How do empirical biomedical research articles argue? Examining the layers of rhetorical, domain-specific, and citation-based argumentation.

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ABSTRACT: Argumentation in research articles has been analyzed from a variety of perspectives, yet there is no integrative description of how these various accounts of scholarly argumentation interrelate. Since a full analysis of scholarly argumentation must take into account domain-specific elements, this work focuses on biomedical research articles, to examine how scholarly argumentation is layered by combining argument structures relating to research methods, citations, and rhetorical aspects of argumentation.

KEYWORDS: biomedical research articles, field-specific argumentation, medical argumentation, scholarly argumentation

1. INTRODUCTION

Argumentation in research articles has been analyzed from a variety of perspectives, including sociology of science (Latour, 1987), rhetoric of science (Prelli, 1989), applied linguistics (Davis, 2015; DuBois, 1997; Livnat, 2012), computational linguistics (Al Khatib et al., 2021; Liakata et al., 2012), and knowledge representation (Kircz, 1991). Yet there is no integrative description of how these various accounts of scholarly argumentation interrelate. Further, a full analysis of scholarly argumentation must take into account domain-specific elements such as the selection and defense of particular research methods. This work focuses on biomedical research articles, to examine how scholarly argumentation is layered by combining argument structures, relating to research methods, citations, and rhetorical aspects of argumentation.

I argue that the argument in an empirical biomedical article has at least three key aspects: rhetorical moves, domain-specific elements (methods, or research designs), and citations. In particular, I argue that each of these aspects is fundamental; they are found in different places; and they are different.

2. RHETORICAL MOVES

Rhetorical moves study how the goal of a paper is realized. They answer the question: What "goals" do sentences achieve, in a paper's narrative? Rhetorical moves have been widely studied by applied linguists, often to support language learning, in a field called English for Academic Purposes" (a part of the larger endeavor referred to as "English for

Specific Purposes"). An example is John Swales' model of research paper introductions, Creating a Research Space (Swales, 2011; Swales, 1990).

Computational linguists have also contributed to this area: Simone Teufel, who wrote about rhetorical moves for argumentative zoning model for her 1999 dissertation (Teufel, 1999) and subsequently described the High Level Goals that must be satisfied to get a paper accepted (Teufel, 2014).

3. DOMAIN-SPECIFIC ELEMENTS IN EMPIRICAL BIOMEDICAL RESEARCH ARTICLES

Empirical research in biomedicine is constrained by use of specific methods, more commonly termed "research designs". These describe how was the work done. Importantly, the methods of a paper constrain what the paper can tell us: What claims this paper, based on these methods, can authorize. The logical structure of an empirical paper is determined by the methods, in the sense that they determine what premises we must accept in order to rely on the outcome of the paper.

Research designs are widely studied inside the biomedical enterprise. Methods such as case reports and case series, case-control studies, cohort studies, and randomized controlled trials are widely agreed upon, described in epidemiology textbooks and frequently appear in paper titles. Specific training is offered to learn specific techniques such as clinical trial through the Clinical and Translational Science Centers funded by the U.S. National Institutes of Health. Methods for reporting clinical medical research are the subject of numerous reporting guidelines in the EQUATOR network (Altman & Simera, 2016; *EQUATOR Network*, n.d.) such as STROBE (Vandenbroucke et al., 2007) for observational studies and CONSORT (Begg et al., 1996) for randomized controlled trials.

To aid in information retrieval, methods have specific terminology indexing in the biomedical literature. Numerous designs have a Medical Subject Heading (MeSH) which can be used for retrieval. Information retrieval groups make and evaluate search filters; for instance McKibbon et al. (2009) compared 38 filters for retrieving randomized controlled trial. Recent work in my group evaluated machine learning tools for dozens of types of methods, which were created with training data from MEDLINE/PubMed (Cohen et al., 2021). In some topics more specific evidence curation has been undertaken, such as the drug-drug interaction evidence types in DIDEO, that I've been involved with (Brochhausen et al., 2014), which have the potential for more specific automated retrieval (Hoang et al., 2020).

There is a standard evidence pyramid in biomedicine (Ho et al., 2008) which continues to have influence even as methodologists seek to incorporate new types of evidence (Brown et al., 2022; Greenhalgh et al., 2022). New methods can be introduced but must be "argued into" a field (Jackson & Schneider, 2018). They get revised over time (Jackson & Schneider, 2023). Sally Jackson and I have studied as empirical examples Cochrane Review (Jackson & Schneider, 2018), Randomized Clinical Trial (Schneider & Jackson, 2018) and recent innovations building on the Randomized Clinical Trial (Schneider & Jackson, 2020).

4. CITATIONS AS ARGUMENTATIVE ELEMENTS

Citations can be used to increase the acceptability of a proposition, to indicate the expected audience/background, and for other purposes such as to support higher-level goals (a sort of rhetorical move). Citations can answer: What factual info is relevant? What work inspires this one? How can I tell that the problem is important/novel/significant? Science studies and scientometrics communities analyze citations for various purposes.

My work has studied when citations are a fundamental part of the argument. Yuanxi Fu and I introduced the term "keystone citation" for a citation whose unreliability threatens the argument of a paper; the term is inspired by masonry, where damage to the keystone can threaten the arch it supports (Fu & Schneider, 2020). Under our framework:

1) A scientific research paper puts forward at least one **main finding**, along with **a logical argument**, giving reasons and evidence to support the main finding.
2) The main finding is accepted (or not) on the basis of the logical argument.
3) Evidence from earlier literature may be incorporated into the argument by citing a paper and presenting it as support, using **a citation context**.

This draws on work from the knowledge representation community in formally mapping the arguments underlying papers (Clark, 2015) in standard data formats suitable for information system processing (Clark et al., 2014), which my group has been experimenting with for several years (Schneider & Sandhu, 2018)

Our framework (Fu & Schneider, 2020) is particularly suitable for testing whether there is an epistemic impact to citing work that is outdated or retracted. High school students used this approach to audit the citations to an infamous retracted paper (Addepalli et al., 2022), and my group is currently evaluating which of the ~300 citations to a computational chemistry protocol were impacted by a code glitch (Zheng et al., 2023).

5. WEAVING THE THREE TYPES OF ARGUMENT STRUCTURES

I argue that each element is fundamental, in any biomedical paper. Rhetorical moves seem to me required for a convincing narrative.[1] It is not possible to have an empirical paper without methods or research designs—though a paper may certainly introduce and argue for a method that is not in an existing catalog. New reporting guidelines are frequently created, in fact. Citations are necessary in any mature research field.

The elements are found in different places. Rhetorical moves are found in the whole text and are most noticeable in introduction and discussion sections that contextualize and argue for the importance and place of the work. Likewise citations are found throughout the text, especially in the background section, and often supporting the statements in the introduction and discussion. Citations that appear elsewhere in the text

[1] Phil Bourne (Bourne, 2005) has argued that biomedical papers should be overtaken by biomedical databases. In this case, no rhetorical moves are necessary because the community has already agreed upon the structure of a meaningful contribution to the field, hence, no narrative (and no paper) are required. There is very interesting work in this area, particularly implementing nanopublications (Bucur et al., 2023). So, while narratives are rarely convincing without rhetorical moves—CONTRIBUTIONS may be.

deserve further study. In empirical biomedical research articles, citations in the methods and results sections have particularly importance often in justifying specific materials, novel methods, or inferential reasoning to a conclusion (Fu et al., 2021; Fu & Schneider, 2020). Domain-specific elements may appear throughout the text; in empirical biomedical research articles, a section, often called "Methods" is devoted to describing the research design.

The elements are different. At the conceptual layer, rhetorical moves sit "above" the text: The same structural move can be realized in different textual embeddings, that all realize the same concept. In a structural layer, methods or research designs are a scaffolding underlying the "meaty" contribution of the paper. Methods are often standardized within a research community (that can "argue" new methods into being and refine them; see Jackson & Schneider 2018). Citations are a special purpose format for encapsulating information; they appear to support both conceptual and scaffolding functions.

Each of these aspects is fundamental; they are found in different places; and they are different. Thus an empirical biomedical article has at least three key aspects: rhetorical moves, domain-specific elements (methods, or research designs), and citations.

6. CONCLUSION

This paper has argued that an empirical biomedical article has at least three key aspects: rhetorical moves, domain-specific elements (methods, or research designs), and citations.

Argumentation theory has an opportunity to lead in unifying work from all the research communities studying arguments in science. Numerous questions of interest to other scholars may also bear on the argumentative aspects of scholarly research papers, such as: Which rhetorical moves are associated with citations? With methods? What is the relationship between rhetorical moves and citation purposes? Under what conditions is a database sufficient for conveying empirical research results? How do "discourse communities" figure into the arguments that are persuasive?

Argumentation theory itself stands to benefit from this endeavor: Scholarly research papers are accessible and well-documented locales for studying argumentation. Especially, understanding the innovation and invention in scholarly argumentation may also help us form questions for argumentation theory more generally (Jackson & Schneider, 2023). Comparison of different types of scholarly communication could be particularly helpful in deepening argumentation theory related to field-specific reasoning.

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