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# Explicating and Negotiating Bias in Interdisciplinary Argumentation Using Abductive Tools: PAPER

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**Abstract:** Interdisciplinary inquiry hinges upon abductive arguments that integrate various kinds of information to identify explanations worthy of future study or use. Integrative abduction poses unique challenges, including different kinds of data, too many patterns, too many explanations, mistaken meanings across disciplinary lines, and cognitive, pragmatic, and social biases. Argumentation tools can help explicate and negotiate bias as interdisciplinary investigators sift and winnow candidate patterns and processes in search of the best explanation.

**Keywords:** abductive reasoning, applied argumentation, argumentation tools, cognitive bias, disciplines, inference to the best explanation, inquiry, integration, interdisciplinarity, philosophy of science

## 1. Introduction

Successful interdisciplinary inquiry requires integrating various kinds of information to generate several alternative explanations and then deciding which one is best (Hall & O'Rourke, 2014). The main reasoning task here is making inferences to the best explanation, which in this paper I equate with abductive reasoning (Douven, 2011). Integrative abductive reasoning is especially tricky given the diversity of data and perspectives available for making inferences. Several tools have been invented to assist interdisciplinary inquiry, but none of them focus on the core task of abduction. This presents an interesting and fundable opportunity for argumentation theorists and tool developers. I hope to inspire new work with the following sketch of how abductive reasoning manifests in interdisciplinary inquiry and how tools can enhance it.

I am an interdisciplinary investigator myself, and I realize many of you are argumentation theorists. I am probably going to run roughshod over your excellent and nuanced work on theories of abduction, and I apologize. But in exchange, I am offering a street-level view of abduction-in-practice that harnesses insights from measurement theory, social psychology, and cognitive science. Together I believe we can sharpen the following sketch to do some excellent work.

## 2. Abduction in practice

I'll begin with a story of abduction in a single discipline and then apply this abductive model to an interdisciplinary case. About six years ago, I began a research project in forest hydrology. The data had already been collected, and my task was to calculate what fraction of forest precipitation escaped every year through evaporation versus transpiration (which is when trees exhale water vapor). But when I ran the calculation, the answer came up positive—as if there was no loss of evaporated water but rather a gain! I looked for a plausible explanation: were my calculations wrong? I checked for errors: None. Were my assumptions wrong? I checked my inferences: Solid. Was there in fact an addition of evaporated water? I returned to the basic theory of isotopes and discovered a possible mechanism that had never been reported in this type of forest, so no one had ever bothered to look for it! After I developed this alternative explanation, my

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collaborators and I ran calculations and arguments that reproduced the observed positive answer and other graphical patterns in the larger dataset. The paper was published last November entitled, "Stable Water Isotopes Suggest Sub-Canopy Water Recycling in a Northern Forested Catchment" (Green, Laursen, Campbell, McGuire, & Kelsey, 2015).

This is a classic case of inference to the best explanation, and here are the three phases I see in the process:[1]

1. **Pattern recognition**—There was a pattern of positive gains in certain isotopes. There were other patterns, too, but I decided this was the most interesting and potentially fruitful pattern to explain.
2. **Process imagination**—I imaged many different scenarios that could explain the pattern, e.g., I had made a mistake, violated an assumption, etc. Every time I formulated an option, I checked its viability with a pattern match.
3. **Pattern matching**—In thought experiments, each proposed explanation not only reproduced the pattern but also a host of other inferences that I could check against my data and findings from other studies. Only the recycling explanation produced inferences that matched our data and other existing findings.

In summary, I first noticed a hint of a small pattern and generated many potential explanations for it. To winnow these down to the best explanation, I extended each explanation into a thought experiment and compared the results of these experiments with the existing data. The option that could explain the larger patterns was considered the best explanation, worthy of future study.

At each of these three phases, I had tools that helped me accomplish the task at hand. In pattern recognition, I used data visualization tools, inferential statistics, and simple algebra. Process imagination was more fun: I used concept mapping and drawing to assist my wide-ranging readings and discussions with collaborators. We had fewer tools for pattern matching, though: my collaborator tried using a quantitative model but there was still too much uncertainty so we relied upon defeasible arguments. Our arguments depended upon plausible but unconfirmed circumstances. So even in this disciplinary case, we see an opportunity to develop more helpful abductive tools, especially for the pattern matching phase.

Now, I'll complicate this model by showing how it works differently in interdisciplinary inquiry. About five years ago I started an interdisciplinary Master's degree studying social-environmental systems. For my thesis, I collected social network data about expert's information sharing patterns; observations of their interactions in meetings; interviews about their management roles; and observations of the physical landscape. My task was to evaluate expert's capacity for managing their landscape sustainably. So, I was combining theories from forestry, social network analysis, governance, and resilience, and I was combining several kinds of data. I spent weeks finding many different patterns in the data and agonizing over which were important to explain. I settled on a pattern showing a rigid division of information and collaboration between forestry and agriculture experts. But there were many viable ways to explain this pattern: certain network measures predicted others; the landscape topography lent itself to this division; some experts had been there longer than others; the governing committees played power games; and a historic policy event got the ball rolling. How was I to infer the *best*

[1] Explaining exactly how these three phases correspond to existing theories of abduction remains an important future project.

explanation among these? Rather than choose only one, which would have reverted to a disciplinary approach, I developed a story that integrated most of them. The story showed how one of these key explanations caused each plot twist and in the end yielded the observed division between forestry and agriculture. My committee gave me my degree, and my community stakeholders found new ways to think about their self-governance (Laursen, 2013).

Despite noticeable differences from my hydrology work, the same basic features of abductive reasoning could be applied to my interdisciplinary experience. To recap, once I had my data, I went through three phases:

1. **Pattern recognition**—I found lots of patterns! And I had to choose one to explain.
2. **Process imagination**—There were a lot of candidate explanations because there were many processes happening at once. An interdisciplinary approach does not consider every alternative explanation to be mutually exclusive. Rather, the belief is that each reveals something true and important about the system. So I integrated a single explanation in the form of a story.
3. **Pattern matching**—I told the story in a way that each plot twist was plausible and ultimately yielded the pattern I was trying to explain.

Here as before, I had tools that assisted me with each phase. In pattern recognition, I used network visualizations, qualitative coding software, and inferential statistics. Also, a theory of change exercise (Center for the Theory of Change, n.d.) showed me a gap in my reasoning that helped me choose which pattern to explain.[2] During process imagination I almost drowned in possibilities but found my way out using concept mapping and storytelling. Pattern matching relied upon storytelling as a form of argument.

## 3. Challenges for abductive reasoning

My reasoning in this project did not go as smoothly as in the hydrology project, and I'm convinced it was because I needed abductive tools more amenable to interdisciplinary work. My story highlights several challenges unique to integrative abductive reasoning that tools could support.

**1. Different kinds of data.** Interdisciplinarity brings many kinds of data together, and these data are generated from different disciplinary theories and methodologies. Data collection can be like going to the supermarket, and data analysis can be like trying to compare apples and oranges. At the supermarket, the cashier uses the same scale to weigh all produce. Some tool like that is needed to bring different kinds of data into conversation with each other in interdisciplinary inquiry.

**2. Too many patterns.** If data are brought into conversation, the number of possible patterns increases exponentially with the number of kinds of data. Moreover, just as with comparing apples and oranges, the patterns one notes depend on what one is looking for. Interdisciplinarity provides many different perspectives on a problem. Thus, for every possible combination of data, there is also a combinatorial set of ways to examine it for patterns. Each lens is partial. The total search space is vast, and yet each investigator can only see part of it,

[2] A theory of change exercise asks one to write down every step in a causal chain of reasoning. It was developed to help social entrepreneurs articulate their ideas for a social intervention.

creating a huge logistical problem that often manifests in communication, epistemic, and cognitive errors.

3. **Biased choice of which pattern to explain**. Which pattern is eventually chosen for further study depends on the negotiation of the various cognitive, pragmatic, and social values each investigator brings to the project (Eigenbrode et al., 2007; Hall & O'Rourke, 2014). In my case, I chose based on theoretical principles, utility of the findings to stakeholders, and ease of analysis. Not everyone would have chosen the same way I did. And looking back, I didn't fully explicate my value choices at the time, and I had a hard time choosing because of that.

4. **Too many processes**. Even after a pattern is chosen for further explanation, multiple perspectives on this pattern can yield a seemingly infinite number of possible processes that could explain it. This recreates the problem of too much information we had solved earlier with our evaluative choice to focus on only one (or a few) patterns. Moreover, each imagination is partial; each process is only part of the story, chosen for its salience to the storyteller.

5. **Biased choice of which process(es) to test**. The few that get tested for a pattern match are chosen, again, based on a variety of values that must be negotiated. For instance, I may favor the simplest process, or the one with the most external evidence, or the one that provides leverage points for action.

6. **Biased choice of which process counts as a best explanation**. Likewise, interdisciplinary investigators must negotiate a range of cognitive, pragmatic, and social values when choosing which explanation is the *best* explanation for that pattern. At this point, investigators are pretty exhausted from all the sifting and winnowing, and they are unlikely (as I was) to take the time to explicate these value choices; indeed, convenience bias is a real threat at the stage of pattern matching.

In addition to these challenges unique to interdisciplinary work, there are also challenges common to abduction in all forms of inquiry that nevertheless manifest in unique ways when working across disciplines.

The first of these is run-of-the-mill cognitive bias. Cognitive psychologists have named at least a dozen kinds of bias, with more posited every year. I will cover only a few here to exemplify the lot. Convenience bias, mentioned above, is the human tendency to mistake what is easy for what is true (Kahneman, 2011, pp. 59-72). The anchoring effect occurs when we fail to consider the entire search space for the optimal solution and instead satisfice with a local maximum anchored near our starting point (Kahneman, 2011, pp. 149-158). Similarly, confirmation bias amounts to the fallacy of wishful thinking: one puts more confidence in findings that support one's desired outcomes (Kahneman, 2011, pp. 80-81). Confirmation bias is supported by our tendency to assume that what we see is all there is: humans rarely consider unknown unknowns as a possibility (Kahneman, 2011, pp. 85-88). Lastly, and this is can be the bane of abductive reasoning, we tend to substitute stories for statistics; that is, we are more likely to announce a pattern match from a story we've spun than from the law of large numbers. When searching for the best explanation, people prefer causal stories rather than descriptive statistics (Kahneman, 2011, pp. 165-195).

The second challenge to abduction in any inquiry is the negotiation of meaning. Even when working alone, investigators depend on the ideas of others. This dialogue creates space for the host of argumentation problems and successes discussed at this conference. Apparent agreement or disagreement, genuine agreement or disagreement, or a simple "talking past" one another are all likely to occur during the course of any inquiry. The negotiation of meaning across

disciplinary lines is often much more difficult than meaning-making within a discipline (Eigenbrode et al., 2007; Holbrook, 2013).

The last challenge to abductive reasoning I will cover here is the ubiquitous challenge of interpreting data. Even in a single disciplinary project, investigators can face difficult choices about data they must negotiate through the bundle of values they hold. One values-based choice is choosing what standards of evidence to use when drawing conclusions about patterns and processes based on limited evidence (Douglas, 2009). I alluded to this above, because interdisciplinary investigators must negotiate the differing values that arise from this feature of all inquiry. Interpretation of data within a discipline can be difficult, but it is even harder to interpret data with an interdisciplinary lens because there are many standards of evidence that might apply and they are difficult to compare (Eigenbrode et al., 2007).

At this point, I've made the interdisciplinary case look nearly hopeless, and indeed, some say it probably is (Abbott, 2001, p. 142ff.). However, we can try taking a page from the disciplinary case and, with some critical thinking and imagination, apply it to interdisciplinary inquiry.

## 4. Integrative abductive tools

You may have noted that I had more abductive tools in my hydrology project than my governance project. Most inquiry tools, such as inferential statistics, were developed for disciplinary inquiry. Disciplinary experts recognized that they needed help finding explanations for datasets that satisfied certain assumptions—assumptions that mainly apply to homogenous datasets. In fact, one might argue that the accretion and use of specialized abductive tools marks the formation of a discipline. By analogy with the disciplines, I argue we need tools uniquely suited to the challenges of interdisciplinary, abductive reasoning. I will now revisit the three stages of interdisciplinary abduction, this time emphasizing the challenges in each stage and principles for tool design. In some cases, tools already exist and merely need to be implemented more often.

1. **Pattern recognition.** The task in this phase is to recognize (and select) a meaningful pattern for further study. Challenges include many different kinds of data, too many patterns from which to choose, and bias in choosing. Interdisciplinary pattern recognition tools must therefore enable cross-talk between data types, which will involve finding some common "language" or symbolism between them. It will be difficult to do this without losing the meaning of either type of data; the common language must be rich, such as a natural language, a creole, (Galison, 1997, p. 832) or perhaps visualizations. Then, the tool should systematically display or help the user display the various patterns that emerge. A good example of such a tool is qualitative data analysis software. Tools for choosing which pattern to pursue should explicate the various cognitive, pragmatic, and social values at play, and facilitate the negotiation of these values. The Toolbox approach is a dialogue tool (a social process) developed to do exactly this for interdisciplinary teams (Eigenbrode et al., 2007). Rubrics are also helpful tools for explicating and negotiating diverse values (Davidson, 2013).

2. **Process imagination.** The task of process imagination is to invent plausible explanations for a pattern. Challenges here can include lacking new ideas but also having too many of them. Imagination is a mysterious process some would say cannot be systematically enhanced through things like tools. Creativity scholars and practitioners, however, disagree (Becker, 2008; Foster & Corby, 2007; Henry, 2011). Tools like concept mapping, storyboarding, scenario building, and modeling formalize explanatory efforts so we are less likely to succumb to

anchoring effects and confirmation bias. They also externalize the products of our imagination so their quantity is less overwhelming and more apt for negotiation of meaning. We also need tools that aid integrative vs. piecemeal explanations. As above, rubrics and other value-negotiation tools are helpful for choosing which options to pursue in the next stages of inquiry.

**3. Pattern matching**. Finally, having generated candidate explanations in the imagination phase, it is time to make an inference to the *best* explanation. This should be done through an explicit and strong pattern match: the process imagined should (mostly) reproduce the observed pattern and others in this dataset and other studies. This is extremely difficult in interdisciplinary work. Many interdisciplinary problems are neither reproducible nor well parameterized. If better matches indicate better explanations, how are we to judge the sufficiency of a match across such diversity? In my governance example, I relied upon an argument that my compelling story accounted for the main pattern and more. A story with an argument may be the best we can do when data come in different formats. But disciplines have developed a few pattern matching tools that may inspire interdisciplinary counterparts. For example, the multi-trait, multi-method matrix (MTMM) (Campbell & Fiske, 1959; Harman, 1965) assigns correlation coefficients to test the strength of a pattern match between a network of theorized concepts and a network of data. Qualitative pattern matching includes visual assessments as well as argumentation (Douven, 2011; Evergreen, 2013). Perhaps visual argumentation software could be useful at this stage (Kirschner, Buckingham Shum, & Carr, 2012). Lastly, and perhaps most importantly here, value-negotiation tools like rubrics, templates, and group discussion can mitigate biases and increase rigor in choosing the best explanation (Davidson, 2013).

## 5. Conclusion

One last note before I close: in this paper I avoided discussion of many of the most interesting argumentation problems in interdisciplinarity, because these arise before the data are collected (Eigenbrode et al., 2007; Hall & O'Rourke, 2014). To me, the challenges of framing and launching an interdisciplinary project are not abductive, but I don't know what they are. Much attention has been paid to the communication challenges of framing and launching, but very little has been paid to the reasoning challenges therein. Argumentation theorists may be able to bridge this gap.

If specialized tools demarcate a discipline, what I am calling for could turn out to be the disciplining of interdisciplinarity (Bammer, 2013). To make progress on tool development, we need to think about the argumentation that happens in interdisciplinary work. The three stages I posit could map onto or illuminate formal theories of abductive reasoning, which could in turn specify the argumentation challenges that integrative, abductive tools could support. We must also pull insights from cognitive science about pattern recognition, process imagination, and pattern matching. There are further horizons to explore when it comes to non-abductive reasoning in interdisciplinary work. A census or typology of interdisciplinary tools could reveal key distinctions among these types of arguments. In summary, given the salience and difficulty of interdisciplinary inquiry, we have found a new field ripe for development. I look forward to your insights.

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