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Critical citations in knowledge construction and citation analysis: from paradox to definition

Frederique Bordignon^{a, b}

^a Ecole des Ponts, Marne-la-Vallée, France

^b LISIS, INRAE, Univ Gustave Eiffel, CNRS, Marne-la-Vallée, France

frederique.bordignon@enpc.fr

0000-0002-4918-9137

Abstract

Critical citations are lacking a common definition in relation to extant research on knowledge construction and citation analysis, whereas studies on these topics seem to provide a fully relevant theoretical framework, making criticism an essential phenomenon for the progress of science.

We propose to explain this paradox by the fact that a citation seems to have a positive polarity by default and that a polarity shift is the result of a stronger commitment on the part of the author. This results in the use of specific cue words. By studying the labels (and their associated definitions) that 53 other studies equated with the concept of critical citation, we identified 3 functions on which to base the definition of critical citation: "to criticize", "to compare" and "to question" other works. While these studies seem to consider the criticize function as central and probably more frequent, the analysis of a corpus of 51 text snippets containing a citation (all retrieved from those same studies) reveals that the citations considered as critical by these same authors are often comparisons between results rather than blunt attacks against the cited works.

This three-function based definition and the set of wordings gathered in this study provide a new basis for the design of tools dedicated to citation polarity detection.

Indeed, the lexical and grammatical markers characterizing comparison must be taken into account in addition to those expressing a negative evaluation and those expressing doubt.

Keywords

Citation;criticism;critical citation

Availability of data and material

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In studies about knowledge construction, criticism has a prominent place since it is considered as "the life blood of science" (MacRoberts and MacRoberts 1984). Indeed, there is a consensus that scientific knowledge is constructed through critical debate. Nevertheless, critical citation is hardly introduced in these theoretical frameworks, although they seem to ideally embrace the concept. We propose here to explore this paradox and to take advantage of it to propose a definition of critical citation. We will then review a number of works related to citation analysis in general, and also works related to academic criticism, some of which include a reflexive approach to citation.

Based on these studies in scientometrics, sociology of science, psychology or natural language processing, our objective is to understand the concept of critical citation in order to propose a definition that can be useful to these same disciplines. Finally, we will validate this definition by confronting it with a corpus of critical citation contexts specially designed for this study.

The paradox of the critical citation

Some seemingly ideal theoretical frameworks for the critical citation concept

In science studies, there is a common view that knowledge construction is achieved by continuous questioning of previous research produced by researchers, including one's own work. Therefore, we might expect the critical citation of a scientific production to be a possible realization of this process of questioning. As a starting point, we consider a citation to be the explicit reference to another scientific piece of work within the full-text of a scientific publication, and thus consider a critical citation to be one that carries a negative connotation towards the cited work.

Influential works in sociology of science offered ideal theoretical frameworks for hosting the concept of critical citation by giving an essential role to academic criticism for the advancement of science. Indeed, they introduced principles suggesting that criticism was a normal or even normative practice, as for example with:

- the falsification process, introduced by Popper (1959), who considers knowledge construction as an incremental process involving conjectures, refutations, a dialectical process of learning from errors.
- organized skepticism, introduced by Merton (1973), who presents it as a norm that invites researchers to criticize the work of their peers by systematically questioning previous claims.
- paradigm shifts, defined by Kuhn (1970), occurring after a period of consensus and normal science, when unsolved anomalies accumulate.

As social activities, falsification or skepticism are expected to occur through the phenomenon of critical citations. We could also expect that increased critical citations towards works of a paradigm are the early stages or even the causes of the ensuing crisis.

In sociology of science, some researchers (Gilbert 1977; Latour 1987) suggest that citations (or references or footnotes) are a rhetorical strategy adopted by authors in their scientific writing to persuade the reader that their propositions are valid. As such, scientists cite to defend their claims against attack, advance their interests, convince others, and gain a dominant position in their scientific community (Bornmann and Daniel 2008; Tahamtan and Bornmann 2019).

And according to Latour (1987), nothing is off limits; on the subject of intertextuality (i.e. the use of source texts), he states: "Whatever the tactics, the general strategy is easy to grasp: do whatever you need to the former literature to render it as helpful as possible for the claims you are going to make. The rules are simple enough: weaken your enemies, paralyze those you cannot weaken... help your allies if they are attacked... oblige your enemies to fight one another; if you are not sure of winning, be humble and understated." But in practice, the critical citation does not seem to be part of the range of "weapons" available to authors and Cheng and Unsworth (2016) conclude that explicit criticism to subvert the opposed study is not the preferred rhetorical option.

While these basic principles may have informed some works on academic criticism in a broader sense, they have not been directly invoked to introduce the concept of critical citation within works on citation analysis. One possible explanation for this is that these works have initially considered a citation to have a positive value by default.

Positive polarity by default

In sociology of science, there is an alternative conceptual approach (to the socio-constructivist on mentioned earlier) that considers a citation as a reward. This is Merton's (1973) point of view: he explains that citations are a kind of symbolic currency that allows one to acknowledge an intellectual debt to the cited authors. Citations are "the pellets of peer recognition" (Merton 1988). Researchers are therefore willing to share their ideas by publishing them and claiming authorship. And they are also motivated by the hope that their work will be recognized by their peers, especially in the form of future citations. This echoes Newton's aphorism (Newton 1675): "If I have seen further it is by standing on the shoulders of Giants" and Merton (1973) communal norm that sees science as a collective effort from researchers to contribute to the construction of knowledge. This approach cannot be fully valid for critical citations, as they do not convey peer recognition in a supportive way. However, they do have the same role as other citations in that they do credit the cited authors for their intellectual contribution, regardless of whether it is disputed.

Clearly, for the influential researchers we have mentioned so far, a citation is not considered as critical, however, the frameworks they propose are suitable for this option, in that they all include the critical debate as an essential process. Therefore, a citation seems to have a positive polarity by default. This is confirmed more explicitly by Small (2004), when he says about a possible theory of citation: "Such a theory must encompass the spectrum of observed behaviours from the most common forms such as ceremonial or perfunctory citation to the less common deviant cases, such as negative citation, self-citation, and misattribution." This is the line of thinking that Lin (2018) has "inadvertently" adopted in his citation annotation protocol: "as long as a citation does not carry a negational attitude, it is considered confirmative."

Polarity shift

Be it in studies on knowledge construction in general or those on citation analysis, citation has a positive polarity by default, although this is not clearly stated by the authors. Whilst it is the context that makes a reference become a citation (Gilbert and Woolgar 1974), this context could therefore also shift the polarity from positive (or neutral) to negative, with dedicated lexical markers. Moreover, if we take the example of a single reference, introduced only in the

bibliography but never mentioned in the text, it is in fact impossible to determine the stance of the citing author towards the work or the author associated with this reference, except perhaps to have precise knowledge of the cited work and to place it in relation to the author's entire contribution in the citing text. There is every reason to believe that an "orphan" reference constitutes a positive or at least neutral citation by default. However, this practice is tending to disappear, especially as journals now often require in their guidelines that all references be present in the text (there must be differences between disciplines and publishers, and this is a hypothesis that would need to be confirmed by a dedicated study). Erikson and Erlandson (2014) explain that with a citation, giving credit is an act of distancing, or showing that the cited idea is borrowed from someone else and as a consequence, this weakens the citing author's arguments. In our opinion, with a critical citation, the movement is reversed and the citing author regains control and asserts his position by disputing what he is actually citing. At the same time, he/she acquires authorship over the questioning or refutation he/she expresses, whereas in a positive or neutral citation, it is mainly a matter of crediting another researcher. The polarity shift, expressed by a critical citation, is the result of a strong commitment on the part of the author, at least stronger than in a positive or neutral citation. As far as researchers' behavior is concerned, a critical citation is not equivalent to an anonymous negative comment on a post-publication peer-review platform (e.g.: PubPeer), or to an anonymous negative vote on an online site (e.g.: Stack Exchange, used by Geras *et al* (2020) to model the impact of a "dislike button" for publications). In the following section, we will endeavour to define what a critical citation is by trying to identify what causes this polarity shift.

Towards a definition of critical citation

In this section, we will first examine the results of three publications that are entirely dedicated to critical citations. Then, we will broaden the scope of our consideration by relying both on typologies of citations and also on studies that have focused on the analysis of critical discourse in academic writings. For the latter, we have focused on those addressing the problem of citation, leaving aside those that deal with academic criticism in a general way by proposing rhetorical analyses of discourse, independently of the citation contexts (Hunston 1993; Zou and Hyland 2020).

What extant research reveals

We have identified three publications dedicated to critical citations:

- a note from MacRoberts and MacRoberts (1984) pointing out the low number of "negational references" and seeking to explain this.
- an article from Catalini et al. (2015) analysing "negative citations" in Immunology, and also looking at the profile of papers receiving "negative citations"; those are identified automatically.
- a communication from Bertin and Atanassova (2016) showing, with automated retrieval, the distribution of "negational citations" in the IMRaD structure of articles.

First, all three publications agree that critical citations are very infrequent, 2.4% in the Catalini et al's study. These results are consistent with many other studies that have counted this type of citation along with positive or neutral ones. The rate is less than 3% in several studies that have used manually annotated corpora (Cano 1989; Lin 2018; Oppenheim and Renn 1978; Spiegel-Rosing 1977) or automatic retrieval (Bertin and Atanassova 2016; Catalini et al. 2015; Stremersch et al. 2015). Furthermore, Catalini et al. showed that few papers receive at least

one criticism (7.1% according to their corpus in immunology). They also show that critical citations were more likely to come from scientists who were close in discipline and social distance to the cited scholars as it may be socially costly to negatively cite the work of a local colleague. MacRoberts and MacRoberts (1984) state that critical citations are toned down, disguised, or away from important people. This is true for academic criticism in general, characterized by caution and politeness, even if this has evolved over the years (Salager-Meyer 1998) and may vary from one genre to another (Zou and Hyland 2020) or from one language to another (Salager-Meyer et al. 2003). At last, the study made by Bertin and Atanassova (2016) shows that the Methods section contains very few critical citations. The largest number of them are found in the Discussion section, then in the Results and Introduction sections. These citations mainly focus on findings rather than methods or theories.

The critical citation itself seems to have inspired few dedicated studies, nevertheless it is almost always included in the many citation typologies that we have been able to examine. Moreover, in their recent meta-analysis of citing motivations, Lyu et al. (2021) identified 25 studies (out of 38 included in their study) that clearly described one of the motivations of the citers as being to criticize. It is difficult to reconcile all these classification schemes insofar as they were not developed for the same purposes, depending on whether they were intended, for example, to facilitate the annotation of corpora or to automate the identification of distinct types of citations in texts, and also depending on whether the aim was to examine the reader's point of view or that of the citing author, even if his/her motives can only be assumed. To build on this extensive work, we used a simple yet original method: we identified in these typologies all the labels used to categorize critical citations, according to the intuitive definition we adopted above. In addition, we identified all the ways in which citations of this type are referred to in the literature on citation analysis, even if no typology was proposed or used. Finally, in the course of our reading we also identified all the examples provided by authors (in supplementary material, and also often in the main body of their studies) and thus constituted a corpus of critical citations which we in turn make available (Bordignon 2021). The first observation we can make is that, even if research on knowledge construction has not fully integrated it and if few studies are dedicated to it, critical citation is nevertheless well present in the literature on citation in the fields of scientometrics, linguistics and natural language processing. In the 53 publications we reviewed, we identified 56 wordings or class labels that we examined to refine a definition of critical citation. From then on, we think that such a definition could be based on 3 functions:

- to criticize, that is to point out a weakness or a fault in the cited work, the only target in the citation context. It is not only a review or a critique but a bad assessment of the cited work, associated with a negative opinion. The labels contain for example the following words: *critical, reject, deny, weakness, negatively evaluated*.
- to compare, with the aim of expressing that one study is better than another, without necessarily including one's own work (it can be 2 other publications). There is more objectivity in this function, even if in the end it can be an opinion as well. The labels contain for example the following words: *comparison, contrast, disagree, juxtapositional*.
- to question, i.e., to convey concerns, doubts, and uncertainty about the cited work. The labels contain for example the following words: *challenging, problematized, discussed, mixed opinion*.

As far as syntax is concerned, the *criticize* and *question* functions are performed in citation contexts that only mention the target publication(s), as in the following examples:

- (1) *Thus, the full model proposed by Nietzsche [3] has remained empirically unproven.*
- (2) *Chiang (2005) introduced a constituent feature to reward phrases that match a syntactic tree but did not yield significant improvement.*
- (3) *However, Koskenniemi himself understood that his initial implementation had significant limitations in handling non-concatenative morphotactic processes.*

In contrast, for the *compare* function, the citation context mentions at least two works (often including the author's own), as in the two following examples:

- (4) *Our results appear to contradict those of [35].*
- (5) *For the Penn Treebank, Ratnaparkhi (1996) reports an accuracy of 96.6% using the Maximum Entropy approach, our much simpler and therefore faster HMM approach delivers 96.7%.*

We have tested and proven this proposal by successfully classifying all the labels found in the literature according to these three non-mutually exclusive options. It is important to say that we have taken into account the explanations and definitions given by the authors themselves to elaborate this classification. This is what led us on several occasions to include a label that overlaps two functions in Table 1. A specific column indicates whether the label is part of a typology or not.

Table 1. Distribution of classes and wordings according to the critical citation functions

Class or wording	Typology	To criticize	To compare	To question
"Negative" (questioning and challenging) (Zhang et al. 2013)	Yes			X
A citation is marked negative if it explicitly points to a weakness of the target paper. It is also marked as negative if it is compared to another paper and deemed worse in some way. (Abu-Jbara et al. 2013; JHA et al. 2017)	Yes	X	X	
Active criticism (Erikson and Erlandson 2014)	Yes	X		
Citation polarity or sentiment: negative (Athar 2014; Di Iorio et al. 2013; Hernández-Alvarez et al. 2017; Sula and Miller 2014)	Yes	X		
Cited source is negatively evaluated (Spiegel-Rosing 1977)	Yes	X		
Citing work corrects cited work (Garzone and Mercer 2000)	Yes	X		
Citing work disputes priority claims (Garzone and Mercer 2000)	Yes			X
Citing work is partially not supported by cited work (Garzone and Mercer 2000)	Yes			X
Citing work is totally not supported by cited work (Garzone and Mercer 2000)	Yes	X		
Citing work partially disputes some aspect of cited work (Garzone and Mercer 2000)	Yes			X
Citing work questions cited work (Garzone and Mercer 2000; Lipetz 1965)	Yes			X

Citing work totally disputes some aspect of cited work (Garzone and Mercer 2000)	Yes	X		
Comparative (Peritz 1983)	Yes		X	
Comparison (Dong and Schäfer 2011)	Yes		X	
Concur - Affirming/conceding concurrence (Cheng and Unsworth 2016)	Yes		X	
Correcting one's own work (Garfield 1964)	Yes	X		
Correcting the work of others (Garfield 1964)	Yes	X		
Corrects, disagrees with, refutes, disputes, parodies, ridicules, critiques (Peroni and Shotton 2012)	Yes	X		X
Counter - Formulations present the current proposition as replacing an alternative one. (Cheng and Unsworth 2016)	Yes	X	X	
Critical citation (Greenberg 2009)	Yes	X		
Critical speech act (Martin-Martin and Burgess, Sally 2004; Salager-Meyer 2017)	No	X		
Criticism, criticizing (Abu-Jbara et al. 2013; JHA et al. 2017)	Yes	X		
Criticize: one work points out the weakness or limitation of another work (Wang et al. 2012)	Yes	X		
Criticizing previous work (Garfield 1964; Lyu et al. 2021)	Yes	X		
Deny - Formulations introduce some alternative position but reject or dismiss it. (Cheng and Unsworth 2016)	Yes	X		
Describe challenges and limits (Zhang et al. 2013)	Yes			X
Direct attack upon existing claims (Salager-Meyer 2017)	No	X		
Disagreement (Cheng and Unsworth 2016; Frost 1979; Giannoni 2005; Hassan and Serenko 2019; Murray et al. 2020; Sula and Miller 2014)	No	X	X	
Disclaiming the work or ideas of others (negative claims) (Garfield 1964)	Yes	X		
Dispute or correct (Tang and Safer 2008)	Yes	X		X
Disputing priority claims of others (negative homage) (Garfield 1964)	Yes	X		X
Disputive (Scite 2019)	Yes	X	X	X
Engaging citations - Identifying inconsistencies in source's position (Harwood 2009)	Yes			X
Engaging citations - Praising but then identifying problems with the source (Harwood 2009)	Yes	X		
Improve: the relationship that one work is obviously better than another (Wang et al. 2012)	Yes		X	
In case of negation, the citing article rejects conclusions of the cited article. (Stremersch et al. 2015)	Yes	X		
Juxtapositional (Hassan and Serenko 2019; Moravcsik 1988; Swales 1986)	Yes		X	
Mixed opinion (Frost 1979; Lyu et al. 2021)	Yes			X
Negational citations (Bertin and Atanassova 2016; Cano 1989; Chubin and Moitra 1975; Hassan and Serenko 2019; Li et al. 2013; Lin 2018; MacRoberts and MacRoberts 1984; Moravcsik and Murugesan 1975; Swales 1986)	Yes/ No	X		
Negative citations (Ball 2015; Catalini et al. 2015; Di Iorio et al. 2018; Erikson and Erlandson 2014; Geras et al. 2020; JHA et al. 2017; Liu 2017; Schneider et al. 2020; Shadish et al. 1995; Small 2004; Teufel et al. 2006a; White 2004; Yu 2014; Zhang et al. 2013)	Yes/No	X		
Negative credit (Brooks 1985)	Yes	X		

Negative - The weakness of the cited work is discussed (Li et al. 2013)	Yes	X		X
Negative/critical citation: Negative/critical is more or less opposite to the confirmatory ones, for example, they focus on lack of reliable results, general low quality, or that the RCT in focus does not meet biomedical standards (Danell 2012)	Yes	X		
Perfunctory-negational and essential-concept-negational (disapproves or questions) (Lin 2018)	Yes	X		X
Problematic cited studies (Cheng and Unsworth 2016)	No			X
Refutational, refutes (Lipetz 1965; White 2004)	No	X		
Results of citing article disprove, put into question the data as interpretation of cited source (Spiegel-Rosing 1977)	Yes	X		X
Suggests or critiques (Di Iorio et al. 2018)	Yes	X		X
The writer rejects the cited claim (Cheng and Unsworth 2016)	No	X		
This reference has deficiencies that contrast to the strengths of your article. (Shadish et al. 1995)	Yes	X	X	
This reference illustrates a perspective or finding that contradicts a perspective or finding in your article (Shadish et al. 1995)	Yes		X	
This reference reported unique or anomalous findings (Shadish et al. 1995)	Yes	X		X
Unfavourable contrast/Comparison (current work is better than cited work) (Hernández-Alvarez and Gomez 2016; Teufel et al. 2006a)	Yes		X	
Weakness of cited approach (Hernández-Alvarez and Gomez 2016)	Yes	X		
Weakness of cited approach (Teufel et al. 2006b)	Yes	X		
Writers make explicit critique on the weaknesses or inadequacies of the opposed study (Cheng and Unsworth 2016)	No	X		

In order to evaluate the frequency of the 3 functions in the literature examined, we have developed a simple scale: when a label overlaps with 2 functions, we apply a coefficient of 0.5. Sometimes the same label (with the same meaning) is used in several publications, so we take it into account by counting them for each publication. Consequently, if we stick to the wordings and labels proposed by the researchers, the *criticize* function is the most frequent (nearly 68%), then the *question* and the *compare* function (both above 15%).

What corpus analysis reveals

As we read through the works presented in Table 1, we have identified and retained the examples that the authors of these works gave to illustrate what they considered to be critical citations. We could compile a corpus of 51 citations (i.e., citations and the text surrounding them) and labelled them according to the three functions. One could almost say that it reveals another paradox. Indeed, the annotated corpus reveals a completely different distribution with only 25,5% of examples of citations that can be characterized according to the *criticize* function, and more than 60% in the *compare* function. Once again, there is a difference between the theoretical frameworks emphasizing on direct criticism while data shows mainly comparison strategies (Figure 1).

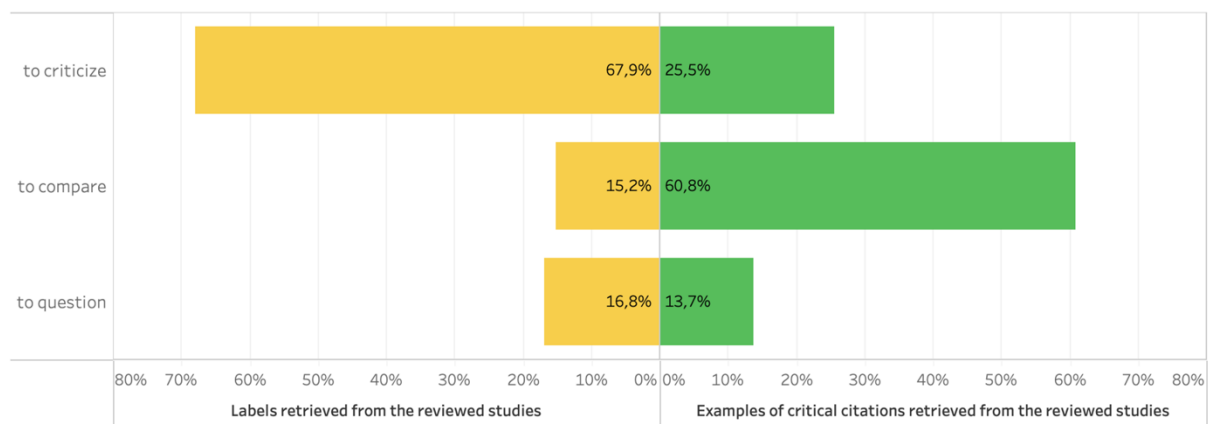


Figure 1. Critical citation functions according to labels retrieved from the reviewed studies vs examples of critical citations retrieved from those studies

This result confirms that it is important to integrate the *compare* function in the definition of critical citation. This may have consequences in the design of tools for automatic citation polarity detection. Indeed, the lexical and grammatical markers characterizing comparison and showing that one paper is "better" than another must be taken into account (e.g.: *better, faster, lower, improve, simpler, to contradict...*) in addition to those expressing judgment or negative evaluation and those expressing doubt. These are the elements that contribute to the shift from positive/neutral to negative polarity and are therefore the very essence of critical citations.

Conclusion and perspectives

In this study, we start from the observation that there was a lack of definition for critical citation in relation to the numerous works on knowledge construction and citation analysis, whereas research on these topics seems to provide a fully relevant theoretical framework, making criticism an essential phenomenon for the progress of science.

We propose to explain this paradox by the fact that a citation seems to have a positive polarity by default and that the polarity shift is the result of a strong commitment on the part of the author, at least stronger than in a perfunctory citation. This stronger stance might be associated with a higher social cost (Catalini et al. 2015) that can explain why critical citations are so scarce and also why it seems easier to criticize anonymously on post-publication peer review platforms like PubPeer, and also in book reviews (Zou and Hyland 2020) where criticism is by essence the rules of the genre.

By studying the labels (and their associated definitions) that 53 studies equated with the concept of critical citation, we identified 3 functions on which to base the definition of critical citation: "to criticize", "to compare" and "to question" other works. While these studies seem to consider the *criticize* function as central and probably more frequent, the analysis of the corpus revealed that the citations considered as critical by these same authors are often comparisons between results or methods rather than blunt attacks against the cited work.

This work is not only a literature review, it provides a hitherto non-existent synthesis of the phenomenon and also a definition based on three functions that can serve as a basis for future research. Indeed, we believe that it can contribute to the current studies on the automatic retrieval of critical citations. The stakes are high since these tools can be used to identify

controversies related to certain claims and to understand how science progresses or, on the contrary, where it fails to self-correct, even though there are weak signals that could be detected thanks to the critical citations they contain.

In this endeavour, we therefore believe that it would be possible to tackle another complex problem where a positive (or neutral) citation of a study is made while this study cites other works and criticizes them. Scientometric studies that use citation networks to detect communities do not take this phenomenon into account. Only the presence or absence of citations matters in the construction of an intellectual affinity network. We also intend to compare the utter absence of citations (either as an outright absence, or from a given period) with the occurrence of critical citations. It is likely that not citing at all is stronger from a criticism point of view than a critical citation itself.

Furthermore, although it is regrettable and not compatible with the Declaration on Research Assessment (DORA members 2013), many research administrators rely on the number of overall citations and related indicators in their evaluation of researchers. These calculations can have consequences for funding grants or career advancement. With the possibility of differentiating types of citations, it is conceivable that evaluation could be better conducted. Nevertheless, one must be careful of the potential risks of gaming the metrics, with, for example, the temptation that some researchers might have to critically cite a competitor. It is therefore essential that such tools are highly reliable.

Finally, we have seen that critical citations are not quite common in written academic discourse. Proposing a reflection on critical citations is also a way of rehabilitating them and even encouraging them, since there is already a consensus that criticism is essential to the progress of knowledge construction.

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