Title

The Structure of the Methods Section in Research Articles Across Eight Disciplines

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Abstract

There appears to have been little previous research into the structure of research article (RA) methods sections. This paper reports a corpus-based analysis of the communicative move structure of 288 RA methods sections across eight disciplines: physics, biology, chemistry, environmental science, business, language and linguistics, law, and public and social administration. Preliminary examination of the corpus found seven different moves, though not in all RAs or necessarily in this order: *overview*, *location*, *research aims/questions/hypotheses*, *subjects/materials*, *procedure*, *limitations*, and *data analysis*. A number of interdisciplinary differences were found in moves and move cycles, including clear differences between the sciences and other disciplines. The existence of move cycles in methods sections seems not to have been previously predicted.

Keywords: methods section; research article; genre analysis; research writing; communicative move

1. Introduction

Since Swales's (1981) discussion of communicative moves in research articles (RAs), a lot of attention has been paid to the move structure of introductions in academic writing, for example, Swales (2004) and Samraj (2005). However, little previous research has apparently examined methods sections, and there appears to be no model of its move structure.

The RA was chosen for this research because of its importance for the spread of academic knowledge. Berkenkotter & Huckin (1995) and Hyland (1996) call it the key medium for legitimating findings and disciplines. RAs are the preferred genre through which discourse communities communicate, and their unique language distinguishes different disciplines from each other (Williams, 1998). Corpus-based research is an increasingly popular tool for describing those codes (Williams, 2002).

A move is "a segment of text that is shaped and constrained by a specific communicative function" (Holmes, 1997, p. 325). A move cycle is a reoccurring move pair (or set). An example of a typical discussion section move cycle is *statement of result* □ *reference to previous research* (Dudley-Evans, 1994, p. 225). The standard method for classifying moves is the four-step procedure suggested by moves researchers Dudley-Evans (1994) and Holmes (1997, 2001), which was followed for the purposes of this research:

(1) look for organisation and patterns and identify moves and boundaries
(2) use sentence-level analysis
(3) assign all sentences to a move
(4) authenticate the classification by using two raters, who work independently and then compare their findings.

The aims of this study were to examine the move structure of RA methods sections and interdisciplinary variation, across eight disciplines: biology, chemistry, physics, environmental science, business, language and linguistics, law, and public and social administration. Our corpus included 288 RAs, 36 from each discipline.

2. The Move Structure of Methods Sections

While only a few authors seem to have investigated the move structure of RA methods sections, their results are important regarding our study because of their focus. Each author looked at a fairly small number of RAs from just one discipline. They are Brett (1994), 20 sociology RAs; Nwogu (1997), 15 medicine RAs; Lim (2006), 20 management; Kanoksilapatham (2005), 12 biochemistry; and Wood (1982), 10 chemistry. Results for the first three disciplines, sociology, medicine, and management, were almost identical: the structure was *data collection* → *experiment* → *data analysis*. Findings for biochemistry and chemistry were also very similar: the structure was *materials* → *equipment* → *procedure*. These similarities among certain disciplines are noteworthy, and led us to wonder if the same applies across a broader range of disciplines, thus the investigation reported in this paper. However, regarding comparing the results of this investigation to the previous research, three of the studies are not recent, and writing standards within disciplines may have changed, making comparison problematic. Therefore a direct comparison with our results is only possible for one discipline, chemistry.

The literature tends to downplay the importance of methods sections, but we feel they may be more important than the current research implies. Research writing guides such as Weissberg & Buker (1990) or Swales & Feak (2000) assert other methods section moves exist, including *overview*, *subjects/materials*, *location*, and *restrictions/limiting conditions*. Somewhat less important, though still useful for our study, is previous theorizing on the function, importance, and length of methods sections. Science methods sections have been described as "enigmatic, swift, presumptive…with little statement of rationale or discussion" (Swales, 1990, p. 170). Swales (2004, p. 220) adds that they are "heavily clipped," explaining that this may happen because authors assume their readers already possess sufficient knowledge. Regarding the humanities, Swales (1990) claims they have a more careful step-by-step description of method. However, perhaps the usefulness of these suggestions—that science methods sections are becoming de-emphasized and shorter—is limited because they are based on looking at relatively few RAs. They also differ from Gledhill (2000), at least regarding one discipline: he measured the four sections Introduction-Method-Results-Discussion (IMRD) of 150 cancer RAs and found

methods to be 32 percent of the total[1]. Gledhill's (2000) findings, followed by a preliminary reading of a few methods sections in our target disciplines, led us to wonder if the assertions that methods sections are of lesser importance really are true.

The above descriptions of the move structure and function of methods sections may lead us to think that writing them is relatively uncomplicated, but this is not the case (Swales, 2004). This may be particularly true for non-native speakers (NNS) (Paltridge, 1993; Wood, 2001), and if so NNS will have real difficulties publishing within their discourse communities research writing is not easy for native speakers (NS) either. These difficulties will be even more acute if, as Vassileva (1997) asserts, NNS research writers tend to be unaware of genre conventions, and these conventions probably differ across disciplines.

While all of the above suggests that NNS and NS research writers need to know the move structure of methods sections, few studies have investigated their structure, and they examined only a small number of RAs from a few disciplines. Other authors describe function or length and importance, though they looked almost exclusively at the sciences. We suggest that the area has not received the attention it deserves, that NNS in particular need help with research writing, and that our research may help by providing profiles of methods sections in a number of disciplines. There have recently been calls for further research; Lim (2006) asserts that methods sections are crucial and that we need to look at their generic structure, which has been neglected in the sciences. Kanoksilapatham, referring to all disciplines, states that there is still no clear model because methods sections have received "scant attention" (2005, p. 287). Also, while move cycles appear in RA discussion sections—Dudley-Evans (1994) describes them as important, and Swales as "well-established" (1990, pp. 172-74)—they seem not to have been observed or predicted in methods sections.

We suggest that further empirical research into methods sections is needed, and that such research should use larger corpora to assess variation across a wide range of disciplines. The findings may tell us much about the true nature of methods and also allow teachers of research writers to inform learners of typical move sequences and cycles.

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[1]**Notes**

[1] He included titles and abstracts in his count, so we recalculated his data to exclude these and only include the four sections IMRD.

3. Methodology

This study examined communicative moves in 288 RA methods sections across eight disciplines: biology, chemistry, physics, environmental science, business, language and linguistics, law, and public and social administration. As previous models differ, methods sections were searched using the move names and not models proposed by the five previous researchers who investigated method section move structures (Brett, 1994; Nwogu, 1997; Lim, 2006; Kanoksilapatham, 2005; Wood, 1982) or the writing guidebook authors (Weissberg & Buker 1990, Swales & Feak 2000).

The aims of this research were to:

(1) Examine the move structure of RA methods sections across eight disciplines.

(2) Examine interdisciplinary variation in RA methods sections.

(3) Compare the move structure to previous models and provide new descriptions.

4. The RA Corpus

The corpus comprised 288 published RAs, 36 from each discipline. The disciplines were selected because they represent a wide range of academic subjects and also contain large numbers of research writers in this writer's university and around the world. Researching these disciplines may increase the usefulness of this research regarding recommendations for teaching. Also, previous research into method sections, apart from Wood (1982), did not cover these disciplines. Six leading refereed journals were chosen from each discipline. Four were taken from law as it was not possible to find six journals that contained empirical data-driven RAs. We visited the relevant academic departments and asked two informants from each discipline to name ten leading journals in their field. The 46 journals are listed in the Appendix. We note that the journals represent variation within individual disciplines. For example, within language and linguistics there is variation in the objects of study between *English for Specific Purposes* and the *Journal of Neurolinguistics*. Another example is public and social administration and the different research strands represented by *Evaluation and Program Planning* and *Social Science & Medicine*; this is probably also true for other disciplines. This variation was unintentional. That these sub-discipline variations could influence the structure of methods sections may be a factor in this research.

Six RAs from 2000/2003 were randomly selected from each journal. This was done by giving each RA a number and drawing six numbers for each journal from a box. Only empirical data-driven RAs with an explicit Introduction-Method-Results-Discussion format were selected, to allow comparison of moves. Review essays, discussions, and RAs by writers already selected were not used. The corpus size was 288 RAs, much larger than in previous studies. We suggest that the disciplinary corpora are acceptably representative because of their size and because of the use of expert informants to select journals. We realise that our corpus is heterogeneous in that it covers eight disciplines, yet we could not avoid this in order to examine interdisciplinary variation. Also, we found considerable parallels in the function of moves across disciplines, as we shall see below. For example, the common move *procedure* functioned in every discipline to describe the data-collection actions taken by the researcher/s.

We thus satisfied Sinclair's (2005) requirement for corpus building, which is to build corpora according to communicative function.

5. Classifying Moves in the Corpus

Two raters were involved in this procedure—the researcher himself and a local university lecturer who has an MA in Applied Linguistics and knowledge of RA move structure. Classification was done using the standard methods described above (Dudley-Evans, 1994; Holmes, 1997, 2001, p 1): Look for organisation and patterns, identify moves and boundaries; (2) use sentence-level analysis; (3) assign all sentences to a move; (4) authenticate the classification by using two raters, who work independently, and then compare their findings. Sentence-level analysis means looking at individual sentences and to be aware that a single sentence can constitute one move. Using steps 1, 2, and 3 to identify and classify moves (step 4 is an added safeguard) was recommended or used by several previous theorists on and researchers into moves (Brett, 1994; Kanoksilapatham, 2005; Samraj, 2005).

The first stage of our analysis was a thorough examination of the corpus. As noted above, this search used the move names, but not models, suggested previously. We found that seven different moves occur, though not in all RAs or in this order: *overview*, *location*, *research aims/questions/hypotheses*, *subjects/materials*, *procedure*, *limitations*, and *data analysis*. Our assertion that seven different moves occur means that we found seven functions within method sections in the entire

corpus. We will now define the function of and exemplify all these moves. Typical examples, all quoted from our corpus, are included below.

Overview. This move gives a brief overview of the research method, at the start of or early in the methods section. For example:

This study examined the portrayals of police officers and criminals in this context, paying specific attention to racial representations and the use of force by police officers. (Law)

Research aims/questions/hypotheses. This move describes the goals of the research and the questions to be answered, and outlines the hypotheses if any. For example:
The aims of the evaluation study were to determine whether "enhanced" serves as a bridge to substance abuse treatment, care for HIV disease, and other services. (Public and social administration)

Subjects/materials. This move describes *subjects* in business, language and linguistics, law, and public and social administration, and *materials* in the sciences. *Subjects* are the people or organizations from whom data were collected. *Materials* are the equipment and supplies used during the research. An example of *subjects* follows:
The subjects involved in this study were 12 Japanese university students (six men and six women, average age approximately 20 years). (Language and linguistics)
An example of *materials* follows:
All solutions were prepared with de-ionized water (18 M cm-1) from a Milli-Q analytical reagent-grade water purification system (Millipore, Bedford, MA). (Chemistry)

Location. This move describes the research site, the geographical location where the research took place, occasionally with reasons why that site was chosen. For example:
The 59.8 km2 catchment of the Aar River in the south-eastern Lahn-Dill hill-country was chosen as the test area because it reflects a representative sample of the region. (Environmental science)

Procedure. This move describes the data-collection actions taken by the researcher/s. For example:

Colonies were then lysed on the membrane by freeze-thaw, then incubation with lysozyme (4 mg/ml). (Biology)

Limitations. This move describes the ways in which the research was restricted or limited, sometimes with reasons for the limitation/s. For example:
However, modelling such a complex structure is difficult because the variables are nested within one another. (Business)

Data analysis. This move describes how the data were analysed, the analysis method. For example:
All performances were scored at the time of the interview by the interviewer and the observer, using the analytic rating scale developed for the Foreign Services Institute (FSI) speaking test. (Language and linguistics)

To put steps 1, 2, and 3 into practice, we identified sentences which matched the above definitions. For example, to identify *procedure*, we searched for sentences which describe the data-collection actions taken by the researcher/s; to identify *data analysis* we looked for sentences which described how the data were analysed. We classified all moves by examining the move structure of all 288 RAs in terms of the above seven moves. First, the researcher classified all moves, and second, to measure inter-rater agreement, the second coder independently evaluated 60% of methods sections. The third procedure measured intra-rater agreement. Two weeks after the initial classification, the researcher randomly selected six RAs from each discipline and classified them again. Inter-rater and intra-rater agreement scores were then calculated by measuring correlations between the results using Statistical Package for the Social Sciences. Both were over 90 percent: the former was 91%, the latter 97%. We found little inter-rater or intra-rater disagreement once we had agreed on the definitions and functions of the seven moves. Steps 1, 2, and 3 had to be done using a purely manual search of the corpus, as the seven moves were expressed using a great variety of words. There appear to be no keywords or collocations for the expression of moves which would have allowed us to identify moves through an automatic search.

6. Results

The average number of moves per methods section was 6. This varied by discipline: biology 7, chemistry 6, physics 4, environmental science 8, business 7, language and linguistics 5, law 6, and public and social administration 6.

A number of marked differences were found in the moves used, move cycles, and methods section structure between three of the sciences, biology, chemistry, and physics and the four non-sciences. The differences between the two groups were fairly striking, and we will therefore present the results separately in order to highlight this dissimilarity between the three sciences listed above and the four non-sciences. Environmental science differed in several ways from all the other disciplines, and therefore those results will be presented independently.

Some representative examples of the typical moves from each discipline were given above. Those which were not will be presented below.

6.1. Overall Frequency of Individual Moves

We noted above that sub-discipline variation might affect the structure of methods sections. However, we found greater variation in moves and move structure *between* individual disciplines than *within* them. Table 1 below shows interdisciplinary differences in the overall move frequency: that is, the percentage of each move across the three sciences and the four non-science disciplines. For example, *procedure* made up 41% of all the moves found in biology, chemistry, and physics. The left column shows move names:

Table 1. Overall Move Frequency: Interdisciplinary Differences (%)

Moves	**Biology, chemistry, and physics**	**Interdisciplinary differences (%) for business, language and linguistics, law, and public and social administration**
Subjects / materials	29	20
Location	3	11
Procedure	41	35
Data analysis	25	12
Limitations	0	5
Research aims / questions / hypotheses	0	7
Overview	0	9

Biology, chemistry, and physics. Table 1 shows that the three most frequent moves were *procedure*, 41% of all moves, *materials* (29%), and *data analysis* (25%). These made up 96% of all moves. *Limitations*, *research aims/questions/hypotheses*, and *overview* were very rare. Location was rare, making up only 3% of all moves. Most were in biology, none in physics.

Business, language and linguistics, law, public and social administration. We see that the three most frequent moves were *procedure*, 35% of all moves, *subjects* (20%), and *data analysis*, 12%, less than half as frequent as in the three sciences above although in contrast with them, these made up only 68% of all moves. However, the variety of moves was greater than in the three sciences. *Location* was much more common, making up 11% of all moves. *Limitations*, *research aims/questions/hypotheses*, and *overview* were also much more prevalent, making up 5%, 7%, and 9% of all moves respectively.

6.2. Frequency of Appearance of Individual Moves

Only *procedure* appeared in all 288 RAs. Table 2 shows interdisciplinary differences in move frequency: that is, in how many percent of RAs the move appeared. For example, *materials* appeared in 97% of biology RAs:

Table 2. Frequency of Appearance of Individual Moves: Interdisciplinary Differences (%)

Moves	Biology	Chem.	Physics	Environ. Science	Business	Lang. & Ling.	Law	Public & Social
Subjects / materials	97	100	75	31	92	94	86	86
Location	36	8	0	67	47	58	58	75
Procedure	100	100	100	100	100	100	100	100
Data analysis	86	100	67	78	72	67	56	50
Limitations	6	0	0	69	44	19	28	6
Research aims / questions / hypotheses	3	0	6	11	36	22	58	67
Overview	3	0	0	50	25	19	42	54

Biology, chemistry, and physics. Table 2 shows that *materials, procedure*, and *data analysis* were very frequent, *materials* and *data analysis* less so in physics. *Location* appeared more often in biology.

Environmental science. Compared to the other three sciences, *materials* appeared far less frequently, 31%, while *location*, *limitations*, and *overview* were much more common at 67%, 69%, and 50% respectively.

Business, language and linguistics, law, public and social administration. Table 2 clearly shows that the variety of moves was greater than in the three sciences. *Data analysis* appeared in only 61% of RAs, compared to 84% of RAs in the three sciences. However, *location* was found in 60% of RAs. *Limitations, research*

aims/questions/hypotheses, and *overview* appeared in 24%, 46%, and 38% of RAs respectively.

There were individual discipline differences. *Location* was in only 47% of business RAs, whereas *data analysis* and *limitations* were in 72% and 44% respectively. *Research aims/questions* appeared in only 22% of language and linguistics RAs, and *overview* in 19%. Public and social administration used *location*, *research aims/questions*, and *overview* more frequently (75%, 67%, and 54%), and *data analysis* and *limitations* less frequently, in 50% and 6% of RAs respectively.

6.3. Move Cycles and Move Structure

Move cycles were common. The cycles, and overall structure, differed between the three sciences and other disciplines.

Biology, chemistry, and physics. Only two cycles were found, *materials* → *procedure* and *procedure* → *data analysis*. These made up 53% and 47% of all cycles, respectively. Repeated cycles were common: 50% of RAs had two or more of the cycle *materials* → *procedure*, and 37% had two or more of *procedure* → *data analysis*. 69% of RAs opened with *materials* → *procedure.* Some biology RAs opened with *location*, and 75% closed with *procedure* → *data analysis*. Some physics RAs closed with *materials* → *procedure*.

The typical move structure was *materials* → *procedure* → *materials* → *procedure* → *procedure* → *data analysis*.

Business, language and linguistics, law, public and social administration. Move cycle structure was much more complex, and a greater number of cycles were found. The most common cycle was *procedure* → *data analysis*, which made up 24% of all cycles and appeared in 53% of RAs. The second commonest was *subjects* → *procedure*, making up 23% of all cycles and appearing in 50% of RAs. Two other common cycles were *subjects* → *location* and *location* → *procedure*: these made up 17% and 16% of all cycles, and appeared in 44% and 41% of RAs respectively. Other less common cycles were *research aims/questions/hypotheses* → *procedure*, *procedure* → *limitations*, and *overview* → *procedure*; these appeared in 17%, 16%, and 12% of RAs respectively. Repeated cycles were rare; the commonest was *subjects* → *procedure*, but this cycle was repeated in only 8% of RAs.

92% of RAs opened with either *subjects, procedure, research aims/questions/ hypotheses* or *overview*, but none of these dominated. The most frequent opening cycle was *subjects* → *location* in 15% of RAs. Another 13% opened with *procedure* → *subjects*, and 12% with *overview* → *procedure*. 83% closed with either *procedure* or *data analysis*; common closing cycles were *procedure* → *data analysis*, 47% of RAs, and *subjects* → *procedure*, 20%.

The typical move structure was *subjects* → *procedure* → *location* → *procedure* → *data analysis*.

6.4. Individual Disciplines

Representative examples of the typical moves from each disciplinary corpus are given (i.e., those which were not given above, in section 2.2). The variations found in individual disciplines will be described below:

Biology and chemistry. Methods sections were remarkably similar within and across these two disciplines. They were very uniform and standardised, and authors gave very precise and detailed descriptions of *materials*, including their origin. Authors often referred back to previous studies: e.g., "we used their method," and sometimes highlighted innovations. Chemistry RAs, however, contained far more details of *data analysis* than did biology RAs.

The typical move structure in biology and chemistry was *materials* → *procedure* → *materials* → *procedure* → *materials* → *procedure* → *data analysis*.

Example moves from biology follow:

Materials:

PEG 4000 (molecular weight distribution of 3500-4500), NaH2PO4 and Na2HPO4 were obtained from Merck, Germany.

Data analysis:

The data sets were tabulated as a time series (distance between pairs of GFP dots as a function of time).

An example from chemistry follows:

Procedure:

Elution of mercury(II) content in foam column was achieved quantitatively by percolating 100 cm3 acetone at 5 cm3/min flow rate.

***Physics*.** Methods sections were very similar to those in biology and chemistry, though shorter, and were also standardised across the discipline. Authors also tended to refer back to previous studies regarding method. However, while the majority opened with *materials* → *procedure* and closed with *procedure* → *data analysis*, fewer did than in biology and chemistry. Physics methods sections contained much more on physics theory, and on the mathematical models that the authors employed, than did the other sciences.

The typical move structure was *materials* → *procedure* → *procedure* → *data analysis*.

Examples from physics follow:

Materials:

The alloy Ti-6Al-4V was used in the form of cylindrical billets, fabricated by cold- and hot-isostatic pressing of elemental powders by Dynamet Technology (Burlington, MA), as described in [28].

Data analysis:

The energies of the ground and core-ionized states were calculated at the Hartree–Fock level, using the norm-extended quadratically convergent SCF [17 and 18] method.

Environmental science. Methods sections were longer and more complex than in any other discipline, and also differed in structure as noted above in 3.2. However, as in the other sciences, they were precise and detailed.

The typical move structure was *location* → *overview* → *procedure* → *limitations* → *procedure* → *data analysis* → *procedure* → *data analysis*.

Examples from environmental science follow:

Overview:

In December 1991 a 3-way factorial experiment was set up to examine the relationship between original stem size, cutting height, and post-harvesting pruning on resultant coppice yield.

Procedure:

The bales were stored in three stores located 8, 10, and 12 km away from the heating plant, respectively.

Data analysis:

All data were tested for normality (Proc Normal; SAS Institute, 1994) and homogeneity of variances (Levines test; Steel & Torrie, 1980).

Business. More explanation/description of the data-collection method was given than in the sciences and also more justification. *Hypotheses* were sometimes given, and also, less often, the cycle *data analysis* → *limitations*, found only in this discipline.

The typical move structure was *procedure* → *subjects* → *location* → *procedure* → *limitations* → *procedure* → *data analysis*.

Examples from business follow:

Procedure:

The subjects, who are managers from one selected industry (the plastic processing industry), were each assigned to one of the eight treatments.

Subjects:

The main survey was conducted among firms which had some (however limited) experience of supply chain partnering.

Data analysis:

Data was processed with LISREL (Joreskog & Sorbom, 1993), which is a structural equation modelling technique frequently used in marketing research.

Language and linguistics. This discipline had the shortest and simplest methods sections among the four non-science disciplines. There was some emphasis on innovation.

The typical move structure was *subjects* → *location* → *procedure* → *data analysis*.

Examples from language and linguistics follow:

Location:

…at the Department of Applied Psychology, Okayama University, Japan.

Procedure:

The interviews were videotaped and audio taped. The interview format was structured, with two parts, the first part being designed to elicit short answers, while in the second part the subject was expected to produce longer responses.

Law. Methods sections often opened with *overview*. Two cycles, *hypotheses* → *subjects* and *overview* → *hypotheses*, were found only in this discipline. They appeared in about 30% of RAs.

The typical move structure was *overview* → *subjects* → *location* → *procedure* → *procedure* → *data analysis*.

Examples from law follow:

Subjects:

A two-week sample of primetime television (8–11 p.m., EST) was constructed in the fall of 1997.

Procedure:

Analyses were conducted at the character level. Every police officer (*n*=393) was coded, whether in plainclothes or uniform.

Data analysis:

The reaction to or initiation of force was measured as either retaliatory force or initiating force.

Public and social administration. *Procedure* was often long, and involved descriptions of multiple methods, described sequentially. And as noted above in 3.2, the discipline showed a greater use of *location, research aims/questions*, and *overview* and lower use of *data analysis* and *limitations*.

The typical move structure was *overview* → *research aims/questions* → *subjects* → *location* → *procedure* → *data analysis*.

Examples from public and social administration follow:

Subjects:

The sample consisted of 194 child protection officers from all over Israel.

Location:

Such officers are appointed by the Ministry of Labor and Welfare, and are employed by the social service departments of the country's municipalities.

Procedure:

The child protection workers were asked to fill out all three questionnaires on two children, between 3 and 13 years old, with whom they had dealt in the previous 6 months.

Data Analysis:

MANOVAs and Univariate ANOVAs were carried out to examine the continuous variables.

Finally, while testing the assertions of Swales (1990, 2004) that RA methodology sections are becoming shorter would require investigation of changes over time, we did measure their length. They made up 25% of RA length[2]. Table 3 below shows interdisciplinary differences.

Table 3. Length of Method Sections as a Percentage of the Whole RA: Interdisciplinary Differences

Biology	**Chemistry**	**Physics**	**Environ. Science**	**Business**	**Language and Linguistics**	**Law**	**Public and Social Admin.**
23	18	21	44	28	24	19	22

Environmental science had much longer than average methods sections, and chemistry shorter. There was little variation within individual disciplines, though we found a few exceptions; the *International Journal of Research in Marketing* had much longer methods sections (42%), while *International Business Review* and *Acta Materialia* had much shorter methods sections, 19% and 10%, respectively.

7. Discussion

Only one move, *procedure*, appeared in all 288 RAs. However, two other moves were extremely common in biology, chemistry, and physics: *materials* and *data analysis*. *Subjects* and *data analysis* were important in business, language and linguistics, law, and public and social administration, *data analysis* somewhat less so. Also, RAs from these disciplines had a greater range of moves: *location*, *limitations*, *research aims/questions/hypotheses*, and *overview* appeared often. Additionally we found move cycles to be almost universal, and repeated cycles fairly important in three of the sciences, although the type and order of cycles differed sharply between the three sciences and the four non-science disciplines, and to a lesser extent among the latter. None of these seems to have been predicted previously, and the discovery of these

[2] The lengths of other sections were: Introduction 20%, results 29%, discussion section 26%.

clear differences allowed us to present discipline-specific descriptions. We suggest that our finding of greater variation in moves and move structure between individual disciplines than within them indicates some disciplinary conformity and increases the value of the descriptions.

Regarding the *structure* of the methods sections, our findings differ from previous work. They do not match Wood (1982), who did not mention *data analysis* or move cycles, perhaps because our corpus was larger, or Brett (1994), Nwogu (1997), Lim (2006), or Kanoksilapatham (2005), who investigated different disciplines. However, regarding the *function* of methods sections, our findings do confirm the usefulness of some previous descriptions. We did find Swales's (1990) hypotheses to be partially accurate for biology, chemistry, and physics methods sections in that they tend to rely on shared knowledge and have "little statement of rationale or discussion" (1990, p 170); and for business, language and linguistics, law, and public and social administration in that they are a more careful step-by-step description of method. On the other hand, we did not find that methods sections are short. In our corpus they were usually complex and occupied an average of 25% of RA length. This indicates that they remain important to readers.

It is not easy to explain the differences across disciplines. Our findings indicate a number of clear differences in move structure between the three sciences and the four non-science disciplines. In biology, chemistry, and physics the three moves *materials*, *procedure*, and *data analysis* were all-important, and only two move cycles were found, sometimes repeated: *materials* □ *procedure* and *procedure* □ *data analysis*. Business, language and linguistics, law, and public and social administration had a greater variety of moves, including *location*, *limitations*, *research aims/questions/hypotheses*, and *overview*; and move cycle structure was different across articles and more complex. There were also less important differences between these four disciplines, and environmental science differed from all other disciplines. We believe that the disciplinary differences in moves, move cycles, and methods section structure that we found inform us about disciplinary norms, and that the patterns revealed are accepted within the relevant discipline as being the recognized way for writers to present their methods. Based on the results from our corpus, it is evident that in biology, chemistry, and physics it is very important for authors to let their readers know full details of *materials*, *procedures*, and *data analysis*. We went back to our corpus to try to find out why these and only these details are covered in

methods sections in these three sciences. It became apparent that the research very often involved detailed investigations of extremely complex materials and substances, the origin of which was important for readers to know. In environmental science, on the other hand, we found that it is important to describe *location*. On further investigation of this corpus we found that a thorough description of the site where the research took place (which was very often farmland, river systems, wetlands, or industrial areas) is of prime importance to understand the research context and results, and conclude that this information is certainly needed by readers. All these are examples supporting Hyland's (2000) suggestion that RA authors need to "project an insider ethos" (p.78). This is similar to his earlier proposal that discipline differences reflect rhetorical constraints within a discipline (Hyland, 1999). No doubt RA authors, who face considerable pressure to publish, must therefore look for acceptance among editors and readers, and face sanctions such as rejection if they step outside discipline conventions. If much depends on publication, sanctions must strongly motivate authors to follow discipline conventions. The need to gain this acceptance may mean there is a discrepancy between laboratory facts and facts as presented in RAs. This discrepancy, and the idea of writing as a social act, is also addressed in social construction literature; Berkenkotter & Huckin call writers "social actors" (1995, p. 24), and Latour & Woolgar (1986) say scientists present claims as fact and construct reality to increase credibility. This leads to questions about research writing: What is this insider ethos, what are these rhetorical constraints and discipline conventions, and do authors follow them? Our answer based on the results, especially our finding of much greater variation between disciplines than within them, is that among these conventions is the structure of methods sections, and that authors do follow these conventions. We suggest that the writers in our corpus are trying to maximize objectivity with their standardized presentation of facts.

In business, language and linguistics, law, and public and social administration, along with *materials*, *procedures*, and *analysis methods*, these discipline constraints mean that details about the *subjects* are also required, and sometimes also *limitations*, *research aims/questions/hypotheses*, and/or a research *overview*. Other individual discipline differences seem relevant. In business (and sometimes in language and linguistics), it is presumably important to let readers know the *limitations* of the research. We returned to our business corpus to try to find out why this is the case, and also why *location* appears less often and *data analysis* more often. It became

evident that the business RAs often explored mathematical models where the origin of the model (and thus location) is a less important factor, whereas analysing problems with the model, and the output of the model, are more central to the argument. We also revisited our public and social administration corpus to investigate why *location* is more frequent, and *procedure* longer and more complex, than in the other non-science disciplines. We found that the research often took place in unique communities and that it is important to describe the differences in these communities in detail, and also that research *procedures* were sometimes extensively modified for these communities. In public and social administration (and sometimes in language, linguistics and law), it is also a discipline convention to state *research aims/questions* or *hypotheses*; and in law and public and social administration to open with *overview*. We suggest that these individual discipline rules (as Swales, 1990 suggests) reflect differences between individual discourse communities, as well as agreement about the appropriate structure of methods sections inside individual disciplines.

8. Conclusion

The discipline-specific descriptions of methods sections may be useful in that they are based on a large corpus, and one such use may be for teaching. Implications for teaching fall into two different areas, the learning of move structures and the acculturation process of student socialisation into their chosen discipline (Ferenz, 2005). Regarding the first area, we propose knowledge of move structure is important for the teaching of research writing, particularly since teaching a subject through a focus on moves is an appropriate approach according to Dudley-Evans (1997). The findings of this study indicate move structures in methods sections vary between disciplines, and therefore discipline-specific teaching of method section structure may be appropriate. Additionally, sensitivity to interdisciplinary variation is required for teachers of research writing. While little has been written on teaching move structures, a first step to teaching them is to understand how communicative functions are linked to linguistic features (Lim, 2006).

Regarding the teaching of move structures to students involved in research writing, the following steps may prove useful to classroom teachers:

1. Introduce students to the concept of communicative moves and check if they know what they are. If not, at this stage use examples from step 4 below for

illustration. Discuss how common moves are, why they are necessary, and how they function

2. Tell students the names of the three moves found in their discipline's methods sections, such as *materials*, *procedure*, and *data analysis*.
3. Tell students the function of each move; *materials* describes the equipment and supplies used during the research, *procedure* describes the data-collection actions taken by the researcher/s, and *data analysis* describes how the data were analysed.
4. Provide examples of moves for *materials*, *procedure*, and *data analysis*
5. Tell students what move cycles are and note those that are common to their discipline, such as *materials* □ *procedure* and *procedure* □ *data analysis* in chemistry, and share the common patterns that RAs open and close with.
6. Show students sample methods sections from their disciplines to act as models. Swales (1990) calls this a necessity, and we agree[3]. Mark the moves for students in the examples.
7. Ask students to read other (unmarked) methods sections and ask them to mark and name the moves.
8. Tell students the methods used in another RA from their discipline, listed in point form, and ask them to write the methods section, in prose using appropriate subheadings. Regarding the second area, the literature on academic writing contains a number of suggestions for facilitating student acculturation into a discipline, which we suggest making part of research writing courses. One such suggestion is appointing mentors for students who can encourage them to participate in disciplinary activities and who the students can identify with (Tardy, 2005). Another option is to promote interactions between students and the academic discourse community (Ferenz, 2005; Lea & Street, 2000), such as through participating in conferences.

[3] Swales further suggests we look at these and see where they fall on the scale between "heavily clipped" and "highly elaborated" (2004: 224).

However, for students to be successful we need to provide them with the necessary linguistic skills to effectively join the discourse of their discipline (Stierer, 2000). Since all writing occurs within a social context, it is our responsibility as educators to make our students aware of that context (Koutsantoni, 2006).

9. Finally, we suggest that this exploratory study is limited in that we did not conduct informant interviews to investigate why these discipline differences occur. Future studies may check this, and also add additional disciplines to their investigations.

Summarising, analysis of our large corpus found a number of differences in the structure of RA methods sections across eight disciplines. In particular, we found differences between three of the sciences, environmental science, and the other four disciplines, and put forward methods section descriptions for eight individual disciplines. We hope that this research has added to the knowledge of genre conventions in academic writing and that these findings improve our understanding of RAs. We also hope that the findings have relevance for the teaching of research writing, and help teachers and course designers prepare discipline-specific courses for students.

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Appendix A. Journals in the Corpus

Biology

Applied Soil Ecology

Biochimica et Biophysica Acta

Biomass and Bioenergy

Chemistry and Biology

Current Biology

Journal of Biotechnology

Business

Industrial Marketing Management

International Business Review

International Journal of Project Management

International Journal of Research in Marketing

Journal of Business Venturing

Journal of Operations Management

Chemistry

Analytical Biochemistry

Analytica Chimica Acta

Corrosion Science

International Journal of Inorganic Materials

Journal of Chemical Thermodynamics

Journal of Solid State Chemistry

Environmental Science

Applied Energy

Atmospheric Environment

Biomass and Bioenergy

Ecological Modelling

Environmental Pollution

Global Environmental Change

Language and Linguistics

English for Specific Purposes

Journal of Neurolinguistics

Language and Communication

Language Sciences

Speech Communication

System

Law

California Law Review

Canadian Journal of Criminology

International Review of Law and Economics

Journal of Criminal Justice

Physics and Material Science

Acta Materialia

Chemical Physics

International Journal of Fatigue

Journal of Luminescence

Journal of the Mechanics and Physics of Solids

Physica C: Superconductivity

Public and Social Administration

Child Abuse & Neglect

Evaluation and Program Planning

Habitat International

International Journal of Public Sector Management

Social Science & Medicine

World development