Data Commentaries in Science and Engineering Research Articles

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Abstract

Data commentaries assume significance in shaping a research article. They accompany visuals in results sections of research papers. Their positioning in results sections of research reports is conventionally determined by discursive practices of a given discipline. In this paper, an attempt is made to understand how data commentaries in science and engineering research articles are discursively constructed. The paper discusses what data commentaries are and their relation to nonverbal materials, the way they are recognized as a subgenre of results sections, the move structure and the interface between visuals and data commentaries in science and engineering research articles.

Keywords: Data commentaries, non-verbal materials, move structure, results section.

Introduction

Nonverbal elements (NVEs) in science and engineering discourse are the visualizations in the form of graphs, tables, diagrams, figures, images, data plots, microscopic images, schematics, chromatographs/spectrographs, 3D models, photographs, pie charts, bar charts, etc. Research indicates that NVEs play an important role in 'the construction of knowledge and its communication across a range of contexts' (Curry, 2014, p. 87) in science and engineering discourse. One important medium through which new scientific knowledge gets communicated is research papers in journals. Though NVEs may be present in other sections of the research report, it is the results section that abounds with NVEs in various combinations of visual displays of results. Yet NVEs cannot speak for themselves. It is, therefore, necessary to have what are known as data commentaries (DCs) for directing the reader to the desired interpretation of NVEs.

Data commentaries are verbal interpretations of NVEs that draw the reader's attention to a) the background information of the NVE, b) location and summary of the visual, c) the most important findings in the visual, and d) comment on results presented in the visual. Both the NVEs and data commentaries in the results section of science and engineering research papers are interdependent and make non-linear reading paths (Sancho Guinda, 2012) as there is recursive interplay between the data commentary and the NVE in the communication of scientific knowledge generated (Curry, 2014), as a result of which the reader moves back and

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forth between text and graphics while figuring out 'the story of scientific discovery' (Stoller & Robinson, 2013, p. 49) in results sections. This interplay contributes to the multimodal nature of science and engineering communication.

Data Commentaries as a micro-genre

Since data commentaries 'do not belong to a clear-cut community of practice . . . and straddle between academic and professional domains'(Sancho Guinda, 2012, p. 168), they do not adequately qualify to have a full-fledged genre status. Following Martin's (1992; 1995) classification of macro-genre and micro-genre, the data commentary may be identified as a micro-genre for it comes as embedded in a macro-genre such as the 'Results Section' in a research paper. No matter whether the data commentary is an independent or embedded genre, both NVEs and data commentaries rarely occur in isolation as they share a symbiotic relationship between them.

Data commentaries have evolved from being mere paraphrase of data or *information transfer* in the 70s through the 90s (Swales & Feak, 1997). This evolution can also be tracked in the individual developmental stages of learning to write where individuals demonstrate movement from mere information transfer as '*knowledge telling'* to interpretation as '*knowledge transforming'* (Bereiter and Scardamalia, 1987) which involves explanation, hypothesis, prediction and the application to other situations. According to Sancho Guinda (2012), data commentaries encompass stages such as *graph framing* that indicate purpose and value, *data sorting* through sequencing and grouping, *data highlighting* through selection and *data discussion* in terms of interpretation. Interestingly, while graph framing provides the location of the visual and its summary statement for positioning in the text, data sorting, data highlighting and data discussion are the stages in which data reorganisation happens gradually from 'rearranging data to explanatory and forecasting interpretations' (Sancho Guinda, 2012, p. 167).

Information Transfer as an exercise for comprehension and composition of NVEs in ESP materials popularised by Widdowson (1973) simply puts the obvious information from the NVE into words rendering it redundant. Such a rendering is likely seen in some of the students' writing who may have little awareness of the purpose of interpretation in a research context. Data commentary, on the other hand, entails critical engagement of a student with the data in the NVE by performing a series of activities such as sequencing and grouping of data, selecting and highlighting the key findings, and explaining these key findings in terms of the hypothesis of the study, and discussing their implications for different contexts of relevance. For a learner to move from the stage of information transfer to the stage of data commentary, which demands demonstration of maturity in the form of conceptual abstraction, syntactic complexity and lexical density, the learner has to be scaffolded into disciplinary practices besides encouraging increasing participation in such valued practices. This sort of apprenticeship is warranted because the integration of NVEs and data commentaries involves handling the so called objective data in NVEs with subjectivity and creation.

While NVEs (visual representations of data) are 'work horses of argument' in science and engineering discourse (Poe, et. al., 2010, p. 115), data commentaries extract work from these horses (NVEs) and develop arguments by 'finding the right strength of claim in discussing

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the data' (Swales and Feak, 2012, p. 139). In writing data commentaries, the following are some of the tasks commonly undertaken (Swales and Feak, 2012, pp. 140-141):

- highlighting the results of research
- using the data to support a point or make an argument in your paper
- assessing theory, common beliefs, or general practice in light of the given data
- comparing and evaluating different data sets
- assessing the reliability of the data in terms of the methodology that produced it
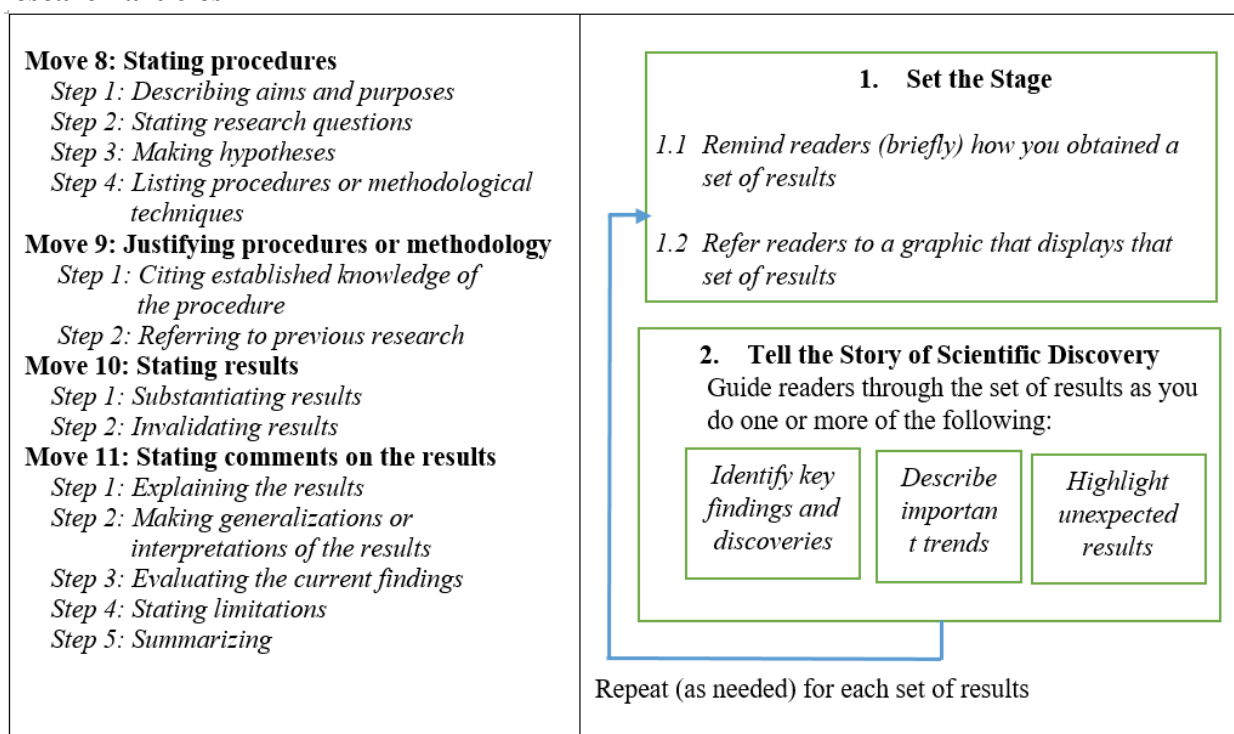- discussing the implications of the data
- making recommendations

NVEs, thus, act as work sites or portals from the data commentary to the visual argument.

Move structure of DCs in the results section of science and engineering research articles

Move structure of research articles across all four sections (introduction, methods, results, and discussion) is highly influenced by Swales' (1990) pioneering work on genre analysis. A move is a structural segment in a text that has a specific communicative function, which contributes to the overall communicative purposes of the genre. The move structure of the data commentary as a micro-genre across disciplinary fields, according to Swales (1994; 2012), usually includes three moves: 1) location elements and/or summary statements, 2) statements highlighting key findings from the data, 3) discussion of implications, problems, exceptions, recommendations, or other interesting aspects of the data. Moves are realized by one or more elements, which are denoted as *steps* (Swales, 1990), or *strategies* (Bhatia, 1993) or *submoves* (Stoller & Robinson, 2013). Data commentaries typify results sections in research papers as these sections present results in NVEs.

Though there have been a number of studies that have focussed on individual sections of research articles in various disciplines (e.g., Basturkmen, 2012; Bruce, 2009; Kanoksilapatham, 2012; Williams, 1999), it appears that few studies have focussed on the move structure of results sections in science and engineering research articles per se. However, a few studies have examined the move structure of full length research articles in science and engineering (e.g., Kanoksilapatham, 2005, 2015; Stoller & Robinson, 2013; Maswana, Kanamaru, & Tajino, 2015). Therefore, in this review, the move structure of results sections alone is considered to focus on the interface between NVEs and data commentaries which constitute the results sections in research papers. While Kanoksilapatham (2005) and Stoller & Robinson (2013) conducted a move analysis of the whole structure of a large number of *biochemistry* and *chemistry* research articles respectively, Kanoksilapatham (2015) and Maswana, Kanamaru, & Tajino (2015) performed a move analysis of the whole structure of a large number of *three* and *five* sub-disciplines of engineering research articles respectively. The sub-disciplines of engineering included in Kanoksilapatham were *civil*, *software* and *biomedical* engineering whereas in those included in Maswana, Kanamaru, & Tajino were *structural*, *environmental*, *electrical*, *chemical*, and *computer science* engineering. The following are the move structures of the results sections from the findings of these studies:

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Box 1A & 1B: Move structures of the results sections in biochemistry and chemistry research articles

Move 8: Stating procedures
  Step 1: Describing aims and purposes
  Step 2: Stating research questions
  Step 3: Making hypotheses
  Step 4: Listing procedures or methodological techniques
Move 9: Justifying procedures or methodology
  Step 1: Citing established knowledge of the procedure
  Step 2: Referring to previous research
Move 10: Stating results
  Step 1: Substantiating results
  Step 2: Invalidating results
Move 11: Stating comments on the results
  Step 1: Explaining the results
  Step 2: Making generalizations or interpretations of the results
  Step 3: Evaluating the current findings
  Step 4: Stating limitations
  Step 5: Summarizing

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1. Set the Stage

1.1 *Remind readers (briefly) how you obtained a set of results*

1.2 *Refer readers to a graphic that displays that set of results*

2. Tell the Story of Scientific Discovery
Guide readers through the set of results as you do one or more of the following:

| *Identify key findings and discoveries* | *Describe important trends* | *Highlight unexpected results* |

Repeat (as needed) for each set of results

Box 1A. Move structure of biochemistry research article results sections (excerpted from Kanoksilapatham, 2005, pp. 290-291)

Box 1B. Move structure of a chemistry research article results section (excerpted from Stoller & Robinson, 2013, p. 49)

Box 1C & 1D: Move structures of the results sections in civil, software, biomedical, and structural, environmental, electrical, chemical, and computer science engineering research articles

Move 7: Summarizing procedures
  Step 1: Briefing procedures
  Step 2: Justifying procedures
  Step 3: Defining terms
  Step 4: Referring to previous studies
Move 8: Reporting results
Move 9: Commenting results
  Step 1: Interpreting results
  Step 2: Explaining results
  Step 3: Comparing results
  Step 4: Exemplifying results
  Step 5: Cautioning limitations
  Step 6: Summarizing results
  Step 7: Directing future research

Move 7: Reporting results
  Step 1: Restating data analysis procedures
  Step 2: Restating research questions
  Step 3: Stating general findings
  Step 4: Stating specific findings
Move 8: Commenting on results
  Step 1: Interpreting results
  Step 2: Comparing results with previous studies
  Step 3: Evaluating results

Box 1C. Move structure of civil, software, and biomedical engineering research article results sections (excerpted from Kanoksilapatham, 2015, p. 82)

Box 1D. Move structure of structural, environmental, electrical, chemical, and computer science engineering research article results sections (excerpted from Maswana, Kanamaru, & Tajino, 2015, p. 6)

As can be seen from these boxes, all the studies have identified three aspects being common to all - restating methodological details, reporting results and commenting on results - that constitute the move structure of the results sections in the disciplines examined in the studies cited above. However, it can be observed that there is a variation in the number of moves that

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realize these three aspects. Kanoksilapatham (2005; 2015), who conducted the move analysis on both *biochemistry* and *civil*, *software* and *biomedical* engineering research articles, identified *four* and *three* moves with varying number of submoves respectively. By treating methodological details separately, she put them in two moves – **Move 8: Stating procedures** and **Move 9: Justifying procedures or methodology** - in biochemistry research articles whereas the same details when found in engineering disciplines, she combined and considered them as a single move - **Move 7: Summarizing procedures**. A possible reason for this combination may be that she would have realized such a possibility much later and would have incorporated it when carrying out the next study on engineering research articles. However, the move analysis studies by Stoller & Robinson (2013) and Maswana, Kanamaru, & Tajino (2015) mapped these methodological details with reporting results and thus identified only two moves configuring the move structure of data commentaries in the results sections of the disciplines studied. Of all the boxes presented above, Stoller & Robinson's (2013) box stands out as its moves and submoves are mapped and numbered in a flow chart reflecting the disciplinary conventions and the objective of the study, which was raising genre awareness among chemistry students and faculty as part of materials-development-project. The move structure identified in these boxes is in congruence with Swales' (1994, 2012) model of data commentary except for methodological details. This difference may be quite understandable as Swales' model is generic and not situated in any disciplinary context while the move structures depicted in the boxes above are all embedded in specific disciplinary contexts of science and engineering. It can also be observed in the boxes that the interface between NVEs and data commentaries can largely be established through the **Move: Reporting results**, which has come as a submove in Stoller and Robinson (2013).

Between biochemistry and chemistry results sections, it can be observed from Boxes 1A & 1B that there is variation not only in the number of moves but in the submoves as well. As discussed earlier and can be observed from the boxes too, the move structure of chemistry results sections include two moves whereas that of biochemistry results sections consists of four moves. In **Move 8: Stating procedures** in biochemistry and **Move 1: Set the stage** in chemistry**,** both results sections restate methodological details. In chemistry, this restatement is brief (Stoller & Robinson, 2013) while in biochemistry, it can be elaborate and can include four submoves such as a description of the study's aims and purposes, research questions, hypotheses, and/or list of procedures or methodological techniques (Kanoksilapatham, 2005) as indicated in Box 1A . This move is followed by **Move 9: Justifying procedures or methodology** in biochemistry with two submoves and the author comments that this is unique in biochemistry research articles. In sharp contrast to this, this move is not found in chemistry results sections as is evident in Box 1B (Stoller & Robinson, 2013).

Unlike in chemistry, as can be seen from Box 1A**, Move 10: Stating results** in biochemistry is realized as a full-fledged move and highlights the results obtained from the study and most often points the reader to a NVE and establishes the interface with the data commentary in two submoves: *Step 1: Substantiating results* and *Step 2: Invalidating results* (Kanoksilapatham, 2005). However, in chemistry results sections, reference to a NVE is made as a submove of **Move 1: Set the stage** (Box 1B) to establish the initial interface with the data commentary, and then, while narrating the story of scientific discovery in **Move 2,** frequent references to NVEs are made to present results which get realized though submoves such as *identify key findings*, *describe important trends*, and/or *highlight unexpected results* as is shown in Box 1B. Typically, **Move 2** of chemistry results sections do not include interpretation and reference to the previous literature as they are 'deferred until the

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Discussion section (although combined R&D sections blur this distinction)' (Stoller & Robinson, 2013: 54). In contrast to this, in biochemistry, results are commented on in **Move 11: Stating comments on the results** in as many as five submoves.

In biochemistry results sections, while all moves have cyclical patterning, **Move 10** remains not only as the core of a cycle but also gets repeated till the end of the discussion of data (Kanoksilapatham, 2005). In chemistry results sections, both the moves are repeated for each group of findings (Stoller & Robinson, 2013).

Box 1C and 1D depict the move structure of engineering results sections taken from full length research articles of two studies carried out by Kanoksilapatham (2015) and Maswana, Kanamaru, & Tajino (2015). As can be seen from Boxes 1C and 1D, while Kanoksilapatham, focusing on the move structure of three engineering sub-disciplines - *civil*, *software* and *biomedical* - identifies three moves: **Move 7: Summarizing procedures, Move 8: Reporting results, and Move 9: Commenting results**, Maswana, Kanamaru, & Tajino focussing on five engineering sub-disciplines - *structural*, *environmental*, *electrical*, *chemical*, and *computer science* identify only two moves - **Move 7: Reporting results and Move 8: Commenting on results.** Maswana, Kanamaru, & Tajino have considered restating data analysis procedures as a submove under **Move 7** whereas Kanoksilapatham has treated the same as an independent move with four submoves. In both the studies 'reporting results' is the obligatory move while restating procedure and commenting on results have a high rate of occurrence conventionally in these disciplines like biochemistry results sections. This finding contrasts with chemistry results sections where commenting on results is deferred till the discussion section. Also, both the studies report that the moves are cyclical when reporting individual or a set of results.

Drawing on various representations of the move structure of results sections from both science and engineering, Nordrum and Eriksson (2015; 2018) developed an integrated move structure model for results sections with three moves realized by several submoves stating that types and sequences of moves and submoves may vary between disciplines. The model is as follows:

Figure 1: Move structure of data commentaries (Nordrum and Eriksson, 2015, p. 69)
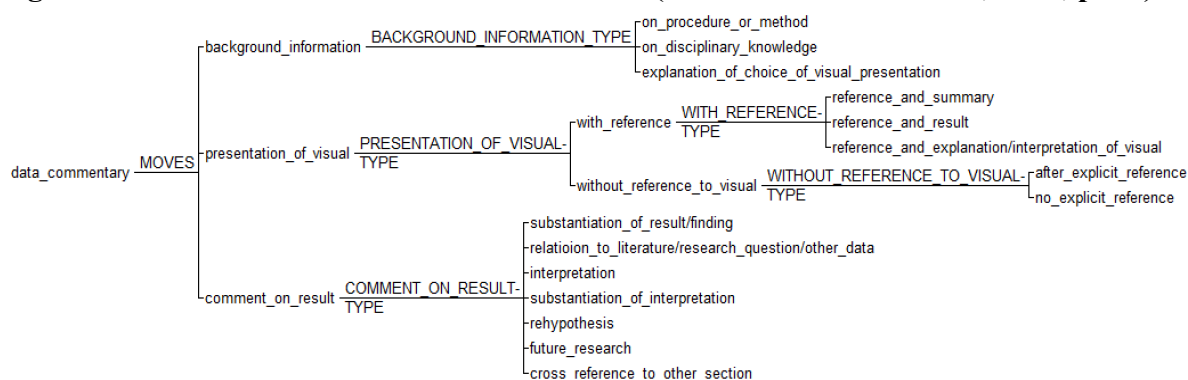
As can be seen from **Figure 1**, **Move 1: Background information (**though tends to be optional) is conventional in science and engineering with a high rate of occurrence in different combinations of three possible submoves of information. **Move 2: Presentation of**

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visual is what establishes the interface between NVEs and data commentaries and hence is obligatory in science and engineering results sections. This move can be realized either with reference to NVEs or without reference to NVEs. In cases where presentation of visual has reference to NVEs, the interface between NVEs and data commentaries is established in any one/two of the three or all three combinations of possible submoves in terms of locating the NVE and summarizing the NVE in an indicative statement, referring to the NVE and highlighting the key findings through an informative statement, referring to the NVE and explaining or interpreting the NVE. In cases where the presentation of the visual has no reference to the NVE, the interface happens either through explicit anaphoric reference or no explicit reference. **Move 3: Comment on results** is conventional in science and engineering results sections and concludes the results section by providing 'a channel for situating current findings in context' (Kanoksilapatham, 2015, p. 83). Though in disciplines like chemistry, comments on results are deferred till the end of the discussion section, in many other disciplines, this move has a high rate of occurrence (Kanoksilapatham, 2005, 2015; Maswana, Kanamaru, & Tajino, 2015; Basturkmen, 2009). This move, as can be seen from figure 2, can be realized in as many as seven submoves.

Interface between NVEs and data commentaries in science and engineering

In the previous section it was discussed that it is **Move 2: Presentation of the visual** in data commentaries that would guide the reader back and forth through the data in NVEs and thus establishes interface between the visual and the data commentary in the results sections of science and engineering research articles. It was also discussed that **Move 3: Comment on results** sometimes would draw the reader's attention to the data in the visuals. However, the central focus of the studies that were reviewed in the previous section was not the interface between NVEs and data commentaries. In this section, relevant literature relating to the interface between NVEs and data commentaries is reviewed though such literature is very sparse.

Though the centrality of the interaction between nonverbal elements and data commentaries in science and engineering research writing has been pointed out by many scholars (e.g., Swales & Feak, 1994, 2012; Poe et al 2010; Sancho Guinda 2011; Wharton, 2012; Roth, 2013) research into how the text (data commentary) accompanying the visual (NVEs) guides the reader back and forth through the data in the visual does not seem to have caught much scholarly attention.

It appears that there are relatively a few studies on this important area in science and engineering research writing. One study that is most relevant to the interface is the study by Busch-Lauer (1998). She investigated the relationship between the text and the visual in three medical research genres – research papers, review articles, and case reports - and found that the use of visuals was largely determined by the communicative purpose of the genre, the specialized nature of the text, and the experience of authors and their responsibility for the reader.

A few studies around the late 90s seemed to have taken interest in the topic but have focused on other aspects. A study by Palmer and Posteguillo (1997) examined nonverbal elements in research articles and found differences between those that appeared in journals, edited collections and conference proceedings. Another study by Miller (1998) compared science

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research articles with their popularizations in *Nature* and noted that images serve various functions in thematic structure in these two genres. Yet another study by Myers (1995) provided pedagogical implications of visual elements in a biology textbook whereas a study by Johns (1998) focused on the use of visual representation in student writing in macroeconomics reading and writing classes.

Recent work has put the data commentaries and visuals in focus though from a pedagogical perspective (Sancho Guinda, 2011, 2012; Nordrum & Eriksson, 2015; Eriksson & Nordrum, 2018). Drawing on the findings of the writing samples produced by her students in an ESP environment, Sancho Guinda makes a case for explicit instruction of visual data commentary for university students and claims that visual data commentary is a 'multi-skill and cross-disciplinary practice' (p.115). Nordrum & Eriksson (2015) propose an approach to teaching and learning of data commentary in science writing by integrating a small, specialized corpora of learner (master's theses) and expert texts (published research articles) annotated for move structure using the UAM corpus tool (O'Donnell, 2008). By integrating top-down discourse analysis with bottom-up corpus analysis, their work demonstrates how corpus-informed activities can be used for developing formative self-assessment practices of data commentaries. The type of corpus-informed activities includes 1) 'teacher-designed activities on moves in data commentaries, 2) teacher-designed peer-assessment activities for master's thesis corpus data, and 3) teacher-and-student-initiated activities involving students' own writing' (p.72). In another study, Eriksson & Nordrum, (2018) report research that has investigated the challenges of data commentary writing faced by students and supervisors of mater's theses in chemical engineering. Data have been collected by conducting a workshop for master's students on data commentary writing and by interviewing both the students and the supervisors about their challenges in writing data commentaries. The major findings include that students have difficulties with the selection of content and clarity and that there is a close connection between data commentary and disciplinary learning in chemical engineering.

Recent years have seen a growing interest in the possible applications of corpus for analyzing the move structure of academic genres, more particularly research articles as a genre. This is possibly because a specialized corpus has the affordance of providing relevant material, characterizing the language and move structure of different sections of research articles in a particular discipline, for example (Nordrum & Eriksson 2015). The studies reviewed in the previous sections have used small, specialized corpora. Kanoksilapatham (2005, 2015), Stoller & Robinson (2013) and Maswana, Kanamaru, & Tajino (2015) have used small, specialized corpora of biochemistry, chemistry and engineering research articles for investigating move structure of all four sections of research articles. Similarly, Chang and Kuo (2011) used a corpus of computer science research articles by combining top-down and bottom-up analysis for developing and evaluating online materials on a data commentary task.

Conclusion

The evolution from being a mere information transfer/data paraphrase to data commentaries/data interpretation is intricately tied to the discursive practices of a given discipline in which this subgenre is embedded. The move is driven by the fact that the commentary directs the reader to the way the visual presented in the results section needs to

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be interpreted guided by the purpose of the research article in focus. The interface between the visual and the data commentary that accompanies the visual seems to slightly vary from science and engineering research papers. A sense of how the interface between the visual and the data commentary gets established helps novice research scholars to shape the results sections in line with the disciplinary expectations so as to enable their legitimate and full participation in the activities of their respective discourse communities.

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