a comparison of the three representational systems is that the graphical approach of the two CSAV tools is cognitively superior because it poses less cognitive load on the user than textual representations. This should be an advantage when it comes to coping with more complex argumentations.

However, there is another feature of the CSAV tools that might be more important. Any software tool poses certain normative constraints on the user. These constraints can—and should—be designed so that the use of the tool achieves certain cognitive effects.

Normative constraints ("normative" in contrast to those that are arbitrary or changing from situation to situation) are present in every technical tool. This can easily be seen if you try to brush your teeth with a sledgehammer. It will not work as nicely as with a toothbrush. Both tools constrain the activity of brushing your teeth in a general, normative way. Similarly, it makes a difference if you are free to draw on a piece of paper whatever you want—constrained only by the physical features of pencil and paper, say—or if you are constrained by the ontology and rules that are implemented in a software application. Both Rationale and AGORA-net constrain the user's freedom by providing only a limited set of entities and rules. One rule in AGORA-net, for example, is that statements must be connected. It is impossible to place unconnected statements on the canvas. This, obviously, has the cognitive effect of challenging the user to consider everything in relation to something else. And this relation itself is always specified, by terms such as "therefore," "objects to," "comments on," and so on. This way, the attention of the user is always directed at very specific relations.

It is important to note that ontologies and rules of representational systems do not only constrain the set of available operations, but that they also enable certain activities. For example, the option to distinguish clearly between arguments with co-dependent reasons and independent arguments for the same claim that is available in both CSAV tools discussed here motivates a deliberate reflection on a distinction that is usually not even visible in ordinary language. A similar potential is given by the argument schemes that are provided by Rationale and AGORA-net. They invite the user to take several distinctive options to structure arguments into account. A further potent cognitive effect of all graphical argument visualization tools is that they force the user to distinguish clearly between a main argument and further sub-arguments that justify given premises.

Another very specific constraint in AGORA-net is given through its limitation of expressional means to logical argument schemes. In a logically valid argument, a statement is not only justified by one or more reasons, but also by an additional premise—the enabler in AGORA-net—that represents the relationship between the reason(s) and the conclusion. Reflecting on the acceptability of the enabler allows the identification of weaknesses in an argument and promotes, hopefully, its improvement. Since there is no argument without an enabler in AGORA-net, there is always a place, a location on an argument map, where such a reflection can—and should—"take place."

The significance of this feature can be shown with regard to the disjunctive syllogism at the bottom of Fig. 6. In this reconstruction, I am using a disjunctive syllogism to represent what Kant develops in the first lines of his "Proof" when he writes:

> I am conscious of my existence as determined in time. All time determination presupposes something persistent in perception. This persistent thing, however, cannot be an intuition in me.

It is clear that Kant—in order to demonstrate that the existence of external objects is indispensable to explain the possibility of our common experience "as determined in time"—needs to exclude the possibility that the "persistent thing" necessary for time determination is "an intuition in me." If it could be something "in us," then no external objects would be necessary. This argument, however, is only strong and convincing if there are, indeed, only these two possibilities: "Either," as the enabler in the disjunctive syllogism in Fig. 6 states, "this persistent something can ... be an intuition within me or the perception of this persistent something is possible only through a thing outside me." Dicker, by contrast, argues—implicitly—that there is a third option. He suggests, thus, to improve Kant's argument by adding what he counts as premise (4) in his reconstruction: "Time itself cannot serve as this persisting frame of reference."

So the question is whether Kant simply missed something that should be added to his argument or whether he deliberately did not mention Dicker's third option. In AGORA-net it is easier to discuss this question than in either Dicker's reconstruction or in Rationale because the enabler—which is clearly visible in the AGORA-map when we reconstruct this part of the argument as disjunctive syllogism—presents a distinctive location at which this question must be decided. This enabler is either convincing or it should be amended. Now, I think this enabler is perfectly acceptable. The reason is that time—as an "a priori form of intuition"—could never be a "persistent something" for Kant. Time simply is not a "something"—be it persistent or not—at which we could look as though we are looking at the "starry heavens above" or anything else.

This reflection on the cognitive potential of certain enabling and constraining features that can be implemented in computer-supported argument visualization tools, but not in tools that we usually use for the textual representation of arguments, leads to a second argument in favor of CSAV tools. These tools are superior because they can be designed so that they, first, direct the user's attention in certain advantageous directions and, second, prevent operations that should be avoided, such as claiming something that is not connected to anything. It is, to be sure, an open question what exactly makes a good or optimal system of constraining and enabling software features. But it should be clear that the possibility alone to design such a system is advantageous.

A third and last argument focuses on *collaborative* CSAV tools in contrast to noncollaborative ones. Based on the comparison of Rationale and AGORA-net in the previous section, I would argue that collaborative tools are, in general, superior to stand-alone software applications.[15] This claim can be justified by the following reasons.

First, as already argued above, critical reflection on one's own argument can be effectively stimulated by objections and comments provided by other people.

Second, collaborative argument visualization tools allow debate as part of the argument construction process. In AGORA-net, for instance, any premise that is not justified by another argument can either be countered by a counterargument or defeated—if it is a universal statement—by a counterexample. These two sorts of objections can again be attacked by counter-counterarguments, and so on.

Third, the possibility of debate as part of the process of argument construction should lead to better arguments, and to a better understanding of the problem an argument is about. Objections by other people might illustrate perspectives on the problem that the creator of an argument did not see before. Additionally, if I am not able to counter those objections, their existence should challenge me to revise either the conclusion of my argument or the entire structure of an argument or argumentation.

Fourth, the possibility of online collaboration on argument maps allows a fundamental shift in the practice of arguing in philosophy and other disciplines. We are all familiar with the four-step process of developing arguments in texts, publishing these texts, reading other texts that react to our arguments, and new responses. This recursive process is not only time-consuming, but also a process that is characterized by a clear separation between individual and social activities. Papers and books are written by individuals or, usually, small groups of authors, while social exchange happens at conferences, in seminars, and in person-to-person communication.

As in "open source" software development where individuals and groups from all over the globe collaborate on the creation of freely available and openly shared software (Raymond 2001), it is possible to supplement or replace this traditional method of arguing—and of knowledge production by arguments—by a process in which these four steps happen virtually simultaneously and the individual-social divide is largely overcome by synchronous and asynchronous collaboration on argument maps over the internet. Everybody, for example, can "Enter the AGORA-net" at http://agora.gatech.edu/, go to "Philosophy," then "Epistemology," to find several versions of the Kantian argument that I presented in the previous section. Registered visitors can add objections and comments to particular statements, are able to provide additional arguments, and can copy entire argument maps by clicking on "Save map as" to completely revise them. This way, it is possible to move large parts of the academic debate about the most convincing structure of Kant's argument—and any other argument—online. It is possible to provide feedback immediately from all over the

[15] The only exception to this rule I can think of concerns the possibility of vandalism on published argument maps. Vandalism happens in many online settings, for example online games (Smed et al. 2002).

world, to learn from others' input, and to improve arguments in either collaborative efforts or adversarial competition.

A fifth reason for the superiority of collaborative argument visualization tools is that they support division of labor in complex projects. The potential of collaborative argument mapping on the web could be interesting especially for large-scale collaboration among experts who need to connect compartmentalized areas of expertise. John Hardwick famously described—under the heading of "epistemic dependence"—the development of a 3½ pages long journal article in particle physics that has been published by 99 authors after a series of experiments that were performed in five geographically separated groups. Many authors of an article such as this one, he writes, "will not even know how a given number in the article was arrived at," and there would be no point for a single author to understand all the details because in the time that it would take the results will probably already be overturned by new research (Hardwig 1985, p. 347). For a publication, however, all the justifications that are provided by a variety of fields must be connected in one consistent and clearly structured argument. To achieve this goal, it should be helpful to collaboratively develop such a structure in web-based argument maps. If the overall structure of an argument is agreed upon, then the efforts of all the contributors can be compartmentalized.

A sixth and final reason to be mentioned here is that collaborative tools allow us to identify and clearly localize all the areas of disagreement in an argumentation, in contrast to those areas where there is consensus.

5. Conclusion: Changing the practice of philosophy by collaborative and adversarial argument mapping

Computer-supported collaborative argument mapping on the internet can, as I tried to show in this paper, change the practice of doing philosophy in a variety of ways. The graphical structure of argument "maps" that can be developed in a virtually infinite space can improve philosophical reflection by supporting efforts to cope with complexity.[16] If we conceptualize complexity as the experience of feeling overwhelmed by a multitude of ideas, data, knowledge, assumptions, and so on that are not well structured, then argument mapping can be seen as means of empowerment. Tools that challenge users to focus on inferential relations between statements and the overall structure of complex argumentations, and that help them to develop those relations and structures, promote reflection on these crucial components of rationality. These tools cannot only change philosophy, but they also have the potential to contribute to human flourishing in general. The visualization of networks of justifications can facilitate deliberation and rational communication.

Furthermore, software tools that are designed for collaboration can substantially change communication and workflow. By overcoming boundaries of space and time and those

[16] The "monstrous waste of space" (Moktefi and Shin 2012, p. 656), that Ernst Schröder criticized in Frege's "conceptual notation" for predicate logic in which symbols are spatially arranged is no longer a problem when, as in AGORA-net, the available space is really infinite.

between individual and social activities, argument mapping on the internet can foster more collaborative modes of knowledge production and exchange. Tools such as AGORA-net provide an online infrastructure in which everybody can develop arguments for positions, recommendations, or theses, or can contribute to debates with further arguments or counterarguments.

There is also the possibility of a more fundamental shift from the publication of individual "contributions" into the direction of a collective development of arguments that are available in a "World-Wide Argument Web" (Rahwan et al. 2007). I introduced above the notion of synergetic logosymphysis to describe a process in which an argumentative structure grows in a collaborative effort. To a certain degree, this concept puts the growing argumentation in the center of attention, in contrast to individual contributions. Instead of keeping the familiar individualistic perspective that perceives cognition as centered on an individual—and software tools as "augmenting" human cognition (Engelbart 1963)—synergetic logosymphysis can stand for a shift to the growth of knowledge itself; a growth to which individuals contribute in an auxiliary and serving role.[17]

All this should support the hope that well-designed collaborative argument mapping tools can improve reflection, communication, and collaboration, thus changing the practice of doing philosophy.

Acknowledgements

This research and the development of the AGORA software described here is supported by a grant from the U.S. Department of Education (FIPSE Grant P116S100006). The AGORA project is part of a collaboration between the Georgia Institute of Technology and Bauman Moscow State Technical University. Many thanks to Bryan Norton, Nancy Nersessian, Justin Biddle, and two anonymous reviewers for feedback that helped to improve this paper.

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[17] One of the anonymous reviewers of this paper notes correctly that the "compartmentalization" that is possible in collaborative argument mapping would lead "to a serious problem of authorship in philosophy: who has written the final text in the end?" The notion of synergetic logosymphysis is indeed intended to signify a shift away from the idea of authorship.

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