Methodological roadmapping: a study of centering resonance analysis

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Abstract

Purpose – This paper aims to map the creation and evolution of centering resonance analysis (CRA). This method was an innovative approach developed to conduct textual content analysis in a semi-automatic, theory-informed and analytically rigorous way. Nevertheless, despite its robust procedures to analyze documents and interviews, CRA is still broadly unknown and scarcely used in management research.

Design/methodology/approach – To track CRA's development, the roadmapping approach was properly adapted. The traditional time-based multi-layered map format was customized to depict, graphically, the results obtained from a systematic literature review of the main CRA publications.

Findings – In total, 19 papers were reviewed, from the method's introduction in 2002 to its last tracked methodological development. In all, 26 types of CRA analysis were identified and grouped in five categories. The most innovative procedures in each group were discussed and exemplified. Finally, a CRA methodological roadmap was presented, including a layered typology of the publications, in terms of their focus and innovativeness; the number of analysis conducted in each publication; references for further CRA development; a segmentation and description of the main publication periods; main turning points; citation-based relationships; and four possible future scenarios for CRA as a method.

Originality/value – This paper offers a unique and comprehensive review of CRA's development, favoring its broader use in management research. In addition, it develops an adapted version of the roadmapping approach, customized for mapping methodological innovations over time.

Keywords CRA, Centering resonance analysis, Methodological roadmapping, Methodological innovation

Paper type Research paper

1. Introduction

Case studies have been essential to the development of management theories. The evolution of strategic management research – both worldwide (Herrmann, 2005; Hitt *et al.*, 1998; Hoskisson *et al.*, 1999; Ketchen *et al.*, 2008) and particularly in Brazil (Colla *et al.*, 2011; Walter *et al.*, 2008) – exemplify it.

Case-oriented research[1], differently from variable-oriented studies, allows an intensive knowledge of the study objects (Blatter and Haverland, 2012). Moreover, this possibility enables one to follow distinctive theory-building approaches (George and Bennett, 2005). Nevertheless, to be robust, the research inquiry needs to be done by means of formal analysis (Mahoney, 2000). However, most of the analytical methods that were developed are not applicable to case analysis (Ragin, 2008). Thus, it is necessary to develop methodological alternatives which are adequate to this specific kind of analysis. Some initiatives in that direction have been observed over the past decades, especially in sociology and in political science.

In the late 1980's, for instance, Ragin (1987) published the first qualitative comparative analysis (QCA) book. Since then, more than 500 academic papers about the theme were published (www.compasss.org/bibdata.htm, accessed in 16th October, 2017) – including two other books written by Ragin (2000, 2008), which consolidated QCA principles.

Similarly, event structure analysis (ESA) was proposed in the late 1980's in sociology (Heise, 1989). In addition to the seminal article, Corsaro and Heise (1990); Griffin (1993) and Griffin and Korstad (1998) established the foundations of the method. Because of its originality and logical rigor, ESA – together with QCA – established a new methodological category called formal qualitative analysis (Griffin and Ragin, 1994). Several applications of ESA procedures have been made in the social sciences during the 1990's and 2000's (www.indiana.edu/~socpsy/ESA/ESApubs.html, accessed in 16 October 2017).

More recently, original approaches were developed to track these causal chains observed in case studies (Bennett, 2010; George and Bennett, 2005; Hall, 2008; Blatter and Haverland, 2012). Amongst them, the causal process tracing has been gaining importance on comparative historical research (Hall, 2008; Kittel and Kuehn, 2013; Rohlfing, 2013). Even combinations of this approach with ESA (Mahoney, 2012) and QCA (Baumgartner, 2013; Schneider and Rohlfing, 2013) have already been proposed.

Nonetheless, once again, management research confirms itself as a late adopter of these methodological innovations, appropriate for case analysis (Stevenson and Greenberg, 1998, 2000; Valorinta *et al.*, 2011; Freitas, 2014).

Finally, this same gap is observed in centering resonance analysis (CRA). Developed in the social communication field (Corman *et al.*, 2002), CRA is a methodological innovation for case analysis which is being used to infer:

- the most important words in a speech (either a transcript or a written text);
- the way in which these words interact between themselves; and
- the similarity between different texts.

Frequently adopted in information and computer sciences, CRA was only recently introduced into management-oriented journals (Hofer *et al.*, 2012; Tate *et al.*, 2010; Barbosa *et al.*, 2017). Yet, there are only some few works published using this method in this area and no Brazilian publication has been found. This observation can also be done for several other case-oriented research methods[2]. However, it is not the goal of this section to exhaustively review these possibilities. The proposition of this article is that there are methodological innovations in case analysis which could be more broadly and effectively used in management research.

As it is one of the most recent case analysis innovations, CRA has been chosen as this article's focus to facilitate its diffusion among management scholars. Thus, the overall aim of this research was to map CRA's methodological evolution. The specific objectives were:

- to build an adequate typology to classify the analytic processes associated with CRA;
- to evaluate the methodological innovations of CRA's publications;
- to track the evolution of CRA, identifying its main historical patterns, development periods and turning points; and
- to characterize CRA's state-of-the-art by inferring possible scenarios for this methodological strand.

2. Methodology
To achieve the objectives, a literature review (Hart, 1999; Knopf, 2006) has been made which included a bibliographic survey, a narrative review and a graphic review, by means of a methodological roadmapping procedure.

The bibliographic survey was done in the following databases: ISI Web of Science (WoS), Scopus e SciELO[3] – all of them are multidisciplinary[4]. While WoS has been chosen for its selective indexing of only high-impact journals (c.f. *JCR – Journal Citation Reports*), Scopus has been selected because of its broader search reach. On the other hand, SciELO has been included for its Ibero-American representativeness. Table I lists the five search entries that were used.

Table I shows that the search entries used both the method's full expression and its initials, were made both in the "topic" and in the "title" search fields and were made both in English, in Portuguese and in Spanish.

The results were narratively revised, focusing on the most relevant points for the objectives of this research. The review was also done in a graphical format (Grant and Booth, 2009), adapting the typical roadmap structure (Freitas *et al.*, 2013; Freitas, 2014; Freitas *et al.*, 2011b; Phaal and Muller, 2009; Phaal *et al.*, 2010; Oliveira *et al.*, 2012). The detailed procedures can be found in the next section, together with the roadmap itself.

3. Results
The bibliographic survey results are shown in Table II. Out of the 20 items, full text access was not granted for only one paper (Willis and Miertschin, 2010b). Most of these publications were journal articles but there were also some book chapters and conference papers. Few publications had high citation levels but most of them had not yet shown a high impact on academic literature, as expected.

3.1 Introductory publication
CRA was proposed by Corman *et al.* (2002). In this introductory publication, CRA was presented as a new type of computerized text analysis, but, more specifically, as a

Search	Keywords	Field
Type 1	cent* resonance analysis	Topic (Title)
Type 2	CRA	Title
Type 3	(centralização OR centralidade) AND ressonância AND análise	Topic
Type 4	(centralización OR centralidad) AND resonancia AND análisis	Topic
Type 5	CRA	Keywords

Source: The authors

Table I.
Search entries on
selected databases

#	Work	Publication type	WoS search type	Scopus search type	WoS citations	Scopus citations
1	Corman *et al.* (2002)	Journal article	Type 1 (Title)	Type 1 (Title)	77	118
2	Dooley *et al.* (2002)	Journal article	–	Type 1		12
3	Williamson *et al.* (2004)	Book chapter	Type 1	Type 1	0	0
4	Canary and Jennings (2008)	Journal article	Type 1 (Title)	Type 1 (Title)	14	28
5	Brinson and Stohl (2009)	Book chapter	–	Type 1 and Type 5		0
6	Oliveira and Murphy (2009)	Journal article	Type 1	Type 1	7	10
7	McLaren *et al.* (2010)	Conference paper	–	Type 1		0
8	Tate *et al.* (2010)	Journal article	Type 1	Type 1	59	77
9	Garyantes and Murphy (2010)	Journal article	–	Type 1		2
10	Willis and Miertschin (2010a)	Conference paper	–	Type 1 (Title)		2
–	Willis and Miertschin (2010b)	Conference paper	–	Type 1 (Title)		0
11	Hofer *et al.* (2012)	Journal article	Type 1	–	14	
12	Dwyer (2012)	Journal article	Type 1	Type 1	0	1
13	Weigel *et al.* (2013)	Journal article	–	Type 1		0
14	McPhee *et al.* (2013)	Book chapter	–	Type 2		0
15	Evans *et al.* (2013)	Journal article	–	Type 1		1
16	Evans *et al.* (2014)	Journal article	–	Type 1		0
17	O'Connor and Shumate (2014)	Journal article	Type 1	Type 1	1	1
18	Taylor and Yang (2014)	Journal article	–	Type 1		0
19	Cosenza *et al.* (2015)	Journal article	–	Type 1		0

Note: No article was found on the SciELO database
Source: The authors

representational method – because its goal is to extract an efficient representation of the content of a given text. As these representations have a (word) network format, the authors have also classified CRA as a network analysis method.

According to Corman *et al.* (2002), CRA focuses on texts because these correspond to a detailed level of human communication (i.e. the word level). On the other hand, the fact that it is computerized makes the analysis applicable to a wide range of textual material (i.e. in terms of both quantity and content aggregation level). The authors reinforce that the combination of deepness and range was not possible in common methodological alternatives in human communication research (c.f. cited examples are ethnographic participant observation, conversation analysis, surveys and computational simulation).

Besides that, as it adopts a representational approach, CRA looks forward to extracting the words' meaning without using external references (e.g. dictionaries). Thus, results of different studies are easily comparable. Finally, in representing texts by word networks, CRA brings up the full analytical potentialities of the techniques developed for studying this kind of data structure (Carley, 1997; Carley and Kaufer, 1993).

However, according to Corman *et al.* (2002), what used to differentiate (i.e. in 2002) CRA from other computerized word-network representation methods was its capacity to identify units of analysis and their relations in a text. While other similar methods make use of the word's co-occurrence in the visualization window of a given software to identify these units, CRA unitizes and links the words based on a linguistic theory that considers the way in which texts are produced. Thus, CRA analysis is not based on arbitrary software window sizes but, rather, on a consistent theoretical perspective.

Specifically, CRA is based on centering theory (Grosz *et al.*, 1995; Walker *et al.*, 1998). This theory posits that human beings bring coherence to discourses by using "centers". Centers can be understood as nouns and adjectives (i.e. noun phrases) that work as the

subject or object of a sentence. Therefore, the more these centers refer to each other (both retrospectively and prospectively), the more a discourse becomes coherent.

Another important notion in CRA is "resonance", which is a measure of the discursive similarity between two different texts. This similarity is based on words' co-occurrence weighted by their importance in the corresponding texts (Corman *et al.*, 2002). High resonance values, for instance, indicate that the two texts are very similar on the way that discursive coherence was obtained using words – i.e. how words were articulated and their relative importance.

Corman *et al.* (2002) define four basic steps for implementing CRA. In the first step ("Selection"), noun phrases (i.e. phrases that contain at least one noun, associated or not with an adjective)[5] are identified. These selected phrases are minimally pre-processed to eliminate pronoun ambiguity (by replacing them for their respective noun) and standardize prefixes and suffixes (e.g. plural stemming).

In the second step ("Linking"), words pertaining to a same noun phrase are connected (not directionally). Besides, the last and the first words of two consecutive noun phrases are also connected. The underlying assumption is that this way of connecting words reflects the writer's centering (unconscious) process. Once linked, words form a semantic network.

The third step is "Indexing". Here, a word's betweenness centrality is calculated to measure how much the discursive coherence of a text depends on that specific word. Once betweenness values are calculated, the resonance between two texts can be obtained. Resonance is calculated by the sum of the products of the influence of two exact same words which occurred in different texts. Resonance can also be found for pairs of words (instead of an individual word) by using pair influence (betweenness) as its input parameter. Both single-word and word pair resonance must be standardized to compensate for texts' size differences.

Finally, the fourth step is "Application", in which the indexed network (or a part of it) can be used for specific analytical purposes (e.g. visualization, scaling, clustering and information retrieval).

In short, the CRA's introductory publication highlighted that the method introduced a new way – consistent from a theoretical perspective and semi-automated from a technical point of view – of identifying important words and similar texts in a textual *corpus*[6].

3.2 The evolution of the method

This section reviews the evolution of CRA from this seminal publication by Corman *et al.* (2002). The 19 papers collected were classified by chronological order. For each of them, we listed:

- the type of data used;
- the analytical procedures (categorized by type and group), in the order in which they were reported; and
- the results obtained.

Finally, each analysis–result combination was assessed[7] for its innovativeness in relation to the preceding published combinations. Table III exemplifies this description for the Williamson *et al.*'s (2004) innovative article.

Analyzing the 19 papers in this way, it is possible to observe the data diversity that was already analyzed in CRA applications – for example, from short excerpts (Dooley *et al.*, 2002) to thousands of pages (Tate *et al.*, 2010); from interview transcripts (McPhee *et al.*, 2013) to

Data	Analysis	Group	Result
521 incident reports (c.f. system failures) in IT services managed by a global corporation, with up to 12 pages each, categorized by three former locations and written by experts	Calculation of the average influence of each word across the reports	Influence	Most influential words in the reports
	Categorization of each word based on an Ontological Dictionary developed by IT experts	Text	Number of influential words (out of the 500 most influential, on average) by category
	Comparison and contrast of words' average influence, by location and seller	Influence	Locations and sellers more/less influential in reports
	Exploratory Factor Analysis by Principal Components with Varimax rotation for the set of reports, based on the influence values of the words that occurred in at least 10% of the reports	CRA + other methods	Main underlying factors for words, interpreted as key themes in the set of reports
	Calculation of the influence of a theme in a report as the average of the influences of the words associated with it (the theme) in that report	Influence	Influence of each theme for each report
	Analysis of the stability of the influence of themes over time by Statistical Process Control Charts, using the influences of a theme over a period of 1 month (i.e. in 3 to 10 reports) as a subgroup	CRA + other methods	Stability/Significant variations of themes' influence over time
	Time Series Analysis, by analyzing significant correlations between the influence of themes whose occurrences were not too much dissociated over time (i.e. from 0 to 3 months away)	CRA + other methods	Inferences of possible causal relationships between themes, consolidated in a causal map, in which: nodes represent significantly correlated themes; arrows indicate the inferred causal direction; and their values means the elapsed time between themes` occurrences (a format that enables the differentiation between root causes and symptomatic effects) [Knowing that correlation does not imply causation]

Table III.
Data, analysis and
results of an
innovative CRA
application by
Williamson *et al.*
(2004)

Source: The authors

corporate codes (Canary and Jennings, 2008). Besides that, 26 kinds of analysis were made in the applications of the method (Table IV). It is also noted that these types could be grouped into five distinct groups[8]. In the following subsections, we highlight the main innovations for each of these groups of analytical procedures.

Type	Analysis	Group
A	Word network interpretation	Word network
B	Word network comparison and contrast	CRA + other methods
C	Comparison of CRA results with other results (validation) or data (triangulation)	Resonance
D	Clustering analysis of a set of texts, based on the resonances between them	
E	Multidimensional Scaling (MDS) of a set of texts, based on the resonances between them	
F	Calculation of resonance between different types of texts (e.g. questions and answers)	
G	Statistical comparisons for significance	CRA + other methods
H	Calculation of the influence of words or word pairs	Influence
I	Word categorization	Text
J	Comparison and contrast (non-statistical) of the influence of words or word pairs between texts (aggregated or not)	Influence
K	Exploratory Factor Analysis by Principal Components with Varimax rotation for a set of texts, based on the influence values of the words included in the analysis	CRA + other methods
L	Calculation of theme-leve influence	Influence
M	Stability analysis of influence over time by statistical process control chart	CRA + other methods
N	Time Series Analysis, by analyzing significant correlations between the influences of themes not much dispersed over time	Resonance
O	Comparison and contrast (longitudinal and transversal) of results from exploratory factor analysis	
P	Calculation of resonance between sequential texts	
Q	Comparison between results of cluster analysis and exploratory factor analysis	CRA + other methods
R	Latent coding for words associated with a factor	Text
S	Comparison of cluster analysis results with other clustering results (validation)	
T	Pre-processing of original text (c.f. content and size)	
U	Correlation between word influence values	CRA + other methods
V	Calculation of theme-level resonance	Resonance
W	Discounting of the preexisting cognitive similarity effect between two writers when calculating resonance	Word network
X	Calculation of network indices (except betweenness/influence)	
Y	Calculation of word pair resonance	Resonance
Z	Comparison and contrast (non-statistical) of resonance between texts (aggregated or not)	

Source: The authors

Table IV.
Types of analysis
identified and
grouped

3.2.1 Combining centering resonance analysis with other methods. Most of the methodological innovations corresponded to combinations of CRA with other methods (group "CRA + other methods"). Among these, the comparison between CRA results and those from other methods for cross-validation was the most innovative type (Type C). Dwyer (2012), for example, pointed to the superiority of the CRA resonance index in its ability to distinguish influential writers from writers susceptible to influence, in sequential texts (e.g. posts from a blog and their subsequent comments). Another type of innovative analysis was the introduction of statistical tests to verify the significance of values (or differences in values) of the CRA indexes (Type G). Tate *et al.* (2010), for example, applied some of these tests to compare the influence values of discursive themes between industries.

Other notable innovations in this group include:

- cluster analysis of a set of texts – based on the resonance between them – to identify groups of similar texts (Type D, Corman *et al.*, 2002);
- exploratory factor analysis by principal components for a set of texts – based on the influence values of the considered words – to identify general themes (Type K, Williamson *et al.*, 2004);
- analysis of a theme stability over time (Type M, Williamson *et al.*, 2004); and
- correlation analysis between the influence of words to identify thematic word pairs (Type U, Hofer *et al.*, 2012).

Cluster analysis (Type D) and exploratory factor analysis (Type K) were the most reproduced procedures in subsequent articles (i.e. seven and six times, respectively).

3.2.2 Calculation and comparison of influences. The second most analytically innovative group was the one concerned with calculations and comparisons of influences ("influence" group). Comparing and contrasting the influence values between groups of texts (Type J) can be considered an innovative approach because of how this procedure was operationalized (i.e. differently from other analysis). O'Connor and Shumate (2014), for instance, compared the highest and the lowest influence of words and word pairs between distinct groups of texts to identify typical terms of each group. Another type of analysis from this group was the calculation of theme-level influence[9] (Type L). Both the sum (Hofer *et al.*, 2012) and the average (Williamson *et al.*, 2004) of the word influences associated with the theme were used (for a hybrid procedure, Tate *et al.*, 2010).

Finally, there was also some innovation in calculating the influence of words or word pairs (Type H). A simple innovation was the introduction of the word's influence calculation in a set of texts as the average of the word's influence on each of the corresponding texts (Williamson *et al.*, 2004). This was only an incremental innovation, but it seems to be more consistent than the alternative solution (Canary and Jennings, (2008)) to calculate this aggregate influence by treating the set of texts as a single text.

3.2.3 Calculation and comparison of resonances. This group was classified as the third most important when considering the number of innovations, but the most innovative, proportionally (i.e. eight of the nine analysis-outcome combinations). We note, however, that no innovation of this group has been replicated so far.

In this group, the most important type of analysis was the calculation of the resonance between sequential texts (Type P). All four analytical procedures of this type were innovative. Canary and Jennings (2008) have introduced this way of using the resonance indexes (i.e. longitudinally). Dwyer (2012) has developed it considerably by distinguishing source resonance (i.e. between a text and a later text) from target resonance (i.e. between a

text and an earlier text). Based on this differentiation, the author proposed a new set of metrics to identify the influence of a writer or a theme in a sequence of texts (Dwyer, 2012).

Dwyer (2012) also innovated by proposing a way of discounting the effect of homophilia (i.e. preexisting cognitive similarity) in calculating the resonance between two writers (Type W). Another innovation introduced by the author was the calculation of theme-level resonance (i.e. not of words or word pairs alone) – Type V. Considering that different people can use different words to refer to the same theme, Dwyer (2012) proposed that different words (that, nevertheless, correspond to the same theme) should also be considered the same in the resonance calculation.

Finally, another interesting innovation in this group was the calculation of the resonance between different types of texts (Type F). Dooley *et al.* (2002) calculated the resonance between consulting demands (expressed in the form of inquiries) and teachers' resumés to identify which teacher would be the most recommended to answer each question.

3.2.4 Interpretation and comparison of word networks. The group of interpretation and comparison of word networks also introduced some innovations. The way that Corman *et al.* (2002) interpreted a network became the standard for later publications (Type A). The same was true for the comparison between different networks. On the other hand, the way in which Garyantes and Murphy (2010) compared and contrasted two networks is not recommended, as they focused the analysis only on the identification of unique or shared words, or word pairs (Type B).

3.2.5 Preprocessing of texts. Finally, the last group of analytical procedures, with the lowest level of total innovations, but proportionally innovative (i.e. five of seven analysis-results combinations), was the preprocessing of texts. Willis and Miertschin (2010a, 2010b) inserted implicit centers in the original text to increase their textual coherence. O'Connor and Shumate (2014) fixed the number of texts per set of texts to limit the undesirable effects of the difference in text size (type T). Williamson *et al.* (2004), on the other hand, developed a specific ontological dictionary for his CRA application to associate the original words with semantically broader categories. With the same purpose, Dwyer (2012) used an English standard thematic dictionary to automatically categorize all words of the texts under analysis.

3.3 Graphical review

After reviewing the main innovations introduced during the evolution of CRA, Figure 1 illustrates this methodological development graphically. The bubbles represent the 19 publications (see numbering in Table II). Bubbles' size corresponds to the number of different types of analysis performed in each publication, ranging from 1 (articles 15 and 19) to 11 (article 10). The arrows represent the citations (i.e. when a previous publication was cited by a subsequent work). As it is cited by all publications except the 19th, the arrows from publication 1 were formatted differently to indicate this paper's widespread impact without visually polluting the map. The asterisk indicates turning points, highlighting publications that were highly cited – and which, therefore, are outstanding. The underlined numbers, on the other hand, emphasize very innovative publications that were subsequently not mentioned at all – thus, representing items relevant for building a new agenda of CRA's methodological research and development.

The bubbles are positioned in relation to two axes: publication typology (vertical) and time (horizontal). The typology was inductively constructed, from the categorization of publications in two dimensions: transversality (i.e. transversal versus focal) and innovation (i.e. innovative versus conservative). A publication was considered transversal if its respective analytical procedures covered at least three of the five analysis groups – and focal, if not. Similarly, from the analysis of the distribution of innovative analysis-outcome combinations[10], a publication

Figure 1.
Methodological
roadmap of CRA
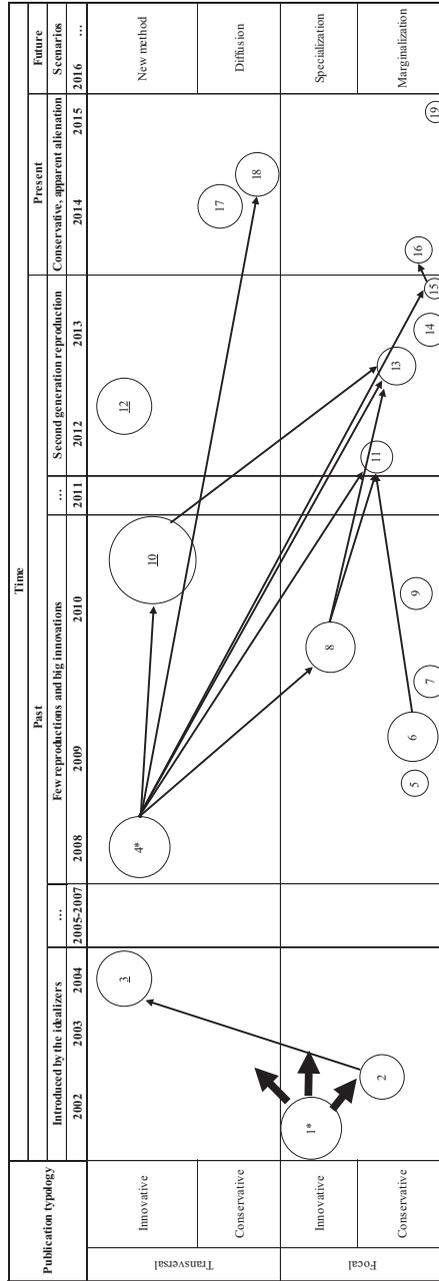
Notes: Legend. Bubble: reviewed work (Table II); bubble area: number of types of analysis; underlined bubble number: item selected to the research and development agenda; arrow: citation; (*): turning point
Source: The authors

was considered innovative if at least four of their respective combinations were categorized as innovations – and conservative, if not. Within each category of transversality, height differences in bubble positioning represent differences in the innovativeness of the publication (i.e. the higher – closer to the top of the Table – the more innovative. For example, the "3" is more innovative than "1", which is more innovative than "2").

In the horizontal axis, analyzing the distribution of publications per year, the past was divided into three main historical phases (separated by two periods without publications). The first phase (2002-2004) was entitled "Introduced by the idealizers" because it comprises three publications authored by the proponents of the CRA method (Steven Corman, Timothy Kuhn, Robert McPhee and Kevin Dooley). The second (2008-2010) was entitled "Few reproductions and big innovations" because it reproduces publication 1 in a focal and conservative way (i.e. publications 5, 6, 7 and 9), but it also includes considerable innovations, such as publications 4 and 10 (transversal) – and in a lower degree, publication 8. Finally, the third historical period (2012-2013) was named "Second generation reproduction" because the major part of its publications is conservative and based on publications of the second period (c.f. citations of 4, 6, 8 and 10). The recent past/present, or state-of-the-art, has been called "Conservative, with apparent alienation" because, until this moment, it is restricted to conservative publications, unaligned with developments from previous periods.

From this visualization, we suggest four scenarios from the combination of the publications' typology (Figure 1). A possible scenario would be the persistence of a conservativeness focused on a small set of well-established practices of the method. In this case, CRA may become marginalized, being treated as a method of minor importance or small analytical potential.

A second scenario would result from some aspects of CRA gaining prominence over others because of the emphasis on some of its technical particularities in its future developments. In this scenario, CRA could evolve to an updated version, specialized in the technical improvement of a subset of its initial characteristics.

A third scenario could be the reproduction of applications of the current version of method. In this case, a widespread diffusion of CRA can be expected. However, the diffusion's speed would depend on the publication rate per year and on the capability of these new publications to incorporate the CRA's methodological benefits that were developed over the past years.

Finally, a fourth scenario would be characterized by a group of methodological innovations in various aspects of the method, driving CRA to a notable change when compared to its original proposition. In this case, new text coherence theories, for example, vein theories (Cristea *et al.*, 1998), new semantic network centrality calculations, new similarity matrix metrics and new combinations with other methods (e.g. with ESA, due its focus on verb phrases, and not on noun phrases) could foster the emergence of a new method, more robust than CRA.

This literature review was done precisely to contribute to the further evolution of CRA in this direction, towards a type of scenario that considers the rich methodological framework that has already been developed for the application of the method.

3.4 Centering resonance analysis' contributions to management research

CRA is relevant for management research in similar situations in which other content analysis methods are applied – as in the applications identified by Duriau *et al.* (2007), for example. After all, like these other methods, CRA consists, essentially, a quantitative analysis of textual data. In this sense, CRA can support any analytical work intended to

infer the most important words of a discourse (transcript or written), the way these words relate to each other or the similarity level among different texts (Corman *et al.*, 2002).

However, unlike the most common approaches of content analysis, in CRA, the importance of each word is determined more accurately (i.e. by calculating betweenness centrality) than by counting its frequency of occurrence. The method selects words and links them based on centering theory and not on subjective criteria or on software arbitrary characteristics (e.g. window text size). Finally, CRA provides a robust index to compare texts' similarity (i.e. resonance), whereas other methods limit themselves to the comparison of the most frequent words used in each text.

Specifically, regarding management research, CRA could be applied for:

- literature reviews (e.g. most important words from a research stream; similarity between articles; article clusters);
- interview analysis (e.g. identification of main themes and their connections; similarity between interviewees' discourses); and
- document analysis (e.g. conduct codes; CEOs/shareholders' letters; advertisements and releases; corporate reports).

For example, Barbosa *et al.* (2017) highlight some possible applications of CRA in supply chain management:

- analysis of documents exchanged between suppliers and buyers;
- job description studies (i.e. knowledge, tasks and responsibilities) in supply chain management;
- identification of the competitive forces that influence the supply chain of an industrial sector, from an interviewee's point of view; and
- corporate report analysis to understand how companies publish their social and environmental strategies.

Finally, we suggest Visone (www.visone.info/html/extensions.html) as a supporting tool for CRA's application – specifically, its "Natural Language Processing (NLP) extension". This extension includes a CRA "module" capable of transforming an input text into a word network, using centering theory rules and the *Stanford Lexicon Parser*, embedded in the program. The software also provides a tutorial for using this module.

4. Conclusion

The underlying proposition of this paper is that management research does not satisfactorily explore the methodological innovations that are applicable to case analysis, despite their potential for theoretical development. Specifically, we have argued for a widespread use of CRA because, as our literature review emphasizes, it is still a relatively unknown method, but considerably useful to analytical approaches involving written or transcribed materials (e.g. case studies).

To contribute to CRA's wider adoption, this paper mapped the evolution of the method, highlighting main publications and innovations that contributed to its development. We reviewed 19 publications from selected databases and identified 26 technical analysis types concerning CRA. These were clustered into five distinct groups, for each of which we pointed the corresponding methodological innovations. Besides that, we presented a methodological roadmap of CRA's evolution, divided in past, present and future scenarios foreseen for the method.

Surely, this paper has its own limitations – opening up future refinement possibilities. First, new article databases, less selective in nature, should be incorporated to increase the number of papers included. During the literature review, we identified new references associated to CRA that were not included in this paper. In this sense, a citation analysis of each reviewed publication could refine this initial search results.

Besides that, the innovativeness categorization and assessment may be refined. Instead of executing this process simultaneously by two research assistants, this task could be done independently to evaluate coding robustness *a posteriori*. This strategy would strengthen results' reliability and, therefore, the corresponding inferences.

However, we hope that this paper, despite its limitations, will contribute as a reference for how a methodological roadmap can be constructed and analyzed, so that other relevant innovations may be mapped and tracked over time.

Notes

1. i.e. Research projects involving the analysis of just a few cases. Regarding the nomenclature, see Mahoney (2000) and Blatter and Haverland (2012). To get acquainted with the discussion on the differences between case-oriented research and variable-oriented research, see Rihoux, B. (2006). qualitative comparative analysis (QCA) and related systematic comparative methods: Recent advances and remaining challenges for social science research. *International Sociology*, 21 (5), 679-706.

2. To have an overview of these other methods, related to historical-comparative approaches, see seminal papers like Mahoney (1999, 2000) and Mahoney, J. (2004). Comparative-historical methodology. *Annual Review of Sociology*, 30, 81-101.

3. We also searched on ANPAD's database, but no results were found.

4. Moreover, these three databases are the ones singled out at the citation tracking field of "Plataforma Lattes" – from the "Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq)".

5. The other elements that separate the noun phrases from each other (e.g. verbs and adverbs – i.e. verb phrases) were not considered in the analysis. Corman *et al.* (2002) argue that noun phrases are not prone to ambiguity – differently from verb phrases, which are dependent from other elements to have their meaning properly qualified.

6. Arguments in favor of this form of calculation can be found in Corman *et al.* (2002). Specially, it is noted that the betweenness index is not usually correlated with word frequency – which is the most used index to search for important words in a text.

7. This assessment (i.e. innovative or not in relation to previous publications) was carried out on a qualitative basis and decided upon consensus by two research assistants.

8. Both the identification and the grouping of the analytical procedures were decided upon consensus by two research assistants.

9. In this paper, "themes" are considered to be concepts or constructs that underlie a group of words.

10. The innovative analysis-result combination distribution median was equal to 3.

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