

Weak Links and Strong Meaning: The Complex Phenomenon of Negational Citations

Marc Bertin¹ and Iana Atanassova²

¹ Centre Interuniversitaire de Recherche sur la Science et la Technologie (CIRST),
Université du Québec à Montréal (UQAM), Canada,
`bertin.marc@gmail.com`

² Centre Tesnière, University of Franche-Comté, France,
`iana.atanassova@univ-fcomte.fr`

Abstract. The latest advances in research in the field of bibliometrics take into consideration in-text references. The purpose of this paper is to focus on citation contexts that express negational citations and which are relatively rare in articles. Our goal is to automate the extraction of negational citation contexts and to put them in relation to positions in the text progression of articles. After extracting sentences from the full text body of articles, we construct linguistic resources in order to identify some of the negational citation discursive patterns. We show the distribution of negational citations in the IMRaD structure. The identification of negational citations has numerous potential applications and might be used to improve information retrieval of scientific papers.

Keywords: Negative Citations, Citation Context Analysis In-text References, Bibliometrics, Semantic Annotation, IMRaD

1 Introduction

Citations can perform a wide variety of functions. One of the most interesting functions of citations is the expression of a negation when citing authors, papers, work or object of studies. In this paper we examine the nature of negational citations and show some of the complexity of the relation between citing papers and cited papers.

The aim of this work is to focus on the negative discursive forms located in sentences with in-text references. We already know that citations for which the relation between citing paper and cited paper has a specific meaning expressed by the author represent only small fraction of all citations (see [1]). In fact, most citations are perfunctory and their contexts cannot be exploited [2] by Natural Language Processing tools.

To study Negational References, we must define the notion of negational citations. According to Garfield, the notion of *Negative credit* refers to the fact of criticizing, correcting, disclaiming and disputing other works using negative references. Gilbert, in *Referencing as Persuasion* (see [3]), suggests that some references in affirmative contexts can be in fact negative. Furthermore, the article

The Negative reference by MacRoberts (see [4], p.92) arrives at the conclusion that there are few negational references in the scientific literature. The essence of negational citations is related to the very nature of the discourse and of the scientific debate. Hyland [5] argues that it is the relationship with the scientific truth, "the idea being that the facts must be allowed to speak for themselves with no human intrusion". One of the consequences is that:

"Hedges (underlined) indicate interpretations and allow writers to convey their attitude to the truth of the statements they accompany, thereby presenting unproven claims with caution and softening categorical assertions." (see [5], p.33)

If the phenomenon of negational citations is complex, the first attempts for their identification in texts were made using machine learning. By having access to the author of the article or an expert in the field, the categorization of citations can be done for a training dataset. For example, Catalini et al. proposed to study negative citations in the Journal of Immunology [6]. After manually annotating the training set of 15.000 citations, they used NLTK Naive Bayes algorithm and cosine similarity to identify other negative citations.

Citation contexts have to be explored in order to determine these relations. This field of study is part of Content Citation Analysis. In the field of context citation analysis, the relations between citing papers and cited papers are determined by exploring citation contexts. The main approach is to focus efforts on the categorization of citations by studying the linguistic context, generally located near the in-text reference. The context window could be defined by the number of words on the right/left side of the reference, or by sentence boundaries because sentences are textual units that can express meaning which is relatively independent from their context. This last method is more technical but more accurate for this purpose.

In fact, the question of the definition of the context windows around in-text references is all the more difficult as, in the words of Athar and Teufel (see [7], p.597), we face a "non-local expression of sentiment". Their study based on the annotation of 20 papers extracted from the corpus ACL Anthology shows that we need to increase the context window for the task of sentiment citation analysis. However, linking sentiments to contexts still remains a difficult task. This work is in the continuity of the works of Teufel et al. [8]. Their protocol mentions the fact that they use "the last sentiment mentioned in the context windows as this is pragmatically most likely to be the real intention (MacRoberts and MacRoberts, 1984)" (see [8], p.598). They demonstrate that for negative sentiments, this approach triples the recall (see [7], p.598, table 2). This is an essential point, which is at the heart of our experimental protocol.

2 Method

We propose an exploratory study to define a conceptual framework around the identification of negational references. For this purpose, we set experimental benchmarks around the location of negational references.

Firstly, we have constructed a dataset of scientific articles, including meta-data, full-text, information of IMRaD (Introduction, Methods, Results and Discussion) structure, segmentation into sentences and identification of in-text references. Secondly, we have built linguistic resources allowing the identification of negational references. These resources do not cover the full spectrum of negational references. From a methodological point of view, the linguistic resources were not built to be exhaustive, but to limit the false positives. Thirdly, after building a set of Finite State Automata (FSA), we have extracted sentences with in-text references. The results obtained allow us to propose a prototypical framework to put into relation negational references to both the IMRaD structure (see [9]) of articles and enhanced context windows.

2.1 Protocol

Our experimental protocol for the exploration of citation contexts in view to identify negational citation considers the following limitations. The only use of contexts including in-text references is insufficient. This implies that new types of processing should be taken into consideration such as anaphoric resolution to enhance contexts. Furthermore, the negational references are often hidden, diffuse or disassembled (see [4]). Moreover, there are few negational references in scientific literature. Having considered these limitations, our study is based on two elements :

1. **The expression of negation** : We consider the discursive forms present in the text that can be identified using linguistic markers, and that express negational relations.
2. **Context windows**: For this study, we work at the sentence level.

Our objective is to study discursive forms that express negational relations in the contexts of in-text references and also outside these contexts. To do this, we consider two types of sentences: those containing in-text references and those without in-text references. For the moment, we cannot identify negational references exhaustively ; we focus on some of the known forms and look into the relationship between their occurrences in sentences with in-text references and in sentences without in-text references.

2.2 Dataset

Our dataset consists of seven peer-reviewed academic journals published by the Public Library of Science (PLOS)³. We have processed the entire dataset of about 80,000 research articles published up to September 2013.

³ Six domain-specific journals (*PLOS Biology*, *PLOS Computational Biology*, *PLOS Genetics*, *PLOS Medicine*, *PLOS Neglected Tropical Diseases*, and *PLOS Pathogens*) and *PLOS ONE*, a general journal that covers all fields of science and social sciences. (<http://www.plos.org>)

We identified the section structure in each article by analysing the section titles, in order to identify the four main section types in the IMRaD structure (Introduction, Methods, Results, and Discussion). More than 97% of all research articles in the corpus contain these four section types. We segmented all sections into sentences and extracted sentences containing in-text references. The dataset contains a total of 12,556,466 sentences without in-text references and 3,601,842 sentences with one or more in-text references.

2.3 Linguistic Resources

From a linguistic point of view, Hyland [10] presents 400 different verbs used in citations. We agree with the fact that verbs are an important feature to understand the acts of citations at the semantic and rhetorical level [11].

The main difficulty is to create linguistic resources for our rule-based approach. Our objective is to obtain a set of rules that have a high level of precision. The recall is not taken into consideration for this study because we want, first of all, to determine whether the same resources could be applied sentences with and without in-text references. This is not a traditional methodological perspective ; however this approach allows to foreground the role of sentences without in-text references in the phenomenon of negational citations.

For the constitution of the linguistic resources expressing negational relations in the act of citations, we focus on verbs and adjectives. The extracted citation contexts were processed using TreeTagger [12, 13] which performs both part-of-speech tagging and lemmatization. In the output verb forms are tagged by labels such as VB, VBD, VBG, VBN, VBP, VBZ that stands for base form, past tense, present participle, ... To identify the relevant verbs we analyse and extract all verbs from citation contexts. Then we focus on author disagreement using counter-factive verbs like : *fail*, *ignore*, *exaggerate*, etc. One particularity of the negation is that it can be expressed in different ways: e.g. *not agree with* — *disagree with*. For example :

- ‘*We do not agree with the methodology of using a training set without MCI to select biomarkers to differentiate between AD and MCI [1].*’
- ‘*Results disagree with Bequet and Przeworski [3] who reported a split time of 1.4 million years and an ancestral effective size of (C.I.).*’

We have also identified some sentences containing qualifiers that we call non-consensual *dubious* and their synonymous (*absurd*, *doubtful*, *farcical*, *far-fetched*, *far-out*, *flimsy*, *frivolous*, *grotesque*, *implausible*, *impractical*, *improbable*, *inconceivable*, *inoperable*, *ludicrous*, *non-viable*, *outrageous*, *questionable*, *remote*, *ridiculous*, *strained*, *uncredible*, *unenforceable*, *unfeasible*, *unlikely*, *unrealistic*, *unreliable*, etc.)

For this study, we have a set of regular expressions for identifying discursive forms. The constituted resources represent a core around the discursive expression of negative citation forms.

3 Results

This work brings one more element in response to the existence of negational citations situated outside the context window located around in-text reference.

3.1 Prototypical Model of Negational Citations

A sample of sentences with in-text references are presented in the tables 2 and 3. Here are two examples:

However, we and other authors (Table S2) disagree with the low percentage of anxious-type OCD in patients with GTS as observed by Shapiro and Shapiro [30].

Note also that I disagree with Livezey and Zusi ([64]: character 1142) regarding the condition in Pelecanus, which I interpreted as possessing the plesiomorphic state (Figure 12).

The tables 4 and 5 present sentences with negational contexts but without in-text references. Some examples are:

Most biologists nowadays disagree with Darwin's view of species, largely because of Mayr's biological species concept.

After 1986, some authors persisted in the confusion.

These sample gives us precise information on the nature of sentences containing negational contexts without in-text references. This allows us to construct the following categorization of the object of negation:

- **model or theory** (Darwin's view of species)
- **actor of science** (proper names of people)
- **object as a material product of research** (work, table, result, report)
- **object as an abstract product of research** (idea, findings, concept, notion, opinion)
- **framework** (classification, norm)

We have also detected specific cases which are more complex and need further investigation. For example, if an author cites an author who gives negative credit. As a last point, we confirm that anaphora play an important role and we agree with the conclusions of Athar and Teufel [7] on the fact that the context window must be enhanced. In some cases, forms such as "*some authors*", "*most biologists*", "*them*", "*him*", etc. are found in sentences before or after citation contexts. The few examples we have given show that if the study of anaphora is necessary, it is not enough and the task will require the implementation of other methods.

3.2 Ratio of Negational References

Table 1 shows the distribution of negational contexts through the IMRaD (Introduction, Methods, Results and Discussion) structure. The second column gives the relative number of negational contexts **with** in-text references and the third column gives the relative number of negational contexts **without** in-text references. This table also shows the ratio between the Negational Contexts with in-text references and the Negational Contexts without in-text references. This shows that by taking into consideration an enhanced context we can increase the recall for some specific sections.

Section	With In-text References	Without In-text References	Ratio
Introduction	12.1%	20.8%	1.1
Methods	2%	0%	0
Results	14.1%	22.4%	1.1
Discussion	71.8%	56.8%	0.5

Table 1: Negational references in the IMRaD structure

The largest number of negational references are found in the Discussion section, then in the Results and Introduction sections. The Methods section contains relatively small number of negational references. It is interesting to note that this number remains small also when we consider sentences without in-text references. In the Introduction and Results sections, we find that the number of negational contexts doubles if we consider contexts without in-text references. In the Discussion section, we find more than 56% of negational contexts without in-text references.

4 Discussion

The low relative frequency of the negational citations is not expressed in this study because the linguistic coverage of the resources and the method used is not optimal. But the most significant result is that the Methods section contains almost no negational citations and that the Discussion section contains the largest number. Regarding the Methods section, this result is consistent with the work of Bertin et al. [9], who show the atypical character of this section in relation to the other sections. The fact that the Discussion section contains the highest percentage of negational citations gives it a new property that has not yet been described in scientific literature.

We show that the ratios obtained in table 1 corroborate the work of Athar and Teufel [7]. It is necessary to extend the context window of study in order to carry out citation analysis with better recall. If this phenomenon can be understood through the action of anaphora, it remains counter-intuitive.

5 Conclusion and Perspectives

This work is not sufficient to provide a comprehensive method for the study of negational references. However, the fact that the context window must be extended for negational references analysis is an important phenomenon which is also counter-intuitive. This study raises a number of questions. For example, we can consider the fact that an author may be cited several times in a paper and study the different categories of the references. Another point is the verification that the last reference near the negational context is the one that will be retained in the analysis. This assumption was proposed by MacRoberts [4] and was used by Athar and Teufel [7].

In our future work, we will focus on the distance between a sentence with an in-text reference and the sentence that carries the negational context. This metric is important to determine the size of the context windows that must be taken into consideration.

If the frequency of negational citations is low, they carry a strong meaning of the nature of the relation between citing papers and cited papers. Indeed, a relationship expressed by a negation induces polarity that can be exploited from a theoretical point of view in the analysis of networks, such as co-citation networks and bibliographic coupling, and also in applications for scientific monitoring.

More precisely, these works are of special interest in the CBRC system construction (Context-Based Recommendation System Citation) [6, 14] as a tool to propose a recommendation system of scientific articles based on the analysis of citation contexts. Another prospect is a better understanding of the motivations for citations in the articles. Furthermore, the negational references can play a predicative role in the detection of articles that may or must be retracted. Naturally, this work will find an impact on networks of co-citations [15], the generation of surveys [16] or in the field of Information Retrieval [17, 18], but also for plagiarism detection [19].

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7 Annex

DOI	Section	Pos. in sect.	Sentence with in-text references
pone.0043984	introduction	6	Buckwalter JA believes that the lumbar spine degeneration initially occurs within then central NP of the IVD [18].
pone.0057889	introduction	8	Thus, the full model proposed by Nietzsche [3] has remained empirically unproven.
pgen.1002739	discussion	1	Our results appear to contradict those of [35].
ppat.1000004	result	6	As these observations contradict those of a similar published study [13] we considered whether some effect of natural T reg might be being masked by the rapidly ascending parasitaemia and early mortality associated with infection with 104 PyL parasites.
pgen.1001340	discussion	10	Our results are in striking contrast with previous findings that co-expression of CGG and CCG expansions in flies leads to mitigated toxicity in a ago2-dependent manner [31], suggesting that toxicity derived from interactions between sense and anti-sense repeat transcripts may be specific to CTG/CAG situations.
pgen.1003389	discussion	4	Our observations in humans also contrast with the molecular responses observed during acute synergist ablation induced hypertrophy [66], raising further doubts over the relevance of such pre-clinical models to inform about physiological muscle growth in humans.
pone.0023920	result	4	These results differ from previously published agglutination data for a frzS insertion mutant (DZ4219) [8].
pone.0012073	discussion	4	They also differ from previous findings of over-activation in occipital regions [35], [38].

Table 2: Negational Citations with in-text References (i)

DOI	Section	Pos. in sect.	Sentence with in-text references
pone.0030965	discussion	4	Our results do differ from previously published vibration reports that have subjected laryngeal fibroblasts to strain and vibration [10], [11].
pone.0012959	discussion	7	However, we and other authors (Table S2) disagree with the low percentage of anxious-type OCD in patients with GTS as observed by Shapiro and Shapiro [30].
pone.0013354	result	4	Note also that I disagree with Livezey and Zusi ([64]: character 1142) regarding the condition in <i>Pelecanus</i> , which I interpreted as possessing the plesiomorphic state (Figure 12).
pone.0022117	discussion	9	However, our findings disagree with a recent report showing that megakaryocytes/platelets specific deletion of <i>Cdc42</i> had no effect on filopodia formation on immobilized fibrinogen or CRP [13].
pone.0044996	discussion	1	Our results disagree with a prior study which showed a mutant form of AICD (Y682A/Y687A) that was suggested not to bind Fe65, was still active in promoting cell death [53].
pone.0065040	discussion	1	However, our results disagree with the results in a recent report that <i>DDX5</i> silencing strongly increased p24 release [59].
pcbi.0010067	result	4	We thus believe that the motif reported in [27] is dubious.
pgen.1000160	method	9	This may suggest that a significant fraction of the variants reported in [16] are dubious.
pone.0070707	introduction	1	Krings et al. [5] reviewed the fossil record of the <i>Peronosporomycetes</i> and concluded that all the reported occurrences of this group older than Devonian are dubious or inconclusive.
pgen.0020052	discussion	4	Furthermore, this study has ignored upstream ORFs, which may contribute many short proteins [39].
pntd.0001986	discussion	2	Some authors believe, these animals pose a major threat to man [7].
pone.0050952	discussion	4	Surprisingly, only four studies [37], [24], [27], [25] performed some form of validation of their models.
pntd.0001001	discussion	4	A study of rabies in Tanzania also suggested dog rabies control was feasible, but was hampered by perceived problems that were largely unfounded [7].

Table 3: Negational Citations with in-text References (ii)

DOI	Section	Pos. in sect.	Sentence without in-text references
pbio.0050068	discussion	1	At first glance, our findings appear to contradict two recent papers that investigate the N-p50 association.
pbio.1001102	analysis	1	In summary, we disagree with the fundamental assertion that it is the total area of transcribed sequence that is most important.
pbio.0030293	discussion	4	These data may appear to contradict our results showing that the amygdala is required for the reconsolidation, but not the consolidation, of the first-order conditioning, and not needed for the formation of the second-order response.
pcbi.1001071	discussion	7	On its own, this information would appear to contradict the knowledge that proliferation rates are highest distally, however Map6 was also the one with a strong distal fanning-out movement along the AP axis (central row in Figure 4B).
pgen.1001174	discussion	1	The conclusions that derived from our observations contrast with the widely held belief that RNAi initiates heterochromatin assembly at fission yeast centromeres.
pgen.1002739	discussion	2	Our results appear to contradict this well-established dogma.
pgen.1000419	discussion	3	One is that all wild strains described from the Midwestern United States (TR388, TR389, and TR403) are dubious.
pone.0014769	discussion	1	These results contradict those obtained by previous analyses where Neanderthals have been traditionally viewed as a species feeding mostly on animal proteins and more specifically large game animals.
pone.0023567	discussion	2	This result may initially appear to contradict the findings in MDCK cells, but the difference may be explained in several ways.
pone.0023842	discussion	3	Our results disagree with this possibility.
pone.0029539	discussion	3	Our results disagree with this assertion as we did not find that parthenolide inhibited caspase-1 in response to AIM2 stimulation.
pone.0029704	discussion	7	This result is similar to the clustering algorithm's results and we disagree with Chang's classification.

Table 4: Negational Contexts without in-text References (iii)

DOI	Section	Pos. in sect.	Sentence without in-text references
pone.0057887	discussion	4	At first glance, our results appear to contradict this finding.
pone.0058442	discussion	1	However, we disagree with this opinion.
pone.0070922	discussion	5	These results appear to contradict the known effects of attention on P300 and N2pc.
pone.0037786	discussion	12	Our results disagree with either of them.
pone.0038998	discussion	2	Some of our observations appear to directly contrast with those previously described (Table 4).
pcbi.1000912	method	2	Whereas some authors consider standard logical functions for all components, we do not impose such a restriction.
pcbi.0020099	undef	7	Some authors can be unresponsive or uncooperative, thus impeding completion of their entry.
pcbi.0030002	introduction	2	Some authors argue that increasing the number of characters sampled per taxon improves the accuracy, while others state that accuracy is better improved by subdividing long branches by including more taxa, resulting in fewer characters overall.
pmed.0050110	undef	3	Some authors have speculated about UTR sequences making direct RNA:RNA interactions with target transcripts and thereby influencing their stability or translation.
pone.0012983	result	1	Some authors think that the initial experiment that leads to hypothesis generation is most important, while others consider the core experiments or figures that lead to the main conclusion of the article to be most important.
pone.0016409	result	3	After 1986, some authors persisted in the confusion.
pone.0045897	introduction	8	Some authors believe that it may be due to a defective extracellular receptor-associated kinase (ERK) pathway.
pbio.0030152	undef	4	Most biologists nowadays disagree with Darwin's view of species, largely because of Mayr's biological species concept.
pbio.0030382	undef	3	Historians still disagree whether or not the degree to which Darwin had tumbled to the idea of evolution while still on the Beagle.

Table 5: Negational Contexts without In-text References (iv)