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How and why: Recontextualizing science explanations in school science books.

Volume 1

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A thesis submitted in fulfilment
of the requirements for the degree of
Doctor of Philosophy

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June, 1995

Abstract

This study extends systemic-functional linguistic accounts of explanation genres in school science books with a view to enhancing explicit, linguistically-based pedagogies, which see students' learning of science as concomitant with their learning to control the semiotic resources that construe scientific knowledge. The study has two main interrelated concerns. The first is a clarification and extension of recent functional linguistic work describing different types of explanation in school science books. The second is an account of the linguistic variation within and across such explanation types and a comparison of this variation across junior secondary school textbooks and information books used by children in the upper primary school.

A total of eighteen texts were analysed comprising three explanations in each of three Fields taken from contemporary secondary school science books and information books for primary school students.

The analyses provide some linguistic evidence to support the distinction of at least three agnate explanation genres: transformational, realizational and orientational explanations. There is also support for modifications to the description of explanation genres identified in previous studies.

A description of schematic structure at the least delicate level of analysis is proposed (ORIENTATION ^ IMPLICATION/DEDUCTION SEQUENCES ^ CLOSURE), which accommodates the variability of previous descriptions at this level. A further description at an intermediate level of delicacy takes account of commonalities and variations at a more delicate level across explanation types in the ORIENTATION and CLOSURE stages. At this intermediate level the ORIENTATION is described in terms of Phenomenon Identification, Phenomenon Background and Explanation Preview and the CLOSURE in terms of Conclusion, Extension and Elaboration. The description of the IMPLICATION/DEDUCTION SEQUENCES at the intermediate level of delicacy is peculiar to the different explanation types, such as the Conditions ^ Trigger ^ Transformation^{n} elements in the realizational explanations of coal formation. There is evidence of distinctive particulate structuring of the IMPLICATION/DEDUCTION SEQUENCES according to the explanation type, as well particular co-patternings of selections from the systems of transitivity and conjunction, which distinguish the explanation types.

The comparative analyses of secondary texts in the same Field enabled an interpretation of the relative effectiveness of linguistic choices in each text in contributing to its explanation of the phenomenon. One text in each of two Fields, and two texts in the third Field, clearly provided more effective explanations than the other texts. The fact that three of these four texts were from the same textbook series with the same authors, suggested that composing effective pedagogic explanations is an aspect of expertise which some authors exercise consistently.

The analyses of the primary texts showed that the proposed accounts of schematic structure potential were applicable across school levels. Although significant inadequacies were identified in at least one text in each of the three Fields, the remaining texts in two of the Fields provided functional approximations to the most effective secondary texts. This

seemed to be due to the capacity of the linguistic construction of these explanation types to accommodate the obvious recontextualizing strategy of keeping explanations brief in primary school books. However, this was not the case with realizational explanations of sound waves, which were problematic in all primary texts. On the whole the primary texts compared poorly with the secondary texts in scaffolding the novice reader's negotiation of the specialised language of school science.

An extension of this research, exploring additional Fields, analysing a greater number of texts and expanding the range of analyses, will be necessary to confirm and/or refine and extend the initial tentative findings. However, the findings to date already encompass productive bases for enhancing educational practices and examples of such classroom intervention are outlined.

Acknowledgements

I am immensely indebted to my supervisor, Jim Martin, for his encouragement and guidance and for all that I have learned from him during the course of this study. I would also like to thank my colleague, Geoff Williams, for his personal and professional support over many years.

Most of all I would like to thank my wife, Loraine, who has made this work possible, and my children, Kirsti and Derek, who have each helped in their own special ways.

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Chapter 1

Improving students' access to the discourse of school science books

1.1 Background to the study

The inaccessibility of scientific discourse for many school students and how this might be understood and addressed is the concern of an increasing body of research by systemic-functional linguists. For many students the alienating effect of the discourse of science is most pronounced when they encounter the institutional status of science as a discipline upon entering secondary school. The study of both upper primary and junior secondary school contexts then, is necessary to the development of an understanding of the nature of the difficulty of this transition. Revealing studies on the nature and evolution of scientific English are now available to inform this work but most of the research directly addressing science education to date has been on the language of teacher-pupil interaction and the language of textbooks in the secondary school, with indirectly related studies of children's writing development in the primary school. The present study extends the territory by further investigating secondary school textbooks as well science books for primary school children and exploring relationships between the language of books at both levels.

The point of departure for this study rests on three fundamental areas of development from previous work. The first of these is that the grammar of scientific English, whether the communication channel is aural or graphic, involves distinctive selections from the grammatical forms that characterise written rather than spoken language. Secondly these forms are functional in actually constructing scientific understanding rather than simply expressing it, and hence cannot simply be replaced by more familiar language forms. Consequently children need to gradually learn to control the distinctive grammatical forms of scientific English. Thirdly, the past experience of many children does not include a strong orientation to these grammatical forms and they need to be supported in developing familiarity.

The broad educational concern here is the elaboration of existing approaches to facilitating children's apprenticeship to scientific discourse taking account of the range of experience with written text among children at primary and secondary level. The general argument is that further explication of the range of appropriate linguistic choices in the construction of pedagogic science texts will influence the production, selection and use of books which both challenge and support children by introducing them to the language of science in a manner commensurate with their linguistic and educational experience. This entails work

toward the development of a linguistic account of what is involved in the construction of alternative recontextualizations of scientific discourse for children at different levels of schooling.

The purpose of this chapter is to indicate the background from which the study developed and to show how its general educational linguistic concerns, indicated above, have led to the formulation of the specific research issues which have been investigated. This will be done in five stages and then the purpose of the study and the theoretical orientation to the research design will be briefly described. The first stage in developing the background to the study very briefly notes the research into "talking science" in secondary school classrooms so that commonality of central issues with research on written texts will become apparent. The second stage focuses initially on children's experience of the written language of factual books in general as they change from primary to secondary school. It indicates many children's lack of preparedness for this aspect of secondary schooling, noting the vulnerability of those who are not high achievers in the primary school, and suggests that the language of science is a major source of difficulty in this area. The third stage briefly reviews the reasons for the difficulty of scientific text from two perspectives: its distinctively problematic grammatical features compared with the grammar of everyday speech and the functionality of these problematic features in the construction of scientific understanding. The fourth stage outlines recent pedagogy based on systemic linguistic research designed to apprentice learners to the language of science and suggests that further research is needed into the linguistic variability of acceptable apprenticing texts for both primary and secondary schools. The fifth stage provides a rationale for the selection of explanatory texts as a site for the development of this research, indicating concerns from science education and outlining developments in systemic linguistic research and associated educational intervention dealing with written explanations in school science. This leads to the statement of purpose of the study and its theoretical orientation.

1.1.1 Talking science

The linguistic form of the oral language of teacher/student interaction in secondary school science classrooms was studied extensively by Lemke (1990). He addressed the alienating effect of certain "norms of talking science" on many students and the difficulty they experience in accessing the language of science. Lemke's concern was to demonstrate ways in which these problems could be overcome through classroom talk by legitimating the use of the colloquial language of commonsense experience in bridging to the less familiar language forms of science.

> Learning to talk science is like learning a foreign language in that both require us to learn to translate back and forth between the two very different systems of expression. In our case these are scientific English and colloquial English. It is not just the vocabulary of scientific English that is foreign to many students. While it doesn't use any grammar you can't also find elsewhere in English, it does tend to follow the patterns of **written** English rather than speech (Lemke, 1990:159)

As well as taking students' everyday experience of science into account and developing a critical socio-historical approach to understanding the construction of scientific knowledge, Lemke emphasised the need for explicit teaching of the linguistic forms of scientific English in teaching students how to talk science (Lemke, 1990:167-176).

1.1.2 Negotiating discipline-based factual texts in secondary schooling

Secondary school also accords new status to the science book and brings about new reading practices in the context of science pedagogy. In primary schools children read fiction, often collaboratively and as the focus of common related work, in the classroom, but they read factual texts individually in the library for more individual purposes which are frequently not linked to common follow-up work. This general situation is reversed in the secondary school. Here the factual books are the common, authoritative, organising texts for classroom work (Lunzer and Gardner, 1979; Beverton, 1986). Children's change of reading diet was also indicated in a study by Beverton (1986) showing that 116 children in the last year of primary school read 155 fiction books while they used only 80 factual books. In the first term of secondary school they read only 46 fiction and 62 factual books. The change was found to be more variable across schools in a survey by Littlefair (1991:89), however in some cases the change was even more dramatic with children from one primary school changing from about 40% of their reading in the last term being factual texts to more than 80% of it being factual texts in the first term of secondary school. This by no means suggests that students do a lot of reading in secondary school science but it does show that children need to make a substantial adjustment to the changed genre-register balance of the texts they need to negotiate.

It is not surprising to find research noted by Neate (1992) suggesting that children are inadequately prepared for the change of reading diet they experience when they reach secondary school. They lack familiarity with the range of written text registers associated with the discipline-based organisation of the curriculum into discrete subjects (Lunzer and Gardner, 1979; Merritt, 1978; Chapman and Louw, 1986; Perera, 1984). More recently Littlefair (1991) showed that while able readers at both primary and secondary schools were effective in distinguishing register variation across written texts, this was not the case for their average and less able peers. A study of writing produced by primary school

pupils reported by Martin (1989:54) seems to complement Littlefair's finding and the findings of the earlier work. The writing study revealed that less than 15% of the children's pieces were factual texts and most of these were written by children judged to be the most effective writers. So the "register shock" associated with children's entry to secondary school is likely to be more of a shock for those who are not in the highest achievement levels of the primary school. Furthermore, the shock is likely to be greatest in science according to the results of studies of text difficulty noted by Davies and Greene (1984:19, 31) and supported by the concern about the discourse of science in the studies of classroom talk by Lemke (1990) and the analysis of science texts by Halliday (1993f).

1.1.3 Explaining the difficulty of science texts

In order to understand the inaccessibility of school science texts to young learners, Halliday (1993f:70) indicated the need not only to identify the problematic features of scientific English but also to try to explain them. There are a number of dimensions to this explanation. One essentially involves identifying problematic lexicogrammatical features of scientific English and showing how these differ from the lexicogrammar of registers with which young learners would be more familiar.

1.1.3.1 Identifying problems in scientific English

Because technical terminology is an obvious distinctive feature of scientific English, teachers tend to see it as the locus of students' difficulty with the language of science, whereas the problems "usually arise not so much from the technical terms themselves but from the complex relationships they have with one another" (Halliday, 1993f:71) and the distinctive skewing of choices from the resources of the grammar involved in constructing these relationships. The general tendency is toward the linguistic features that characterise written rather than spoken language. One index is the density of information in any passage of text, as measured by the number of lexical words per clause and referred to as *lexical density*. Halliday (1993f:76) points out how the lexical density of oral language is low - about two lexical items per clause; for writing the lexical density is often around four to six lexical words per clause; but the lexical density of scientific writing may go considerably higher. When the lexical density becomes very high, the texts are difficult to read, especially where lexical items constitute extended nominal groups with few grammatical items between them as in the following examples quoted by Halliday (1993f:79):

> form recognition laterality patterns
> glass crack growth rate.

This kind of density is achieved by what Halliday calls grammatical metaphor -

> ...a substitution of one grammatical class, or one grammatical structure by another; for example, *his departure* instead of *he departed*. Here the words (lexical items) are the same; what has changed is their place in the grammar. Instead of the pronoun *he* + verb *departed*, functioning as Actor + Process in a clause, we have determiner *his* + noun *departure*, functioning as Deictic + Thing in a nominal group (Halliday, 1993f:79).

Halliday explains that the metaphorical form (his departure) is unlikely to be used when talking to, or in the speech of, a nine year old child (Halliday, 1993f:79). Nor, in fact, would most adults use this form in casual conversation. So the non-metaphorical form makes the grammar *younger* or more typical of the familiar grammar of everyday talk, whereas scientific English is characterised by the use of grammatical metaphor.

> ...almost every sentence in scientific writing will contain some example of it, and it does present a problem to the learner. This is partly a question of maturity; students well into secondary school may still find it difficult to comprehend...(Halliday, 1993f:82).

The difficulty arises partly because these metaphorical expressions are not just another way of saying the same thing. In a certain sense they construct an alternative perspective on reality. While the grammar of oral language constructs a dynamic account in which nouns are for people and things and verbs are for actions and events, the metaphorical forms of written language rework the grammatical construction of reality so that almost everything is turned into a noun (Halliday, 1993f:82). This nominalising tendency creates considerable ambiguity.

> For example, what does *lung cancer death rates* mean? Is it 'how many people die from lung cancer' or 'how quickly people die when they get lung cancer'? Or is it perhaps 'how quickly people's lungs die from cancer'? And does *increased smoking* mean 'people smoke more', or 'more people smoke' or is it a combination of the two, 'more people smoke more'? (Halliday, 1993f:78).

The occurrence of ambiguity of this kind is exacerbated by the frequency in scientific English of polysemous verbs like "may be reflected in"; "are associated with"; and "mean". The following clauses are used by Halliday (1993f:77) to illustrate:

> (h) Increased responsiveness may be reflected in feeding behaviour
> (k) Higher productivity means more supporting services

The verbal expressions "may be reflected in" and "means" are ambiguous in two respects:

> In the first place, we cannot tell whether they indicate a relationship of cause or evidence. Is one thing said to be the *effect* of another or is it merely the *outward sign of it*? For example in (h), does the feeding behaviour *demonstrate* that responsiveness has increased, or does it *change as a result of* the increase? In the second place, supposing that we can identify a relationship of cause, we still cannot tell which causes which. In (k), for example, is higher productivity *brought about by* more supporting services, or does it *cause* more supporting services to be produced? (Halliday, 1993f:77).

The lexically dense, often ambiguous language resulting from the use of grammatical metaphor is characteristic of writing in science. Such texts may not seem impenetrable or ambiguous to a writer or a teacher, but this is often the case for young learners. As Halliday (1993f:77) notes, the learner and the teacher may interpret scientific texts quite differently without either being aware that another interpretation is possible. It is often only when adults attempt to rework passages in the spoken form that they become aware of problems of this kind which hinder young learners' access to the language of science.

1.1.3.2 The functionality of problematic features of scientific English

A second dimension to explaining the problematic features of scientific English is to account for their functionality - why they have evolved as part of the language of science. This is discussed below with respect to the centrality of technical terms and grammatical metaphor.

From the standpoint of systemic functional linguistics understanding the nature of scientific knowledge necessarily entails controlling the linguistic resources that construct that knowledge. Language is viewed

> ... as a system for construing meaning rather than as a conduit through which thoughts and feelings are poured. In other words it (Systemic Functional Linguistics) views language as a meaning-making system rather than as a meaning-expressing one (Halliday and Martin, 1993b:23).

More specifically,

> The language of science is, by its nature, a language in which theories are constructed; its special features are exactly those which make theoretical discourse possible. But this clearly means that the language is not passively reflecting some pre-existing conceptual structure; on the contrary, it is actively engaged in bringing such structures into being ..... A scientific theory is a linguistic construal of experience (Halliday and Martin, 1993a:8).

However all theory, including "folk" theory or "everyday" or "commonsense" knowledge is also a linguistic construal of experience. The question then is how the linguistic construal of scientific knowledge is different from the linguistic construal of commonsense knowledge. The most obvious and common response is in terms of the technical vocabulary which characterises scientific discourse. Reference by some to such technical vocabulary as jargon implies that it is unnecessary and that scientific concepts and reasoning could equally well employ non-technical everyday language. But technical terms reflect the fact that scientific interpretations of phenomena are based on different organising criteria . In the case of commonsense, organising criteria are those that are accessible to direct observation by the senses, whereas scientific criteria are derived ultimately from technologically augmented perception (Wignell et al, 1993:140-41; Martin, 1993c:169-70; Martin, 1993b:229-30). In one illustration, based on information attributed to Dr. Joan Rothery, Martin (1993d:205-206) compares a commonsense classification of well known diseases with a medical classification, as shown in Figure 1.1:

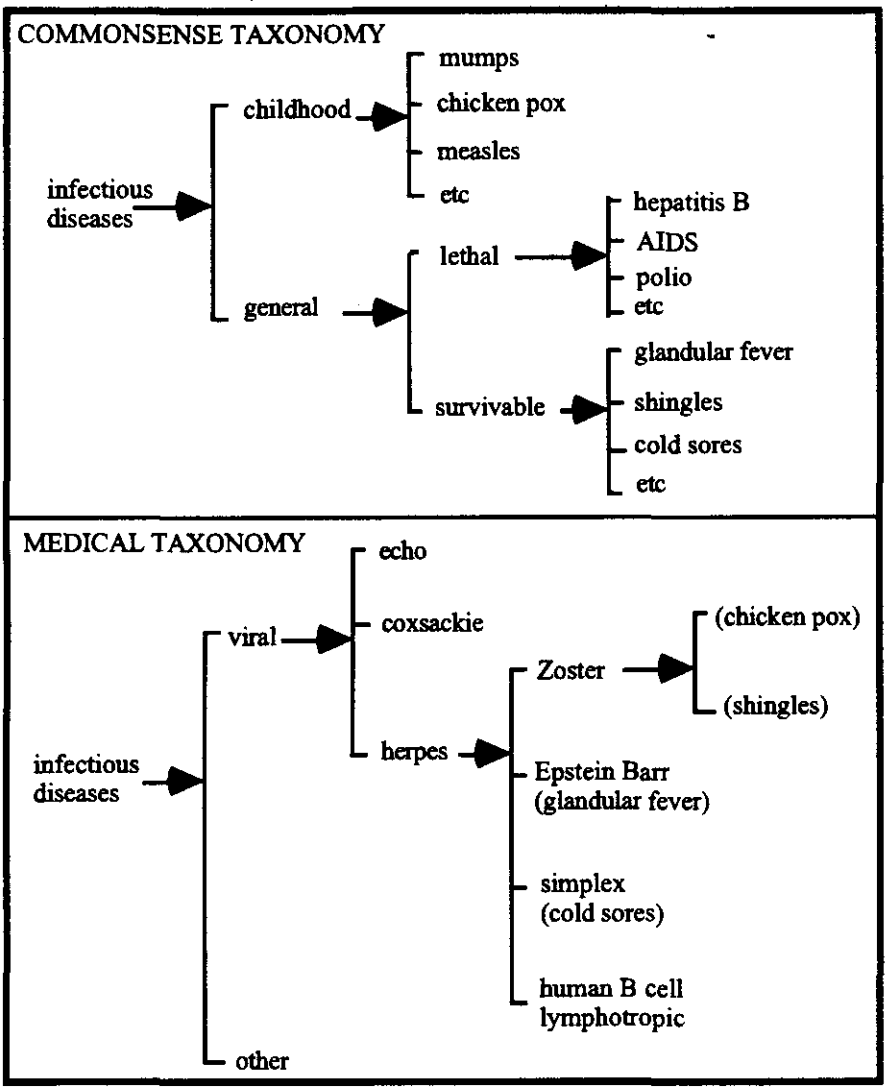


Figure 1.1 Martin's (1993d) comparison of commonsense and medical taxonomies of diseases

Everyday classifications of diseases are based on symptoms and effects, whereas medical classifications of diseases are based on their causes. Martin points out that of the diseases noted above, cold sores, glandular fever, chicken pox and shingles are in fact caused by the same virus. This results in a medical taxonomy which is quite different from the commonsense one and hence referring to a disease with respect to the simplex herpes virus is quite different to naming it cold sores (Martin, 1993d:205). Technical terms then cannot simply be dismissed as "jargon". Understanding technical terms means understanding these specialised classifications and the scientific concepts which led to their construction. This illustration also draws attention to the relationship between science and commonsense. It is not that one is right and the other is wrong. Rather they are different pictures of reality based on different organising criteria.

> The function of science then is to construct an alternative interpretation of our world to that provided by commonsense. In our culture, this is its job (Martin, 1993c:169).

To do this it takes commonsense as a starting point and translates it into specialised knowledge. This entails the definition of technical terms and the delineation of complex relationships between them, which involves intensive deployment of linguistic resources that do not occur as frequently in the language of everyday speech. The most salient among these is grammatical metaphor (Halliday,1994a: 340-353). The centrality of grammatical metaphor to the construction of scientific knowledge has been demonstrated extensively by Halliday (1993e; 1993f) and Martin (1993b; 1993c; 1993d). The following summarised recapitulations from examples of their work illustrate how grammatical metaphor is both functional and integral to the construction of scientific understanding.

Martin (1993b:225) notes that the major semiotic resource for the translating process from commonsense to scientific knowledge is elaboration, which, at the clause rank is constructed through the relational identifying clause (Halliday, 1994a: 122-130). In this type of clause an identity relation between two participants is constructed. More specifically, introducing technical terms means placing a Token in relation to its Value. The technical term is the Token and what is being defined by this technical term must be grammaticalized as a Thing - even if semantically it is not. In the following examples quoted in Martin (1993c:178), "weathering" and "erosion" are defined as technical terms and this relies on the event sequences they summarise being nominalised as participants so that they can be equated with the pseudo things, "weathering" and "erosion".

The production of rock waste by mechanical processes and chemical changes	is called	weathering
Value	Process	Token

The destruction of a land surface by the combined effects of erosion and removal of weathered material by transporting agents	is called	erosion
Value	Process	Token

The active role of language in constructing scientific understanding via the resources of grammatical metaphor is illustrated by Martin's (1993e) analysis of the following segment from a secondary school science textbook:

> (a) As far as the ability to carry electricity is concerned, (b) we can place most substances into one of two groups. (c) The first group contains materials with many electrons that are free to move. (d) These materials are called conductors (e) because they readily carry or conduct electric currents. (f) Conductors are mostly metals (g) but also include graphite. (h) The second group contains materials with very few electrons that are free to move. (i) These materials are called non-conductors (j) and are very poor conductors of electricity. (k) Nonconductors can be used to prevent charge from going where it is not wanted. (l) Hence they are also called insulators. (m) Some common insulators are glass, rubber, plastic and air. (n) There are a few materials, such as germanium and silicon, called semiconductors. (o) Their ability to conduct electricity is intermediate between conductors and insulators. (p) Semiconductors have played an important role in modern electronics. (Heffernan and Learmonth, 1983:212).

~ Martin draws attention to the role of grammatical metaphor in the realisation of the criterion used to classify substances - "the ability to carry electricity".

> This kind of coding involves the nominalisation of potentiality, which in the spoken language would typically be coded as the modal verb (as in substances can/can't carry electricity).
> .....the nominalised rendering of the criterion, "the ability to conduct electricity", opens up a semantic space for substances which are partially able to conduct electricity. This space is not available in the more spoken coding since one of the peculiarities of potentiality, as far as modality is concerned, is the fact that it is not gradable. With potentiality realised as a modal verb, substances either can or can't conduct electricity; there's nothing in between. Potentiality contrasts in this respect with other modalities, like those of probability or obligation (following Halliday, 1985:334-340).
> (Martin, 1993e:95)

He goes on to point out that once nominalised, potentiality becomes gradable ("A low/medium/high ability to conduct electricity."). This expanded meaning potential is used to establish a category of substances whose "ability to conduct electricity is intermediate between conductors and insulators". In other words the construction of this uncommonsense, scientific knowledge

> depends on the grammar of writing - on a process of nominalisation which makes available meanings that are not readily available in the spoken form (Martin, 1993e:95)

As well as its functionality in construing the taxonomic structure of scientific knowledge through the linguistic realisation of definition and classification, grammatical metaphor is also a crucial resource in scientific argument realising uncommonsense accounts of processes. Halliday (1993e) provided a historical perspective on this in his discussion of

the development of "the structure of scientific argument" from Newton to the present. He summarises the necessity for this deployment of grammatical metaphor:

> The core of a scientific text was the development of a chain of reasoning (ultimately based on experiments) in which each step led on to the next. But in order to lead on to the next step you have to be able to repeat what has gone before and is now the springboard for the next move (Halliday, 1993b:131).

The use of nominalisation enables the "packaging" of complex sequences of text to form a single element in a subsequent semantic configuration and hence the construction of a discourse that moves forward by logical and coherent steps, each building on what had gone before. Halliday illustrates the simplest form of this:

> .....both ethyne and nitrogen oxide are kinetically stable.....
> The kinetic stability of nitrogen oxide shows.....
>
> the grammar "packages" what has gone before by nominalising the Process (attribute or event), and making the Medium of that Process a "possessive" modifier. This enables it to function as the Theme of the succeeding clause (Halliday, 1993b:131).

He goes on to point out that sometimes the new step has to include not just the previous step but a great deal of what has gone before and this may necessitate the picking up of several related motifs in a more complex package:

> The great reactivity of flourine in these reactions with non-metals [is explained .....]

In fact Halliday (1993e) shows how increasingly complex packaging of text from the time of Newton has produced the characteristically highly nominalised contemporary scientific discourse.

The functionality of technical vocabulary and grammatical metaphor as resources for both the construction of Field and the texturing of scientific knowledge is indicative of the centrality of the grammar of writing to the construction of the uncommonsense understanding of scientific discourse. It follows then that gaining access to scientific knowledge means gaining access to this grammar and that the grammar of everyday speech is insufficient (Martin, 1993c:200; Martin, 1993d:218; Martin, 1993e:15; Halliday, 1993f:70).

The problematic characteristics of scientific English then are not arbitrary. They are functional in that they make possible the construction of the uncommonsense, technical perspectives on reality that characterise scientific knowledge.

> It would not be possible to represent scientific knowledge entirely in commonsense wordings; technical terms are not simply fancy equivalents for ordinary words, and the conceptual structures and reasoning processes of physics and biology are highly complex and often far removed, by many levels of abstraction, from everyday experience. Hence the language in which they are constructed is bound to be difficult to follow (Halliday, 1993f:70).

Halliday does point out (1993f:70) that the forms of scientific discourse can "take over"

> so that writers get locked into patterns of writing that are unnecessarily complicated and express themselves in highly technical wording even where there is no motive for it (Halliday, 1993f:70).

He further indicates that those who write in the language of science often do so badly and offers two examples of ways in which this creates problems for the learner. The first is that the organisation of taxonomic relations is frequently not made explicit. It is suggested that the text could be made more "learner-friendly" by first introducing the terms in their taxonomic order (e.g. there are five kinds of climate, namely ....), then setting them out in lists or diagrams and finally describing and explaining them as appropriate. The second problem exemplified is what Halliday refers to as "semantic discontinuity". In the case cited a metaphorical expression was used to begin a clause - which is a typical resource for summing up previously constructed information and presenting it as the point of departure in the new clause - however the metaphorical expression was something that had not been previously introduced. Further discontinuity occurred when highly nominalised implication sequences did not include all of the steps which were necessary to the text's conclusion, requiring quite unrealistic inferencing by the learner to supply missing information and the logical relations upon which the text's conclusion depended.

Clearly then, recognising such tendencies and assisting students to negotiate them, as well as drawing attention to the need for authors to avoid this kind of writing in school texts is one approach to the production of a more accessible discourse of school science. Nevertheless, to a significant extent, the difficulty in school science books is inherent in the nature of science itself. Developing scientific understanding means learning to control the discourse forms that construct scientific knowledge. Young learners need to be apprenticed into these discourse forms and this means learning to negotiate the distinctive problematic features of scientific English -

> ...they evolved to meet the needs of scientific method, and of scientific argument and theory. They suit the expert; and by the same token they cause difficulty to the novice. In that respect learning science is the same thing as learning the language of science. Students have to master these difficulties; but in doing so they are also mastering scientific concepts and principles (Halliday, 1993f:84).

1.1.4 Apprenticing children to the language of science texts

Educational linguistic research related to the development of strategies for apprenticing learners to the discourse forms of school science texts has focused on the identification of key genres in school science as a basis for explicit teaching of their schematic structure, discourse semantic and lexicogrammatical features. The emphasis of the pedagogy in terms of student outcomes has been on the development of children's writing of the range of genres identified. However, the reading of science texts is integral to a number of phases in the curriculum cycle (Macken et al, 1989; Christie et al, 1992), such as the "modelling" phase, in which the teacher deconstructs the linguistic form of a prototypical text of a particular genre as a model for children's subsequent writing (first jointly with the teacher and then independently). One pedagogical strategy for supporting children's accessing of "model" texts is the use of the oral language of classroom interaction to "shunt" between the grammatical forms of commonsense and informal talk and the less familiar forms constructing the technical knowledge with which the model text is concerned. This is referred to by Lemke (1989) as "talking out the text".

1.1.4.1 The need for further research

There are two issues concerning the textual resources central to this kind of apprenticing which educational linguistic research has not sufficiently addressed. The first is the possible variation in accessibility across a range of alternative texts dealing with the same phenomenon for the same level of schooling. As Halliday (1993f:82) has noted some texts may be unnecessarily complicated , but it is also possible that pedagogic science texts vary in the ways in which necessarily complicated discourse forms are incorporated. One issue in related research by Fuller (1992) concerns the role of grammatical metaphor in texts of popular science. This work explores the possibility that qualitative differences in types of grammatical metaphor may be exploited to make technicality appear less intimidating. Fuller draws attention to homomorphs (underived verbal nouns) - nouns derived from verbs but retaining the same orthographic/phonological shape such as "squashes" and "stretches" in the following segment of a science book for primary school children:

> The sounds squash together a package of air and when this expands or stretches out again.....
> ... producing a whole series of squashes and stretches (Taylor; 1991a:8).

She also noted the use of nominalised imperfective clauses similar to the following example from a secondary school science textbook:

> ...it is followed by the stretching apart of air particles (Chapman et al, 1989:280)

Fuller suggests that these forms of grammatical metaphor represent an intermediary stage between the world of commonsense and that of technicality in that their "congruent" appearance masks their mode shifting function from minimal to maximal experiential distance. The apprenticing function of such forms of grammatical metaphor in pedagogic science texts warrants investigation.

Halliday and Martin (1993a:21) and Halliday (1993d:22; 1993c:77) have noted that the nature of scientific discourse continues to evolve in its inter-relationship with the continuing evolution of scientific knowledge and that in the late twentieth and twenty-first centuries this may involve a greater tolerance of indeterminacy and flux and an accompanying backing off from its present extremes of nominalisation and grammatical metaphor to accommodate a more process centred technical discourse oriented to a clausal rather than a nominal mode and developing the verbal group as a technical resource. Halliday has also suggested that although contemporary technical discourse must have nominalisation in order to construct taxonomies, it could be nudged away from its obsession with pseudo-things to linguistic forms which lessen the semiotic distance -

> both the experiential distance, which makes the language of technical knowledge so remote from the experiences of everyday life, and the interpersonal distance, which separates those who have the knowledge from those who are left outside (Halliday, 1993f: 78).

School science books, especially those for upper primary and junior secondary schools are contexts in which some nudging of this type might be expected to occur. However, Martin has commented that the interpretation of making science accessible in recent secondary texts reflecting progressive education principles such as learner-centered, activity-based and discovery learning, has resulted in textual forms which are quite counterproductive.

> Because of its fragmented process focused organisation for example, Cull and Comino (1987) is a much poorer source of models of scientific writing than the more traditional Messell *et al* (1964)
> (Martin, 1993c:189).

On the other hand Martin (1993b:222) indicated that the secondary texts used in recent systemic-linguistic research were "very good models of scientific discourse in general" and suggested in support a comparison of research on pedagogic discourse of science (Wignell et al, 1993; Shea, 1988 and Martin, 1993d) with that of Halliday (1993e) on the language of physical science. What we do not have is a comparative study of texts designed for the same level of schooling, so we don't have a basis for determining the range of functional linguistic choices in appropriate recontextualizations of scientific English in school science textbooks.

The second issue concerning textual resources for apprenticing children into the discourse forms of science texts which warrants additional investigation is the potential role of factual texts in the primary school in providing children with a gradual introduction to the more complex forms of scientific English they will encounter in secondary school texts. Many science topics regularly recur at successive levels in primary and secondary school and are dealt with in information books for primary school pupils as well as in secondary school text books. For example nine books on "the water cycle" were found by Cross (1992) to span difficulty levels appropriate to children from about the third year of school to the senior secondary school level. A great deal of concern is expressed about the quality of information books available to primary school children.

> In many cases the children are either offered a banal, insipid version that lacks function, organisation and sufficient challenge, or a demanding specialised version which lacks the characteristics of language with which young children are familiar (Neate, 1992:117).

However, apart from the work by Cross (1992) on "cycles" texts, there is a dearth of linguistic research into the forms of scientific English as it is recontextualized in books at the primary school level and how these recontextualizations relate to those of secondary school texts.

Investigation of both of the foregoing issues exploring the linguistic variation in texts dealing with the same phenomenon within and across school levels is integral to the development of a basis for the selection of science reading materials which would provide a gradual progression toward more complex forms of scientific English as children develop more experience with the register and as they move from primary to secondary school.

1.1.5 Explanation: A site for analysis

1.1.5.1 What counts as explanation in science teaching and science texts?

Educational research has suggested that the lack of explicit knowledge about what counts as explanation in school science is not only a major difficulty faced by children making the transition from primary to secondary school but it is also widely characteristic of science teachers (Horwood, 1988).

Solomon (1986) describes a variety of "precausal" modes of explaining characterised as re-affirmation, teleology, tautology, and simple juxtaposition, which young children learn through the answers they receive from adults to their how and why questions. She notes that even when children have acquired more analytical modes of explaining ..

> ...these early modes remain entirely appropriate for many contexts, even some in school science. The answer to the question "Why do wading birds have webbed feet?" is *not* expected to be about specific genes which are, perhaps, the efficient cause of the shape of the birds' feet. Instead we greet as a correct explanation (that the purpose of such webbing is).. to help the bird walk on mud. This kind of teleological or adaptational reasoning is common in biology, and, although acausal, certainly cannot be dismissed as mere juxtaposition (Solomon, 1986:43).

However Solomon also points out that science learning crucially involves distinguishing what she refers to as "empirical" and "theoretical" explanation. The distinction she suggests can be appreciated by considering two questions: "Why does that gas expand?" and "Why does heat make that gas expand?" She elaborates by indicating that the question "How does this washing machine work?" can be answered either in terms of causation or by theoretical explanation which would include electromagnetic theory applied to the electric motor (Solomon, 1986:47). It is this kind of distinction that Horwood (1988) argues is not at all clear in the practice of many science teachers and in the explanation of phenomena in textbooks. He suggests that the need to "explain why" is often resolved by "describing how" and hence the description of an event or process is seen as equivalent to explaining it. He concludes that

> It is clear that in ordinary science teaching practice and in science texts, the terms "describe" and "explain" and the activities of description and explanation are used in variable, inconsistent and confusing ways (Horwood, 1988:48).

The consequence of this is the kind of educational malaise noted by Solomon:

> ... the young secondary school pupils embark upon their new science lessons armed with a repertoire of modes of explanation most of which may well be inappropriate. It might be hard to teach explicitly about the different forms of explanation. Meta-knowledge about the procedures of a subject is not easy to understand at any age. For whatever reason, or none at all, instruction is not given; it is left to the students to pick up appropriate ways of explaining by the ostensive example of the teacher. There are always some who fail (Solomon, 1986:43).

Just what kinds of children are the ones who always fail, Solomon does not pursue. One highly influential view is that children especially at risk in such contexts are those whose socio-cultural positioning is such that their 'sociolinguistic coding orientation' (Bernstein, 1973; 1975) is consonant with their negotiation of "commonsense" knowledge, but who have limited access to an elaborated coding orientation which is required to negotiate "esoteric" (Bernstein, 1990) or "uncommonsense" knowledge, as it is recontextualized in "official pedagogic practice" (Bernstein, 1990:179). Such children would be disadvantaged in terms of being able to "pick up appropriate ways of explaining", in Solomon's terms. They are less likely to have had information books read to them at home as part of their early reading experience (Williams, 1990) and it would seem to follow, outside of school, are less likely to engage with discourse forms similar to those of which the kinds of explanations valued (often implicitly) in school science are a part. School pedagogic practices then, are centrally implicated in distributing access to uncommonsense or educational knowledge, and developing children's control of the semiotic resources which construe such knowledge is integral to this facilitation of access. From Solomon's perspective this does entail teachers undertaking "to teach explicitly about the different forms of explanation" and systemic-functional linguistic research is contributing to the explication of the "meta-knowledge of the procedures of a subject (science)" which teachers need in order to implement this explicit teaching. As Halliday has argued

> Since the disjunction between educational knowledge and commonsense knowledge is construed in the grammar, it can also be deconstrued in the grammar (Halliday, 1993a:55)

But although Halliday (1993a:55) suggested that "Simply by spreading knowledge about language ... one can do much to demystify educational discourse", he and others (Lemke, 1989; 1990; Martin and Rothery, 1988) have pointed out the importance of teachers' drawing on linguistic understanding as a resource to bridge or "to provide steppingstones from 'commonsense' to technicality. (Halliday, 1993a:55). This entails the kind of "pastoral pedagogy" described by Hunter (1994) in which there is a symbiosis between the valuing and exploration of commonsense experience children bring to learning contexts and strategic teaching of disciplinary norms. Hunter argues that the mediation of the teacher as a sympathetic figure who cares for the students is crucial in joining students' self

examination of their practices to the externally introduced disciplinary practices in such a way that students will be able to take on pedagogical norms as personally meaningful practices. The present study addresses only part of this broader pedagogical context. Its focus is the linguistic understandings that teachers need in order to "teach explicitly about the different forms of explanation". Recent systemic linguistic research into the generic, discourse-semantic and lexicogrammatical realisation of key genres in the discourse of school science has included work on explanations and has formed the basis of educational intervention to encourage the kind of explicit teaching referred to above. An outline of the development of this work will show the kind of contribution to be made by the present investigation into variation in explanation in science books within and across fields and within and across primary and secondary school levels.

1.1.5.2 Systemic linguistic research on explanation in school science

The need for a linguistic account of explanations in books suitable for use in teaching primary school science became increasingly clear during the late 1980's and early 90's as genre-based writing pedagogy was adopted and developed by teachers in New South Wales schools. During this time systemic linguistic studies of explanation in school science books significantly advanced, and at the same time problematized, the development of theoretical accounts of a range of written explanation genres in school science. As well as provoking further research issues in relation to secondary science explanations, this work provided a productive, critical framework for the development of a study of primary school science texts. In addition, it was suggestive of a study linking primary and secondary texts to further explore the semiosis of recontextualizing written explanations of particular phenomena for children at different levels of the school system. As noted above, the importance of this issue of theorising the nature of alternative recontextualizations of written explanations within and across school levels and the appropriate deployment of such explanations in school science teaching had also been given attention in recent educational research. The confluence of problematic aspects of writing and science pedagogy and the expanding systemic linguistic accounts of explanation in school science texts has led to the development of a focus for the present study on the investigation of linguistic variation in explanations within and across fields in both primary and secondary texts and also of the variation in explanation within fields across both levels of schooling.

This section will outline the main influences from recent systemic linguistic-based research and pedagogy on developing the focus of the study. This will involve firstly a brief discussion of genre-based writing pedagogy and how this drew attention to the need for research into the linguistic form of explanations in information books for primary school children and also indirectly began to create an awareness of the limited applicability of the

early modelling of the explanation genre. Then work on primary and secondary science texts identifying a range of explanation genres will be briefly outlined. Following this, it will be shown how a number of issues concerning two of these genres, sequential and causal explanations, suggested how this study, exploring variability rather than prototypicality, could investigate further linguistic dimensions of recontextualizing explanations by elaborating and extending existing work on primary and secondary texts.

1.1.5.2.1 *Explanation in genre-based writing research and writing pedagogy.*

Explanatory texts constituted an almost negligible proportion of the writing produced by infants' and primary school children in the analyses of writing output from Sydney schools undertaken by Martin and Rothery. In one school explanatory texts amounted to only one half of one percent of the writing done and this rarity evoked some caution about the basis for describing an explanation genre in primary school writing (Martin, 1989:11-12). In fact, in this data, "factual texts which focus on reasons" (Martin, 1984:43; Rothery, 1986:17) were referred to as explanations. Their most common use was in justifying attitudes and occurred most frequently in social science or history or as part of thematic work e.g.:

> A friend is important to me because if you don't have a friend you never play. - Year 3
>
> Who were the Phoenicians? Why were they famous? (assigned questions)
> The Phoenicians were one of the great peoples of the ancient world. They were great sailors, navigators and traders. They became famous in history for two achievements. They were among the first to send out explorers and colonies throughout the Mediterranean Sea area, and even beyond the strait of Gibraltar. - Year 6
> (Martin, 1984:46).

A range of narrative and factual genres were identified in the research by Martin and Rothery, but, as previously noted, factual genres, mostly produced by children judged to be good writers, accounted for only fifteen percent of primary school writing (Martin, 1989:53-54). These findings, as well as concern about the range and quality of narrative genres being written, inspired educational intervention to improve all children's access to, and control of, genres crucial to success in the school system. Such intervention included the articulation of a "genre-based" writing pedagogy in published resource materials for teachers which incorporated models of the genres to be taught as well as brief descriptions of their schematic structure and grammatical form. Explanation appeared as one of the factual genres in these materials.

In materials to support the implementation of a genre-based approach to teaching writing for years three to six in the primary school (Macken et al, 1989:16), the function of the explanation genre is described as:

> (A) Factual text used to explain the processes involved in the evolution of natural or socio-cultural phenomena. Explanations are used to account for why things are the way they are. Explanations are more about processes than things. In the school curriculum, explanations are often found in Science and Social Studies.

A general schematic structure is provided:

> * A general statement to position the reader
> * then sequenced explanation of why/how something occurs
> (usually a series of logical steps in the process)
> This sequence continues until the final state of being or thing is produced.

The language features of explanations are summarised as:

> * Focus on generic, non-human participants.
> * Use of simple present tense.
> * Use of temporal and causal conjunctive relations
> * Use of mainly material or action clauses; some passives to get Theme right.

Whilst the schematic structure proposed is consistent with some of the explanatory texts primary school children need to negotiate, it clearly does not apply to explanations of physical science such as why some objects float and others sink (e.g. Robson, 1992:15; Carter et al, 1990c:21), or why a pencil partially submerged in a glass of water looks as if the part in the water is bent (e.g. Carter et al, 1989:13; Taylor, 1989:20), and many other phenomena dealt with in factual books at the primary level. Of the five model explanations provided in the genre writing materials only one is referenced to primary school writing ("Why it rains" - Year 6: Macken et al, 1989:17). One is referenced to a year ten teacher's lesson notes and, although the other three have no reference provided, they also appear to be from secondary school material. Since the proposed model of the explanation genre did not emerge from the documented studies of primary school writing nor from research on explanations in factual texts for primary school children, the extent of its relevance to primary education requires further investigation. It is possible that the model was adapted from the proposed modelling by Wignell et al (1987) of implication sequences in explanatory texts in secondary school geography. In implication sequences, causal relations are set up between clauses such that each step through the sequence implies what has gone before. Wignell proposed the use of transition networks (Winograd, 1983) to model this:

> ...the basic components of transition networks are states (represented by circles) and arcs (represented by arcs with arrows representing the direction of change). An arc represents the movement from one state to another. A state represented by concentric circles is a terminal state. This is a place where the sequence either does, or could, stop. As well as being a potential terminating point for that sequence, it is also a potential starting state for another sequence (Wignell, 1987:53)

The illustrations provided of this modelling were not based on any specific text analysis:

> .....an example of modelling implication sequences. Weather is the topic used, as taught to seventh graders, with some reference to an undergraduate textbook to fill in gaps (Wignell, 1987:55)

Interestingly, three of the five model texts in the primary school writing resource books noted above, were on geography topics (How it rains; How deserts remain dry; Cross bedding). None of the model texts were actually analysed according to the proposed schematic structure. Subsequently published resource materials for genre-based writing in the primary school (Derewianka, 1990; Christie et al, 1992) did not emphasise this kind of modelling of implication sequences but maintained a similar two stage description of the schematic structure of explanations:

* Phenomenon Identification
* Explanation Sequence

Yet again in these publications only one model explanation text (Derewianka, 1990:59-60) is from specified primary school material. Intervention in writing development in primary schools has not been based on any substantial systemic linguistic research on primary school texts to indicate the generic, discourse semantic and lexicogrammatical characteristics of written explanations children need to be able to negotiate in science learning so that they will be apprenticed into the discourse forms of scientific English which will become crucial to their success in secondary school science learning.

The importance of reading materials as the child's major access to the written mode and in providing models on which to base their writing has been well recognised by systemic linguists engaged in educational research in this area (Kress, 1984:2; Martin, 1984:49; Christie et al, 1992:8). It has also been a common view that books for primary school children do not contain appropriate models of factual genres (Rothery, 1986:25; Martin, 1993c:189; Christie et al, 1992:6), however, again these views are not based on documented linguistic research. There is certainly educational research which is critical of the quality of science books for both primary and secondary school, and there is some specific critique of explanatory text. Typically neither the criticisms nor the suggested solutions relate to any

coherent theory of the linguistic construction of scientific understanding, as reflected in the following excerpts from recently reported educational research:

> The lack of connectives at this point is somewhat jolting. In the third paragraph, a lack of connectives again results in text that does not flow easily from one sentence to the next (Meyer, 1991:32).

> The experimental findings showed that these eighth graders benefited from a more explicit, comprehensive explanation with fewer implicitly vague sentences (Holliday, 1991:42).

Nevertheless, the results of one study of science books used in grades one to five in U.S. schools (claimed by the authors to be the only such systematic study listed up to the time of publication) implied that some books might well contain appropriate explanations for children of this age (Meyer, Crummey and Greer, 1988):

> Overall, the four textbook series were quite considerate .....
> For example, Series B averaged fewer than six instances of missing connectives or unclear referents per grade level. Only two instances of illogical structure were identified in all the chapters of this series. Series B also had only one example of an illogical sequence, explanation or procedure (reported in Meyer, 1991:34).

Research to determine whether appropriate models of explanation can be identified in published materials suitable for primary school science teaching is crucial to improving pedagogy in this area. The "curriculum cycle" for genre-based writing development has the reading and "deconstruction" of model texts as an integral element, and in this pedagogy, explicit knowledge of the linguistic organisation of factual genres is considered a resource for the development of children's reading as well as their writing:

> Knowing how a genre like report, explanation or procedure is organised makes reading similar published texts much easier (Christie et al, 1992:9).

Although published information books for primary school aged children are listed as resources in the materials developed by Christie et al (1992) to teach explanation, none are used to model the genre. All model texts were written by the authors specifically for the teaching program. While this may have advantages for introducing the pedagogy, it is not sufficient to support wider and continuing implementation. Nor is it practical to suggest that teachers should continue to write their own model texts. Teachers need to be able to locate, evaluate and use explanations in published books. Systemic linguistic research can facilitate this by specifying the linguistic features of scientific explanations occurring in books for use in primary schools.

1.1.5.2.2 *Different types of explanation: Indications from primary school material*

The lack of detailed study of the explanation genre was noted by Derewianka (1990:60) who drew attention to the commonsense distinction between explaining why and explaining how. No linguistic correlates of this distinction were suggested but a brief field-oriented basis for the categorisation was offered:

A) explaining *how,* e.g.
Mechanical explanation (How does a pump work?)
Technological explanation (How does a computer work?)
System explanation (How does a company work?)
Natural explanation (How are mountains formed?)

B) explaining *why,* e.g.
Why do some things float and others sink?
Why is the ozone layer thinning?
Why do we have different seasons?
Why does iron go rusty?
Why do living things need food?
(Derewianka, 1990:60)

Two of the three example texts could clearly be categorised as explaining how: *How the phone system works* and *How are sedimentary rocks formed?* The other text on *Hubble's Theory* dealt with explaining how the universe was formed, but does not seem to fit comfortably into the "Natural explanation" category. It seems to have more in common with the more abstract fields exemplifying explaining why. The difficulties with these informal categorisations underlines the need for more systematic investigation.

The theoretical inadequacy and practical pedagogical difficulty of working with a unitary model of explanation are implicit in the primary school material Exploring explanations about electricity (Christie et al, 1992). The model explanation provided to the children is "How a torch works". It is clearly oriented to explaining how. Of the twelve conjunctions in the text, ten are "time conjunctions" and only two are "reason conjunctions" (Christie et al, 1992:39). The explanation to be jointly constructed by the children and the teacher is "Why does an electric current flow?". This will clearly require the deployment of linguistic resources to construct cause and effect relationships which have not been emphasised in the model explanation. Then the children make a "steady hand tester" using a simple electric circuit and attempt independently to write an explanation of "How does a steady hand tester work?". The children are given some guiding questions in the book, but are also referred back to the discussion of the linguistic features of "How a torch works" to refresh their memories on "How a technical explanation is organised" (Christie et al,

1992:46). But what is the role of the more causally oriented, jointly constructed text on "Why does an electric current flow?" ? Is it intended that the children should write their "steady hand tester" explanation to emphasise "how" or "why" the tester works? What counts as knowledge and understanding in school science depends on how it is linguistically constructed in classroom experiences of this kind. Explicit knowledge of the linguistic basis for these constructions will provide teachers and children with more control of the kinds of meanings that are being negotiated. Further research is clearly needed to make this kind of linguistic knowledge available to teachers.

1.1.5.2.3 *The scope of early secondary science textbook research*

Until very recently (Veel, in press a; in press, b) studies of secondary school textbooks did not address the specification of different types of explanation (Wignell et al, 1987; Shea, 1988; Martin, 1986; 1993c). As noted above, the proposed modelling of implication sequences in explanations in geography by Wignell et al (1987) did not include the analysis of any specific text and "precipitation" and the formation of "alluvial fans" were the only fields referred to. A wider range of fields was included in Shea's (1988) data:

> water erosion
> bovine digestion
> the water cycle
> osmosis
> sound waves
> the formation of dew
> the transfer of nerve impulses
> how an electromagnet works.

Although she proposed a common schematic structure consisting of the stages of "Link" followed by "Implication sequences" (1988:108), she noted wide variation in the realisation of the Link stage (1988:108), indicated the need for further research to clarify the realisation of Wignell's notion of "terminal state" in his modelling of implication sequences (1988:105), and emphasised the tentative nature of her proposed schematic structure - suggesting that

> further research is required if a more definite schematic structure is to be identified (1988:110).

Martin's work on science texts did not differentiate types of explanation. He used examples from a number of fields (carbonisation; sea breezes; osmosis; igneous and sedimentary rocks; calcification; abrasion) to illustrate the focus of explanations on processes, on the organisation of processes into implication sequences and on the power of

technical vocabulary in condensing the realisation of implication sequences to a single nominal group via the resource of grammatical metaphor (Martin, 1986; 1993c). One study (Martin, 1993b) included a detailed analysis of one secondary school textbook explanation of sound waves, discussing the realisation of reasoning, the role of grammatical metaphor in constructing technicality and in interacting with Thematic choice to realise the text's method of development, and in addition, the interaction of conjunctive relations and method of development to scaffold the schematic staging of the text. Significant information was accumulating on the realisation of explanation in secondary school science texts, but it was derived from a small number of texts, and perhaps the greatest elaboration arose from the extensive and intensive analyses of one text (Martin, 1993b).

1.1.5.2.4 *The explication of a range of explanation genres*

Two studies addressed the explication of a more delicate account of explanation genres. Both were concerned with the impact of changes in the Field and the experience of the intended audience on the generic structure of explanatory texts and on the discourse semantic and lexicogrammatical choices realising the stages in the generic structure. The first study was in the context of "a systemic approach to computer modelling of variant text production" (Cross, 1992). The second study was in the context of educational linguistics and was concerned with the specification of written genres encountered by students in New South Wales secondary school courses (Veel, in press a). The approach to modelling the schematic structure of explanations in each of these studies is outlined below.

Explanations of "matter cycles" (the water cycle, the nitrogen cycle, the nutrient cycle) in a range of books suitable for children from ages of about eight years to fourteen years and older, were studied by Cross (1992). She proposed a generalised Generic Structure Potential (GSP) (Halliday and Hasan, 1985:52-69) for such cycle texts. This is represented by Cross (1992:149) as shown in Figure 1.2:

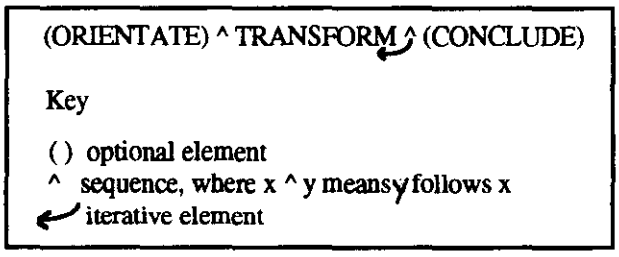


Figure 1.2 Generic structure potential for cyclical texts

A central feature of this proposal by Cross was that the generalised GSP consisted of "hyper-elements" of schematic structure. The construct of the hyper-element enabled the theoretical account of the text's macrostructure to be represented in terms of delicacy. The generalised GSP provided the grand plan for any cyclical text and then it was possible to describe a GSP for each particular cycle. This described the particular elements of structure possible within the constraints of the grand plan. For example, the obligatory, iterative TRANSFORM hyper-element in the water cycle texts took the following form:

EVAPORATION ^ CONDENSATION ^ PRECIPITATION ^ RETURN TO SEA

so the GSP for water cycle texts (Cross, 1992:150) is:

ORIENTATION ^ EVAPORATION ^ CONDENSATION ^ PRECIPITATION ^ RETURN TO SEA ^ CONCLUSION

Here there is no variation in the elements of structure which comprise the iterative TRANSFORM hyper-element. However, the GSP for nitrogen cycle texts indicated the possibility of greater variation in the elements of schematic structure comprising the TRANSFORM hyper-element.

(ORIENTATION) ^
{[(FIXATION) . [ABSORPTION . (INGESTION)] . DECOMPOSITION] ^ (DENITRIFICATION)}
^ (CONCLUSION)

Key - additional conventions

.	optional sequence
{} and [ ]	elements within braces or square brackets are treated as a block in the ordering of contiguous elements

This possibility of variation is also the case, albeit to a lesser extent, for the nutrient cycle texts.

(ORIENTATION) ^ [ABSORPTION . DECOMPOSITION] ^ (CONCLUSION)

This modelling of genre is not inconsistent with that appearing in primary school genre-based writing materials for teachers discussed earlier, in which implication sequences (Wignell et al, 1987) detail how some object or material goes through some process to become another object or material and this sequence continues until the final state of being or thing is produced. However, greater delicacy introduced by Cross made it possible to show how changes in the Field, impacted on generic structure and also how changes in the intended audience might also impact on generic structure. The latter was indicated by

findings that the optional ORIENTATE and CONCLUDE hyper-elements have a tendency not to be included in texts where the intended reader is "a low level novice" (Cross, 1992:155). In addition, although the optional "TRANSFORM" elements in the nitrogen cycle texts showed little evidence of principled inclusion or exclusion, there was a tendency to include more of the optional elements in texts designed for the higher level of novice than lower (Cross, 1992:155).

The approach taken by Cross (1992) to extending the delicacy of the account of explanatory genres then, also facilitates an account of variation in generic structure as one dimension of the semiosis of recontextualization.

The extensive range of secondary school texts examined in recent work in educational linguistics (Veel, in press a; in press b) revealed that for explanations

> ...the very broad model of the genre offered in early genre work cannot possibly cope with the many different ways of explaining phenomena in science and the many different levels at which explanations can operate (Veel, in press b:4).

The range of explanation genres identified, their purposes and the stages in their schematic structures are indicated in Table 1.1 which is extracted from a table showing all of the genres found in secondary science texts by Veel, (in press, a).

Genre	Social Purpose	Stages
Sequential explanation	To explain how something occurs or is produced - usually observable sequences of activities which take place on a regular basis	Phenomenon identification Explanation sequence (consisting of a number of phases)
Causal explanation	To explain why an abstract and/or not readily observable process occurs	Phenomenon identification Explanation sequence (consisting of a number of phases)
Theoretical explanation	To introduce and illustrate a theoretical principle and/or to explain events which are counter intuitive	Phenomenon identification/ Statement of theory Elaboration 1 Elaboration ^{n}
Factorial explanation	To explain events for which there are a number of simultaneously occurring causes	Phenomenon identification Factor 1 Factor ^{n}
Consequential explanation	To explain events which have a number of simultaneously occurring effects	Phenomenon identification Effect 1 Effect ^{n}
Exploration	To account for events for which there are two or more viable explanations	Issue Explanation 1 Explanation ^{n}

Table 1.1. A range of explanation genres in secondary school science texts

Sequential and causal explanations are most relevant to this study for three reasons. The first is that the distinction between explaining how and explaining why had earlier been noted as fundamental to an account of explanation genres (Derewianka, 1990:60) and also seemed to underlie the issues of clarity in what was meant by explanation in the Christie et al (1992) primary teaching materials noted above. The second reason is that the sequential/causal dimension of explanation is a distinction which is not well articulated in science education and this has led to a very loose interpretation of what counts as appropriate explanation in school texts and in teachers' assessing of pupils' understanding of various phenomena (Horwood, 1988:45). The third reason is the problematic nature of

the distinction between these two types of explanation (indicated by Veel, in press a:145) and the suggested relationship of this distinction to recontextualizations of explanations at different "depths" of treatment, suitable to children at different levels of schooling.

More emphasis was given to the study of sequential and causal explanations by Veel (in press a: 113) since it was considered more likely that students would have to read and write these types of explanation than other types. This is based partly on the view that there is a fairly fixed sequence of occurrence of different types of explanation in school science with sequential explanations occurring first and causal explanations later (Veel, in press, a: 112,114; Veel, in press, b:15), although "they (causal explanations) rarely occur in the early years of secondary school science" (Veel, in press, a:136). There is a further implication from this view that explanations in primary school science will be sequential explanations.

> Sequential explanations are used both in primary and secondary science. In primary schools, they either form part of "natural science" - describing plants, animals, weather patterns, seasonal cycles, landforms etc., or part of social studies in the study of technology - describing how electrical and mechanical machines work etc.(Veel, in press, a:118).

There is no documented research to support such assertions about the kinds of explanations occurring in primary school science material. Informal inspection of information books for primary school science indicates that concepts of physical science are also addressed and in fact the fields of texts selected by Veel to exemplify causal explanations such as "sewage in water" and "sea breezes" (Veel, in press, a: 135) can also be found in contemporary primary school books (eg. sea breezes - Carter et al, 1990d:14; sewage in water - Bright, 1987:14). The linguistic form of such texts needs to be the subject of systematic investigation.

1.1.5.2.5 *Problems with prototypicality and typological accounts*

After identifying sequential and causal explanations as distinct agnate genres, Veel noted that -

> Very few explanations in junior secondary school science are 'purely' causal (Veel, in press, a:145);

and that more commonly explanations were not prototypically causal or sequential but combined the linguistic characteristics of both. Two reasons were advanced for this. One reason was the view that methods of scientific enquiry dictate that wherever possible,

phenomena should be explained through visible, measurable evidence rather than abstract concepts. Consequently science pedagogy tended to emphasise the link between observation/experimentation and explanation (i.e. between procedure/procedural recount and sequential explanation in language) rather than on models and concepts. The other reason indicated an essential direction in extending the research on the language of written explanation. This was the assertion that

> Junior secondary school science frequently introduces a number of areas of scientific enquiry to students without going into any topic in great depth. As has been noted earlier, causal explanations tend to be associated with more abstract treatments of topics, and so the need for causal explanations does not arise as often as the need for sequential explanations (Veel, in press a:145).

Two interrelated issues arise from this. The first is that secondary school texts may well vary in the depth to which they pursue explanations of particular phenomena. The second issue is the assumption that the relative depth to which the explanation of a phenomenon is pursued correlates with a more sequential or causal orientation to realising the relationship between events which bring about the phenomenon in question. It has been suggested that, at the outer poles of such a continuum, the same phenomenon could be explained sequentially in one text and causally in another (Veel, in press, b:22), although no textual examples of such recontextualizations were provided or cited. This extreme variation, however, is more likely to characterise the difference between explanations of the same phenomenon in primary texts when compared with secondary texts.

Additional and/or alternative dimensions of variation among recontextualizations of explanations in books at primary and secondary level were identified in the work on "cycle" texts by Cross (1992). As noted above, there was a tendency for optional elements of schematic structure to be deleted in texts for novices. But Cross also made use of Hasan's (1984) distinction between central (nuclear) meanings and optional (elaborative) meanings and showed that there was a tendency for a greater number of elaborative meanings to occur in texts for more experienced learners (Cross, 1992:240). These meanings were more likely to be "implicative" for novices but either explicit or a combination of explicit and implicative for more experienced readers.

The relative depth or technicality of texts may be differentially associated with a range of dimensions of recontextualization including variation in schematic structure, the deployment of temporal and consequential conjunction, the distribution of nuclear and elaborative meanings and their lexicogrammatical realisation. The technicality may be mediated differentially by strategic deployment of qualitatively different instances of grammatical metaphor as suggested by the work of Fuller (1992). A further question is the

relative amenability of the various phenomena dealt with in school science to explanatory recontextualizations which seek to vary these aspects of realisation. Of course, one dimension of recontextualization, arising from inept attempts at making explanations more accessible to younger learners, may be features like inexplicitness and semantic discontinuity which Halliday (1993f:70) noted as instances of poor writing in science. Research which addresses these dimensions of variation will contribute to a further extension in delicacy of the specification of explanation genres and their linguistic realisations, which will enhance the linguistic basis for educational intervention in this area.

1.2. Purpose of the study

The purpose of this work is to enhance the linguistic basis for explicit pedagogies which will facilitate children's access to the discourse of scientific English. The focus is on contributing to a critical, linguistically-based, account of apprenticing explanatory texts for upper primary and junior secondary students. This will involve the further explication of linguistic dimensions of variation which are entailed in recontextualizations of explanations of different phenomena and at different levels of schooling.

The work aims to elaborate aspects of the existing research on secondary science explanations and to relate this to an extension of the limited research on texts at the upper primary level. The intention is to complement the typological approach to the explication of explaining how and explaining why (Veel, in press, a; in press, b) by studying the manner in which writers manoeuvre between the two and the linguistic means by which they achieve their particular orientation.

By analysing a number of secondary texts dealing with the same phenomenon it will be possible to investigate variation in their relative orientation to explaining why and explaining how and to specify the range of linguistic choices exercised in so doing. By undertaking a number of parallel analyses dealing with different scientific phenomena in each case, it will be possible to indicate the effect of Field on the relative orientation to explaining why or explaining how and to compare the linguistic means by which this is achieved across Fields. By undertaking similar analyses of primary school texts, it will be possible to determine the same information in respect of books at this level and then to compare explanations of the same phenomena across primary and secondary school books to show the relative orientation to explaining why and how across school levels for different Fields. Comparing the range of linguistic choices exercised in realising these orientations within and across school levels should contribute to the development of an account of the linguistic options available in constructing such recontextualizations.

1.3. Developing the research design: Theoretical orientation

The theoretical basis of the work in educational linguistics which led to the focus of this study is that of systemic-functional grammar and discourse as developed by Halliday (1985; 1994a); Halliday and Hasan (1976; 1985); Matthiessen (in press) and Martin (1992). In particular, developments in the linguistic theorising of explanation owe most to Martin's (1992) modelling of text/context relations commonly referred to as genre theory. The discussion of the theoretical and research background to the study dealt with to this point suggests some of the relevant linguistic parameters central to an investigation of functional choices in the realisation of alternative recontextualizations of explanations appropriate to different levels of schooling. For example, the relative deployment of linguistic resources for realising temporal and causal relations is suggested as indexing corresponding differences in the relative orientation to explaining why and explaining how; and the relative technicality of explanations may be indexed by the extent of, and qualitative difference among, instances of grammatical metaphor. However, in order to develop a rationale for, and to explicate the nature of, the detailed analyses to be undertaken, the next chapter will first outline relevant aspects of systemic functional linguistic modelling of genre, register, discourse semantics and lexicogrammar. The research on the linguistic realisation of explanation in school science texts will then be reviewed in these terms. Following this, the purpose of the present study will be reformulated and operationalized in terms of the systemic linguistic analyses to be conducted.

Chapter 2

Theoretical orientation and design of the study

There are three main sections in this chapter. The first provides a sketch of the main features of the model of systemic-functional grammar and discourse as developed by Halliday (1985; 1994a), Halliday and Hasan (1976; 1985); Martin (1992) and Matthiessen (in press). The second section reviews systemic-functional linguistic accounts of explanation in school science books and formulates research questions to be pursued in the present study. The third section deals with the design of the study, describing the data to be analysed and providing a rationale for the data selection, indicating the organisation of the analyses in relation to the research questions, as well as detailing the basis of the procedures to be followed in each of the analyses and the method of reporting results.

2.1 A functional model of language

> The form of human language is as it is since it co-evolves with the meanings which co-evolve with the community's contexts of social interaction (Hasan, 1992:24).

Systemic-functional linguistics (SFL) is a theory of text-context relations oriented to extravagance rather than parsimony (Halliday and Martin, 1993b:23). This orientation to the development of an encompassing model of social systems in semiotic terms, means that SFL is well suited to the investigation of educational questions, where the social dimension is particularly significant. Learning is, above all, a social process. It takes place in social institutions, through relationships of parent and child or teacher and pupil, using artefacts such as textbooks, constructing contexts which are all defined in the value systems and ideology of the culture.

> And the words that are exchanged in these contexts get their meaning from activities in which they are embedded, which again are social activities with social agencies and goals (Halliday and Hasan, 1985:5).

What is sketched here is simply the principal aspects of the model which reflect this orientation. The overview firstly distinguishes two communication planes - language and social context. It then deals with the stratification of each of these communication planes. The stratified model of context discusses genre and register from the perspective taken by Martin (1992). The content plane of language is stratified with respect to discourse semantics and lexicogrammar, which have phonology/graphology as their expression plane.

The nature of the metafunctional diversification characterising register, discourse semantics and lexicogrammar and its solidary relation across levels is also addressed.

2.1.1 Communication planes: Language and social context.

From the perspective of SFL the oral and written texts we engage with and produce have their particular linguistic form because of the social purposes they fulfil. The focus is not on texts as decontextualized structural entities in their own right but rather on the mutually predictive relationships between texts and the social practices they realise. SFL then, treats language and social context as complementary levels of semiosis, related by the concept of realisation. The relationship between language and social context has been represented using the image of co-tangential circles as in Figure 2.1 (Halliday and Martin, 1993b:25).

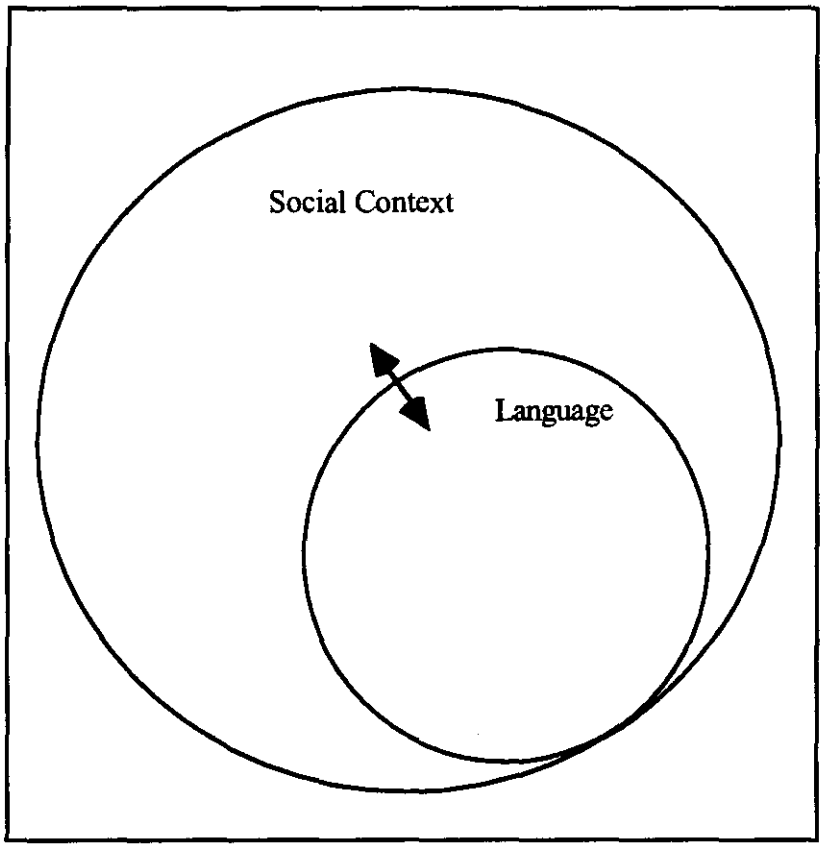


Figure 2.1 Language as the realisation of social context

This representation is intended to establish the semiotic system of language as the realisation of the more abstract semiotic system of social context. The concept of realisation means

that one system redounds with the other; language construes, is construed by and (over time) reconstrues and is reconstrued by social context. The double headed arrow in the diagram symbolises this mutual determination (Halliday and Martin, 1993b:24).

2.1.2 Stratification: Levels of semiosis

2.1.2.1 Levels of context

The social context of a text has been theorised by Halliday (Halliday and Hasan, 1985:12) at one level in terms of the contextual variables of Field, Tenor and Mode.

> The FIELD OF DISCOURSE refers to what is happening, to the nature of the social action that is taking place: what is it that the participants are engaged in, in which the language figures as some essential component?
>
> The TENOR OF DISCOURSE refers to who is taking part, to the nature of the participants, their statuses and roles: what kinds of role relationships obtain among the participants, including permanent and temporary relationships of one kind or another, both the types of speech role that they are taking on in the dialogue and the whole cluster of socially significant relationships in which they are involved?
>
> The MODE OF DISCOURSE refers to what part the language is playing, what it is that the participants are expecting the language to do for them in that situation, the symbolic organisation of the text, the status that it has, and its function in the context, including the channel (is it spoken or written or some combination of the two?) and also the rhetorical mode, what is being achieved by the text in terms of such categories as persuasive, expository, didactic and the like.
> (Halliday and Hasan, 1985:12)

The notion of Field has been further elaborated by Martin (1992:292) defining Fields as "sets of activity sequences oriented to some global institutional purpose" - and citing examples such as linguistics, tennis, cooking, wine making, gardening etc. These activities involve participants, processes and attendant circumstances and are temporally and/or consequentially linked to form sequences. The participants involved in sequences are organised into either compositional and/or superordination taxonomies (Martin, 1992:536-42).

Tenor is concerned with the semiotics of relationships, mediating these along the dimensions of status, contact and affect (Martin, 1992:523-525). Status refers to the relative position of the participants in the social hierarchy of a culture while contact refers to their degree of institutional involvement with each other. Affect addresses Halliday's (1978:33) notion of the "degree of emotional charge" in the relationship between participants.

Mode is discussed by Hasan (Halliday and Hasan, 1985:58) under three sub-headings. The first is the extent to which the language is constitutive of, or ancillary to the social process in which it functions. The second is the extent to which the form of language used incorporates (the possibility of) feedback from the addressee. This variation is referred to as a continuum from *spoken* to *written* medium. Written medium is usually associated with the constitutive role of language, while spoken medium is associated with both constitutive and ancillary. Hasan's third sub-heading is *channel* - the modality through which one comes in contact with the message, which is referred to as the phonic channel and the graphic channel. It is possible for medium and channel to be congruent, i.e. spoken/phonic, written/graphic, but to the extent that one writes using the same grammatical form as when one speaks, the channel may be graphic but the medium more spoken. Similarly, it is possible to speak using the grammatical constructions more typical of written text, so that the channel is phonic but the medium is written.

Halliday's inclusion within his mode category of "rhetorical mode" referring to the social purpose or teleology of the text, represents one aspect of the model which has been treated differently by a number of theorists in the field. These differences are addressed by Martin (1991:121-129; 1992:497-503), but the concern here will be confined to a brief outline of Martin's alternative treatment of purpose, since it involves the stratification of context with respect to the levels of register and genre. Martin (1992:502) uses the term register to refer to the semiotic system constituted by the contextual variables Field, Tenor and Mode. He notes that notions of purpose do not correlate with any one metafunctional component in language and have been associated at one time or another with different variables in the development of register theory. In Martin's view then, a teleological perspective on text function is better set up as superordinate to - rather than alongside or incorporated in - Field, Mode and Tenor.

> The register variables Field, Tenor and Mode can then be interpreted as working together to achieve a text's goals, where goals are defined in terms of social processes at the level of genre (Martin, 1992:503).

In Martin's proposal, text structure is generated at the level of genre and, as part of the realisation process, generic choices pre-select Field, Mode and Tenor options associated with particular elements of text structure. The interpretation of context then includes two communication planes, genre (context of culture) and register (context of situation), with register functioning as the expression form of genre, at the same time as language functions as the expression form of register. Martin (1992:495) schematises this three plane model as shown in Figure 2.2.

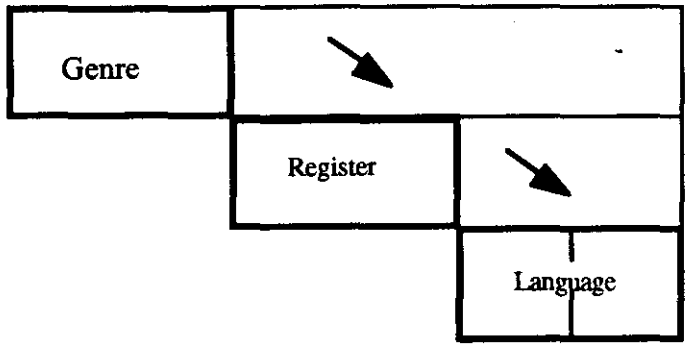


Figure 2.2 Stratifying context as language's content plane

Martin's stratified model of context has been taken up in Australian educational linguistics as an accessible means by which teachers have been able to confront contextual considerations in text/context relations and has been the basis for much of the work cited dealing with theorising the linguistic form of explanatory texts (Wignell et al, 1987; Shea, 1988; Veel, in press a; in press b) and with intervention in children's literacy development and learning (Macken, 1989; Derewianka, 1990; Christie et al, 1992). There are clearly practical, and, as Martin (1992:505-508) has argued, theoretical advantages in this interpretation of context. But whether stratified or unstratified models of context are preferred, the well established and commonly accepted theorising of the solidary relationship between text and context is fundamental to the systemic-functional model of language as a whole.

> ... the context of situation, the context in which the text unfolds, is encapsulated in the text, not in a kind of piecemeal fashion, nor at the other extreme in any mechanical way, but through a systematic relationship between the social environment on the one hand, and the functional organisation of language on the other. If we treat both text and context as semiotic phenomena, as 'modes of meaning', so to speak, we can get from one to the other in a revealing way (Halliday and Hasan, 1985:11-12).

2.1.2.2 Levels of language

Language bridges from the cultural meanings of social context (the social hierarchies and role relationships, the institutional activities, and the related distribution of language use within these) to sound or writing. It does this by moving from higher orders of abstraction to lower ones. These orders of abstraction are organised into three levels or strata - semantics, lexicogrammar and phonology (or graphology).

The stratal role of semantics is that of an interface between social context and lexicogrammar. Pursuing the definition of text as a semantic unit (Halliday and Hasan,

1976), Martin (1992:19) refers to the stratum of semantics as discourse semantics, i.e. a semantics of texts rather than propositions. Discourse semantics generalises across grammatical resources and accounts for relations between, as well as within clause complexes. Discourse semantics is functionally diversified in correspondence with the metafunctional diversification of context. This is shown in Figure 2.3 after Halliday and Martin (1993b:30).

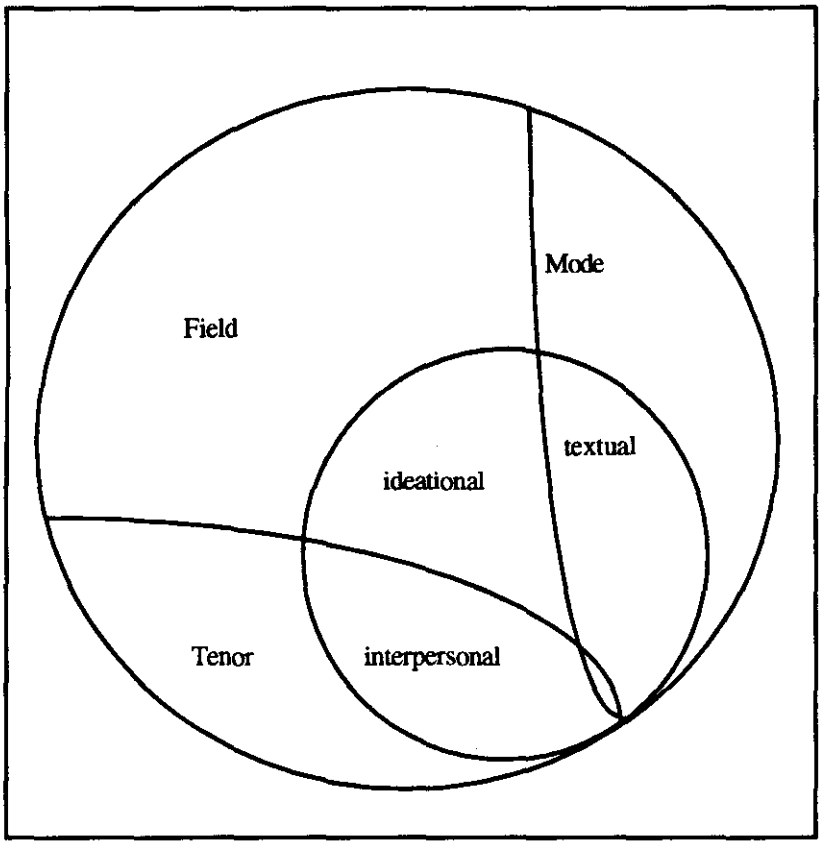


Figure 2.3 Metafunctional solidarity across planes

Ideational meanings realise Field, interpersonal meanings realise Tenor and textual meanings realise Mode. Four discourse systems constituting the discourse semantic stratum were proposed by Martin (1992): negotiation, identification, conjunction and ideation. Negotiation is an interpersonal system concerned with discourse as dialogue, and is based, in part, on Halliday and Hasan's (1976) description of referential cohesion. The systems which address the construal of Field are Conjunction and Ideation. Conjunction focuses on logical meaning - on relations of addition, time, cause, and comparison between messages - again deriving in part from Halliday and Hasan (1976). Ideation deals with experiential relations among lexical items - hyponymy, antonymy, synonymy, meronymy - also influenced largely by Halliday and Hasan (1976). All but negotiation will be addressed in

analyses within this study and relevant analytic procedures will be described in section 2.3.3.

Lexicogrammar is a resource for wording meanings, i.e. realising them as configurations of lexical and grammatical items. This is achieved through hierarchically organised units called ranks, each of which makes a partial contribution to the whole. The ranks are clauses, groups, words and morphemes. The relationship between lexicogrammar and discourse semantics is a solidary one, with both levels making meaning. It follows then, that lexicogrammar is characterised by the same kind of metafunctional diversification discussed above.

Ideational (experiential and logical) meanings construing Field are realised lexicogrammatically by the system of Transitivity. This system interprets and represents our experience of phenomena in the world and in our consciousness by modelling experiential meanings in terms of participants, processes and circumstances. Resources for chaining clauses into clause complexes, and for serialising time by means of tense, address logical meanings.

Interpersonal meanings are realised lexicogrammatically by systems of Mood and Modality and by the selection of attitudinal lexis. The Mood system is the central resource establishing and maintaining an ongoing exchange between interactants by assuming and assigning speech roles such as giving or demanding goods and services or information. Thus the giving of information or goods and services is grammaticalised as declaratives, questions are grammaticalised as interrogatives and commands as imperatives. Modality is the resource concerned with the domain of the negotiation of the proposition or proposal between the categorical extremes of positive or negative. The negotiation may be in terms of probability, usuality, obligation or inclination.

Textual meanings are concerned with the ongoing orchestration of interpersonal and ideational information as text in context. Lexicogrammatically textual meanings are realised by systems of Theme and Information. Theme selections establish the orientation or angle on the interpersonal and ideational concerns of the clause whereas Information organises the informational status or relative newsworthiness of these concerns.

The metafunctions permeating register at the level of social context and also the discourse semantic and lexicogrammatical levels of language, are simultaneous and complementary systems. In the clause each metafunctional resource (Transitivity, Theme and Mood) generates one layer of structuring, but the layers are simultaneous as shown in Figure 2.4.

	Sound waves	will not travel	through a vacuum
TEXTUAL	Theme	Rheme	
INTERPERSONAL	Mood		Residue
	Subject	Finite	Predicator / Adjunct
IDEATIONAL	Actor (Medium)	Process (Material)	Circumstance

Figure 2.4 Simultaneous structuring of the clause by metafunction

Discourse semantics and lexicogrammar represent the stratified content plane of language for which phonology/graphology is the expression plane as illustrated in Figure 2.5 (Martin, 1991: 114).

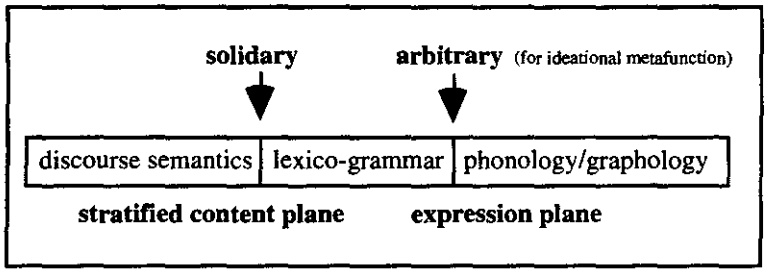


Figure 2.5 Solidarity and arbitrariness across strata

Phonology is a resource for realising abstract wordings as sound and includes intonation, rhythm and syllabic and phonemic articulation. Alternatively this level may be the graphological system of a language. In general, the system of phonology is related in an arbitrary or purely conventional manner to the lexicogrammar, although Matthiessen (in press: 9, note 4) and Martin (1991:note 12) point out that while this is so with respect to the ideational metafunction, it is arguably related more naturally in the interpersonal and textual spheres. This study will not be concerned with issues at the level of phonology/graphology.

2.2 Extending systemic linguistic accounts of explanation in school science books

The following review of systemic linguistic research on explanations in school science texts relates the results to the purpose of this study in order to determine aspects of previous findings relevant to the development of the current investigation and to formulate specific research questions to guide the enquiry. The central educational linguistic concerns of this study can be formulated as a general research question in the following terms:

How can the generic structure and discourse semantic and lexicogrammatical realisation of causal explanations in upper primary and junior secondary science books be further explicated in order to:

(i) provide an account of the linguistic options in recontextualizing explanations at these levels of schooling;

(ii) evaluate such texts as resources for apprenticing children to the discourse of scientific English?

This can be reformulated in somewhat more "operational" terms as follows:

What choices in generic structure, discourse semantics and lexicogrammar are functional in the realisation of alternative recontextualizations of explanations of the same phenomenon within and across junior secondary and upper primary science books? How do these choices vary with explanations of different phenomena?

The study then, is concerned with realizational variation in texts within and across Fields and school levels of the intended readership. As shown in Chapter one, the only work to compare explanatory texts at different levels of schooling and, to a lesser extent, dealing with different Fields, was that of Cross (1992) on "cycle" texts. Although she compared whole texts in terms of genre, her comparisons on other dimensions, such as the meanings defining elements of generic structure and their lexicogrammatical realisation, were restricted to a study of the ORIENTATE element. Hence, although there is considerable information about the linguistic dimensions of school science explanations, relatively little is known about how these vary when explanations deal with different scientific phenomena and are designed for children at different school levels. As a first step toward further systematic enquiry in this area, existing knowledge of the linguistic dimensions of school science explanations which potentially co-vary with Field and school level will be summarised, and then specific research questions relevant to each dimension of variation will be formulated.

2.2.1 Genre

Different proposals for the identification of elements of schematic structure which constitute explanation genres in school science are to be found in the work by Shea (1988), Cross (1992) and Veel (in press a) as well as in materials for teachers dealing with genre-based writing development (Macken et al, 1989; Macken and Rothery, 1991; Christie et al, 1992). These were outlined in chapter one (1.5.2.1 - 1.5.2.4). The more recent of these accounts have moved toward greater differentiation of explanation types and a more delicate specification of elements of schematic structure.

A three-stage schematic structure for written explanations in school science texts was proposed by Shea (1988) and reported by Martin (1993b:257):

> ... scientific explanations begin with a very general Link stage, which in science textbooks bridges between the explanation and the report into which it is embedded. Following this there is an indefinite number of Implication Sequences, any one of which may optionally be explicitly closed with a stage called State.

Contemporary accounts of the genre of explanation in primary and secondary school curriculum contexts suggest a two-stage schematic structure: Phenomenon Identification ^ Implication Sequence ^{n} (Macken et al. 1989; Derewianka, 1990; Macken and Rothery, 1991). One set of classroom materials added the stage - Title (Christie et al, 1992), but this does not seem to be functionally distinct from the Phenomenon Identification.

The Phenomenon Identification stage was not specified by Shea, but it would appear to be subsumed by her Link stage. In the context of teaching primary school children to write explanations and also in factual books for children of this age, explanations of phenomena are more likely to occur as discrete texts rather than as part of an extended treatment of a topic as is the case in secondary school textbooks. It is not surprising then, that in primary education materials the initiating stage was designated Phenomenon Identification rather than Link. Shea's State stage is also absent from the schematic structure provided in primary school contexts. Since "a common function of the State element of the structure" is " arresting the implication sequence to define technical terms associated with processes", it is possible that primary school texts, which are less technical, are therefore less apt to include this stage.

The generalised Generic Structure Potential (GSP) for "cycle" texts proposed by Cross (1992) is somewhat similar to the tentative schematic structure proposed by Shea (1988), and both of these include a final stage not specified in the genre-writing materials for teachers nor in the recent research by Veel (in press a). The proposals for generic structure are summarised in Table 2.1

	Generic Structure		
Shea (1988)	Link ^	Implication sequence^{n} ^	State
Cross (1992)	(Orientate) ^	Transform^{n} ^	(Conclude)
Macken et al (1989)	Phenomenon Identification ^	Explanation sequence	
Veel (in press a)	Phenomenon Identification ^	Explanation sequence	

Table 2.1 Proposed generic structures for school science explanations

The treatment of the initial element of structure by Cross (1992), which she labels as the ORIENTATE element, picks up on the separate functions indicated by the elements labelled Phenomenon Identification and Link in previous accounts. This is achieved by Cross's notion that this initial element orientates the reader through the use of the "summarise" and/or the "contextualize" strategy. The summarise strategy presents a summary or overview of the cyclical process to be detailed in the explanation (Cross, 1992:167) and hence includes the function of the Phenomenon Identification. The contextualize strategy locates the text in a semiotic framework such as "scientific objectivism", where cause and effect are foregrounded and scientific lore canonised (Lemke, 1987), or the framework might be "social geography" in which the relevance to mankind or mankind's impact on the cycle is mentioned (Cross, 1992:169). This strategy could also include Shea's notion of the function of the Link in relating the particular phenomenon to aspects of the Field previously dealt with. As noted in chapter one, Cross (1992:155) found a tendency for the ORIENTATE element not to be included in texts for "low novices", which is consistent with the above interpretation of the two stage generic structure for explanations in the primary genre-writing materials. The schematic structure for sequential and causal explanations proposed by Veel (in press a:119) was again the two stage Phenomenon Identification ^ Explanation Sequence^{n}. The Phenomenon Identification introduces that which is to be explained and apparently optionally includes:

> a technical name for the phenomenon;
> a summary of the explanation;
> one or two sentences of background information about the thing which is being explained
> (Veel, in press a:120)

This is consistent with Cross's account of the ORIENTATE element, although Veel has not specified "background information" in the form of Cross's contextualize strategy.

The implication/explanation sequences forming the following stages of schematic structure were not given differentiated functional labels in the genre writing materials for teachers (Macken et al, 1989) nor in the work by Shea (1988) or Veel (in press a). They corresponded to the iterative hyper-element, TRANSFORM, introduced by Cross (1992). However, as noted in Chapter one, the concept of the hyper-element facilitated such differentiated functional labelling of the TRANSFORMATION elements which occurred in particular cycle texts. The work by Veel (in press a) stopped just short of this, indicating however, that the Explanation Sequence can be broken down into Phases (each consisting of an object linked to a main event) with each Phase taking the Explanation Sequence one "step" further towards its end point (Veel, in press a:121). The only difference suggested between the schematic structure of Sequential and Causal explanations is that Phases in the Explanation Sequence are often linked consequentially rather than temporally (Veel, in press a:138), however, such links are also frequently found to be temporal in explanations designated as "Causal". Further clarification of schematic structures of explanations will be facilitated by the extension of Cross's approach to the functional differentiation and labelling of the particular TRANSFORMATION elements/Implication Sequences/Phases which comprise the PROCESS or Explanation Sequence stage of such explanations.

An optional concluding stage that follows the detailing of the process of the cycle was proposed by Cross (1992:105).

> In functional terms the role of the optional CONCLUDE element is to draw some conclusion to the text such that it steps outside of the detail of the process of the cycle. Informally the central meanings may be identified as naming the cycle, commenting on man's interruption of the cycle and discussing the unending continuity of the cycle (Cross, 1992:106).

No such concluding stage was discussed in the work by Veel (in press a) - the explanation concluded with the implication sequence or Phase which resulted in the emergence of the phenomenon introduced in the initial stage. The closing of an Implication Sequence/Phase was recognised in Shea's work (1988:106) as the element of schematic structure which she labelled "State". This element frequently included the definition of a technical term associated with the process in question (Shea, 1988:106; Martin, 1993b:258) and is consistent with the function of naming the cycle in the Cross (1992) CONCLUDE element. The specification of this optional concluding element of structure is important to the study of variation in the generic structure of explanation as indicated in the findings by Cross (1992:105) that the CONCLUDE element had a high tendency to occur in the nitrogen cycle texts and a somewhat lesser tendency to occur in texts of the water cycle. In fact, as discussed in Chapter one, the work by Cross also indicated variation in the TRANSFORM elements with variation in Field, and, as noted above, a relationship between the inclusion

of the optional ORIENTATE element and the experience level of the intended audience. Although Cross's study was limited to cycle texts, it is clear that the further explication of a more delicate account of a range of explanation genres dealing with different phenomena in school science texts, and an understanding of their recontextualization at different levels of schooling, needs to clarify the differentiation and specification of all elements of schematic structure. This suggests the first specific research question:

> *How does the schematic structure of school science explanations vary with Field and level of schooling?*

The construction of the schematic structure of texts was related by Martin (1992:436; 1993:257) to the interaction of selection of Theme, Conjunction, lexical relations and grammatical metaphor. An understanding of the nature of this "scaffolding of the text with respect to its rhetorical purpose" will assist in the differentiation of elements of schematic structure and in clarifying the relationship between the relative deployment of temporal and consequential relations and the text's rhetorical purpose. Existing work dealing with the patterns of Thematic choice and conjunctive relations in school science explanations is outlined in the following sections.

2.2.2 Packaging: Grammatical metaphor, Theme and New

Grammatical metaphor, as a tool for packaging meaning, greatly enhances the flexibility of the text-forming resources of Theme and Information. Through interaction with Theme and New, grammatical metaphor re-textures the clause enabling it to participate in its context in ways appropriate to the organisation of text as text.

> Theme in a sense provides the text's angle on its field; it is the peg or two on which the rest of the text's meanings are hung. New, by contrast, elaborates the field, developing its meanings - fleshing out the construction of experience with which the text is concerned. Looking upward to context, Theme is genre oriented, angling a text in relation to its social purpose; New, on the other hand, focuses on field, developing the institution at hand. Deployed effectively, grammatical metaphor in writing is a powerful resource for getting a text's angle right and for elaborating its experiential focus in appropriate ways (Martin, 1993b:244).

2.2.2.1 Hyper-Theme and method of development

The information contained within the Themes in the sentences in a paragraph was shown by Fries (1981; 1983) to articulate "the text's angle on its field" in Martin's terms, or in the terminology used by Fries, the Thematic selections create "the method of development of the paragraph" (Fries, 1983:135). Martin (1993b:244) noted that Fries' examples indicated

a tendency for the information in the first sentence or two of some texts to predict their method of development. According to Martin such sentences established the "point of departure" for the paragraph and hence warranted the extension of the notion of Theme to the level of the paragraph. This paragraph-level Theme, Martin referred to as Hyper-Theme, and illustrated its function in his analysis of the following secondary science book explanation of sound waves.

HYPER-THEME
If we look at how a tuning fork produces sound
we can learn just what sound is.

THEMES in the remainder of the text
(Themes in bold, marked Themes in bold italics)

By looking closely at one of the prongs
you can see that it is moving to and fro (vibrating).
As the prong moves outwards
it squashes, or compresses the surrounding air.
The particles of air are pushed outwards
crowding against and bashing into their neighbours
before they bounce back.
The neighbouring air particles are then pushed out
to hit the next air particles and so on.
This region of slightly squashed together air moving out from the prong
is called a compression.
When the prong of the tuning fork moves back again
the rebounding air particles move back into the space that is left.
This region where the air goes thinner is called a rarefaction
and also moves outwards.
The particles of air move to and fro in the same direction in which the
wave moves and do not move along with the compression.
Thus sound is a compression wave that can be heard.

Martin indicated that, since explanations focus on activity sequences, the Hyper-theme in this text predicts a Theme selection in which processes have a significant role to play. Processes participate in this text's method of development in two ways. The first is as enhancing β clauses realised before their α in marked Theme position (shown in italics above). The second is as embedded modifiers in nominal groups functioning as Theme (shown in bold above). The text's remaining Themes refer to the air particles that are affected by the movement of the tuning fork's prongs. The text's method of development is thus "air affected by the motion of the prongs" (Martin, 1993b:246).

2.2.2.2 Hyper-New and Point

In contrast to the text's method of development, Fries (1981/83) identified the message the text is trying to convey as positively correlated with the meanings realised in the Rhemes of clauses constituting the text. This he referred to as Point. Martin (1993b:247) extended Fries' interpretation to show that the Point of a text, constituted by the pattern of New selections, was in a predictive relationship with a clause (or combination of clauses) that could be defined as Hyper-New. By extending the domain of the New to include an additional experiential clause constituent to the left of the minimal New, Martin demonstrated how the pattern of information in News was accumulated in the Hyper-New occurring subsequently in the text. Martin shows in the explanation of sound waves below, how the News elaborate the way in which the motion of the tuning fork produces a pattern of movement among adjacent air particles that constitutes an audible wave. The meanings are then accumulated in final clause as Hyper-New - " a compression wave that can be heard" - defining sound.

(extended New in italics)

By looking *closely at one of the prongs*
you *can see*
that it *is moving to and fro (vibrating).*
As the prong *moves outwards*
it *squashes, or compresses the surrounding air.*
The particles of air *are pushed outwards*
crowding against and bashing into their neighbours
before they *bounce back.*
The neighbouring air particles *are then pushed out*
to hit the next air particles
and so on.
This region of slightly squashed together air moving out from the prong
is called a compression.
When the prong of the tuning fork *moves back again*
the rebounding air particles move *back into the space that is left.*
This region where the air goes thinner *is called a rarefaction*
and also *moves outwards.*
The particles of air move *to and fro in the same direction in which the wave moves*

HYPER-NEW
Thus sound is a compression wave that can be heard.

2.2.2.3 Grammatical metaphor

In the text analysed by Martin above, the grammatical metaphors in Theme position consist of embedded clauses as Qualifiers so they maintain something of the dynamic perspective of congruent grammaticalisation:

This region of slightly squashed together air moving out from the prong

This region where the air goes thinner

The Thematized grammatical metaphors are Value in the Relational: identifying clauses. They contain the lexical metaphors of commonsense knowledge. The grammatical metaphor in the News is in the form of the technical nominalisations of uncommonsense which realise the corresponding Tokens in the Relational: identifying clauses.

a compression

a rarefaction

Although the patterns of Theme and New and grammatical metaphor have been related to the schematic structure of texts in other fields such as history (Martin, 1992:440-443; 1993b: 241-251), there is no other investigation of the "packaging" of explanations in school science texts through the co-patterning of these resources. Nevertheless, the available evidence indicates that an account of the extent of variation in such packaging may be an important part of understanding the nature of recontextualizing explanation in school science books. This suggests a second group of specific research questions addressing variation within and across Field and level of schooling:

How does the pattern of Theme selection and Information focus vary?

more specifically -

How does the pattern of Theme selection and Information focus relate to schematic structure?

and

How does the interaction of grammatical metaphor, Theme selection and Information focus vary across texts?

2.2.3 Conjunction

2.2.3.1 Conjunction and rhetorical structure

In relating patterns of conjunction to genre, Martin (1992:436-444; 1993b:233-241) elaborates the distinction made by Halliday and Hasan (1976:240) between "internal" and "external" conjunction. In Martin's terms, external conjunction is oriented to Field and organises activity sequences, while internal conjunction is oriented to Genre and orchestrates textual sequences. These latter rhetorical relations within the text itself have received little attention in investigations of explanations in school science. In some explanations they are simply not at issue since "text time" is equivalent to "Field time" and the text unfolds iconically with the unfolding of the activity sequences it realises. This is the case with texts classified by Veel (in press a) as Sequential explanations. The secondary science text exploring sound waves which was analysed for Theme and New above (and which would be classified by Veel as a causal explanation) was shown by Martin (1993b:233-235) to have a very simple rhetorical structure in which the internal conjunctive relations meant that the clauses constituting the body of the text functioned simultaneously as the specification of the phenomenon identified in the first two clauses, and the rhetorical means for the concluding clause. This is shown in Figure 2.6, analysed according to the procedures in Martin (1992:235-243). (Internal conjunctive relations are modelled on the left side of the reticulum and external relations on the right.)

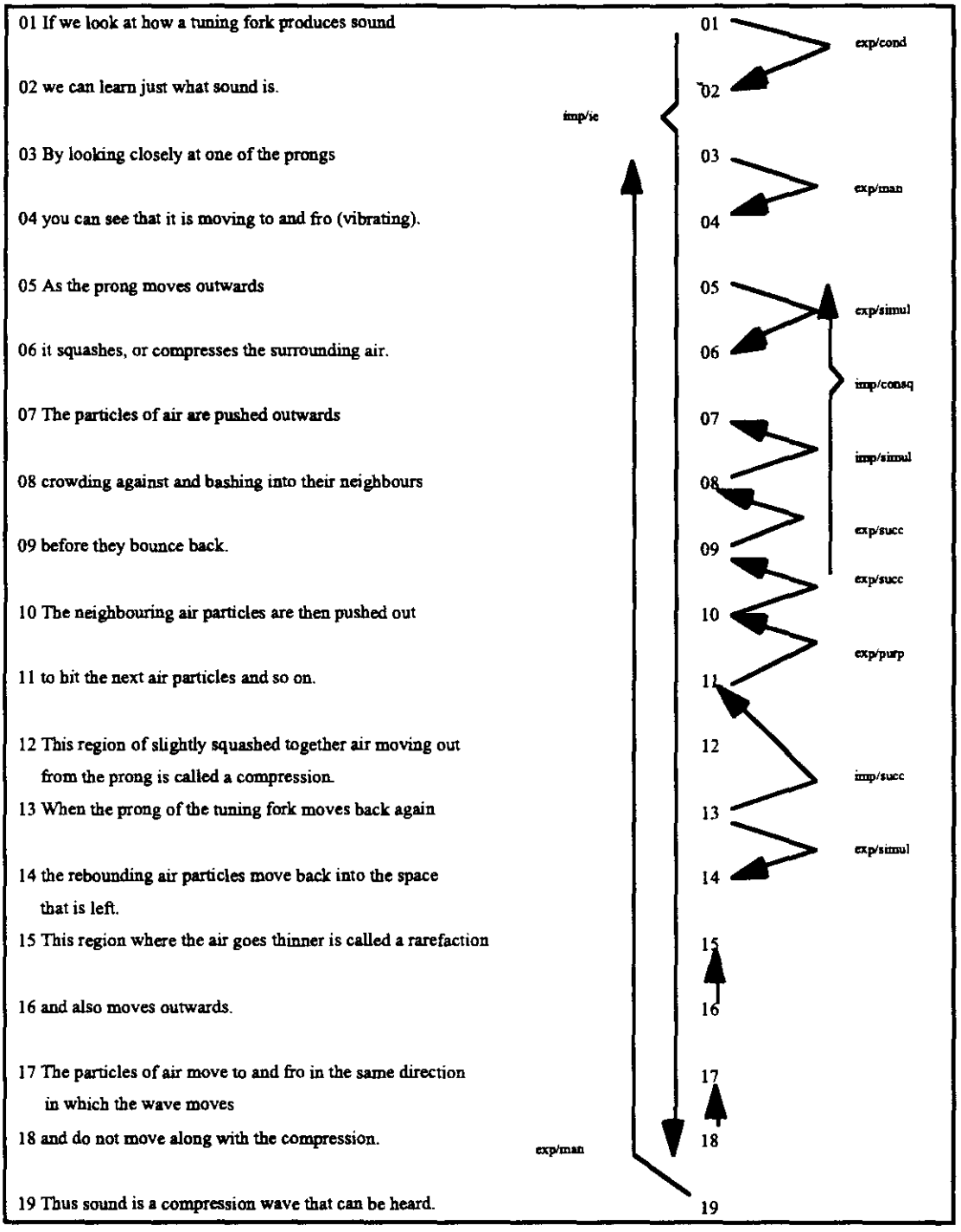


Figure 2.6 Conjunction in a secondary school science explanation

Such "sandwich" structures, Martin suggested, were common in explanatory texts of this kind. However, since this analysis is the only account of the internal conjunctive relations in explanations in school science texts, this aspect of conjunction, as another potential dimension of variation within and across Fields and levels of schooling, needs further investigation. In specific terms we need to know:

What is the relative use of internal and external conjunction?
How does the deployment of conjunction in scaffolding schematic structure vary?

2.2.3.2 Variation in the realisation of conjunctive relations

Logico-semantic relations between processes are realised by paratactic and hypotactic relationships within the clause complex and through cohesive conjunctions relating clause complexes to each other. In addition, Halliday (1985; 1994a) and Martin (1992) showed that these relations can also be realised within rather than between processes - as Circumstances in any process type, within the structure of relational clauses (especially the circumstantial variety) and even within the structure of nominal groups. Figure 2.7 is adapted from Martin's (1992:168-170) account of this diversification exemplified through temporal relations. A parallel account for causal relations is provided by Halliday (1994a:398-403).

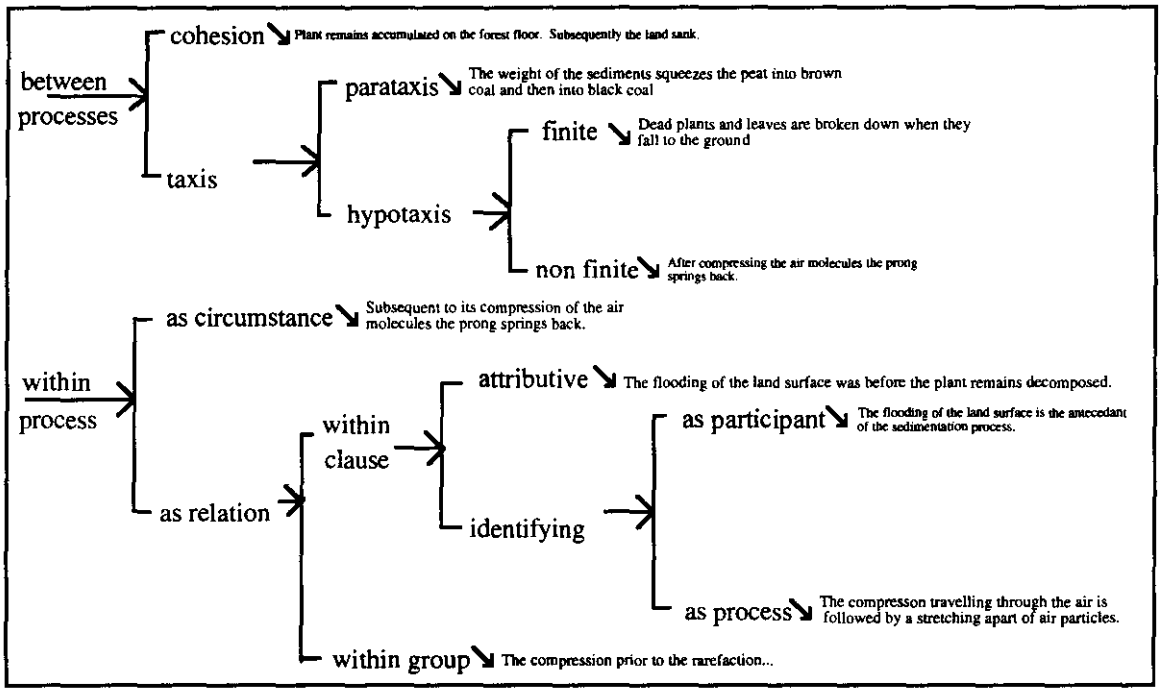


Figure 2.7 Divergent grammaticalisations of conjunction.

2.2.3.2.1 Realisation of conjunctive relations between processes

The realisation of conjunction in secondary school science textbook explanations was characterised by Shea (1988:70) and Martin (1993b:241) as involving logico-semantic relations between processes. One explanation of sound waves was analysed by Martin (1993b) for conjunctive relations, following procedures detailed in Martin (1992:234-248). He concluded that...

> ...reasoning in science Explanations is fairly concrete. Conjunctive relations are realised between rather than within clauses - the text unfolds in a relatively iconic relation to the activity sequence it describes (Martin, 1993b:241).

The presence of hypotactic enhancing clauses was suggested by Shea (1988:70) as the clearest indication to the reader of the text's explanatory function. She noted that such clauses were typically thematic, facilitating the tracing of the implication sequence in the text since the order of events in the text is congruent with the order of events in the experiential world. Paratactic enhancement was also found to maintain the ordering of clauses as iconic with that of the events involved (Shea, 1988:72). Shea's (1988:73-74) brief discussion of the deployment of the resources of cohesion highlights the problem of simply aligning "explaining how" with the selection of temporal relations and "explaining why" with consequential relations (cf Veel, in press, a:142). She points out that the connection between temporal sequencing and causal sequencing can lead to a blurring of the distinction between the two types of conjunction (Shea, 1988:73). In the following example from Shea's data the successive relation of the clause to the preceding clause is expressed in the cohesive conjunction "then":

> The neighbouring air particles are then pushed out to hit the next air particles and so on (Book 3:127)

The temporal relation between the steps in such an implication sequence clearly implies a causal relation.

Anaphoric reference as a further option from cohesion in realising conjunction is also briefly indicated (Shea, 1988:74). A clause may be referred to in a following clause as its Agent:

> Then the springy metal in the hammer's arm causes it to spring back. This reconnects the electricity (Book 4:222).

Here, Shea points out, the demonstrative "this" is referring to the preceding clause. A causal relation is thus being realised between the two clauses - the process in the first clause is a necessary condition for the process in the second clause.

A further use of anaphoric reference to effect a causal relation occurs when demonstrative reference "bridges" from a participant in a clause back to the process of the previous clause of which it is the product. Shea (1988:74) provided the following illustration;

> The heat of the sun evaporates water from the soil and from the surface of lakes, rivers and the sea. This invisible water vapour is carried about by the wind (Book 1:176).

Water vapour is the result of the process of evaporating water from the soil and from the surface of the lakes, rivers and the sea. The anaphoric reference item "this" refers to the preceding clause, expressing a causal relationship between the two clauses.

2.2.3.2.2 Realisation of conjunctive relations within processes

Although not explicitly indicated as such, Shea (1988:72) noted the occurrence of one option for the realisation of conjunctive relations "within process":

> On slightly windy nights, say less than 5-10 km/hr, this cooling effect often produces very small droplets of condensed water, called fog (Book 3:233).

Shea points out that the Circumstance of temporal location (On slightly windy nights) is clearly parallel to a hypotactic enhancing clause complex such as:

> When the night is slightly windy, say less than 5-10 km/hr, this cooling effect often produces very small droplets of condensed water called fog.

It might also be pointed out that the temporal relation realised by such a thematic, hypotactic clause could also be interpreted as conditional - consistent with comments above about the blurring of boundaries between temporal and consequential conjunction in these explanatory contexts.

From the examples quoted from Shea's data, it would seem that further choices from "within process" options do occur in school science explanations, although these are not identified or discussed. For example:

> Then the springy metal in the hammer's arm causes it to spring back. (Book 4:222).

In this case the causal relation is realised as a Relational: identifying: circumstantial process - a causal exemplification of the option illustrated for temporal conjunction in Figure 2.7 (cf Halliday, 1994a:400). Examples of selections from both "between processes" and "within process" options were noted in the work of Veel (in press, a). This indicated additional "within process" selections. As well as the Circumstances of time and processes of cause which occurred in Shea's data, Veel (in press, a) also noted the realisation of "time as a process" and "time as a participant". As a process, temporal sequence was realised in two ways. One was by "phased" processes:

the tree **starts** to lose its leaves
the ice **continues** to melt
the baby **stops** growing when...
(Veel, in press a:126)

The other realisation was by Relational: attributive: circumstantial processes:

In the summer the pupal stage lasts about a week .... (Text 5.1)

...maggots that are fully grown at the end of the summer remain as maggots or puparia until the following spring (Text 5.1).
(Veel, in press a:126)

When time is realised as a participant, the realisation of sequence is achieved by the inclusion of a numerative in the nominal group:

The second stage of recycling begins when the glass is delivered to the recycling plant (Text 5.2).
The next step is to remove some impurities (Text 5.3)
(Veel, in press a:126).

Interestingly, there was no indication of the realisation of cause as a participant (e.g. The result was..; The cause of ...; etc). However, the occurrence of a further extension of the realisation of cause as a process was pointed out. It was noted that when nominalised events have the role of Agent, one "event" can be represented as causing another event in a single clause:

The slow but powerful movement of the ice carves out a large U-shaped valley which is quite different from a river valley (Veel, in press a:143)

Here the causality is not simply realised by the process but rather by the grammatical relationship of Agent · Process · Medium, where the Agent is a nominalised realisation of the prior event which is a precondition for the formation of the U-shaped valley in the implication sequence.

A significant feature of the history of the development of scientific English discussed by Halliday (1993e) is the increased tendency for logical relations to be realised "within process". As part of the trend toward a more nominalised discourse, the movement has been from earlier shifts to the realisation of cause as process to contemporary writing where

> ... The latest step to date, taken in the twentieth century, is the one whereby the causal (or other) relation itself comes to be nominalised, as in **the cause**, **the proof** .. (Halliday, 1993e:66).

The extent to which this tendency has become a feature of school science texts is not known. Neither Shea (1988) nor Veel (in press, a) give any indication of the relative incidence of the various divergent grammaticalisations of conjunction in the explanatory texts they studied. However, their observations indicate that, in some secondary science textbook explanations, to some extent, the transitivity resources take over the reasoning to produce the kind of "buried" reasoning ("within process") which Martin (1993b:240) described as more characteristic of history rather than science texts. This raises a number of issues about the relative incidence and distribution of metaphorical modes of realising reasoning. For example, does the incidence vary with Field, and is there significant variation across texts within the same Field? - how is the distribution related to the relative technicality of the explanations? - are such metaphorical modes more commonly associated with consequential rather than temporal relations and hence with explaining "why" rather than "how"? To ultimately address these issues a further basic research question must be added to those already formulated:

How does the nature and relative deployment of logical metaphor vary ?

2.2.3.2.3 Distinguishing "how" and "why": Logical relations as indexical ?

The linguistic inflections of a distinction between explaining how and explaining why have only been addressed in the work of Veel (in press, a; in press, b). This work proposes covariation between experiential and logical meanings. When implication sequences are concerned with "concrete" participants in events which are (potentially) accessible to direct observation, the relationship between events is interpreted as sequentiality and accounts of such phenomena are construed as explaining "how".

> The main purpose of sequential explanations is to explain how something occurs ...
>
> Although sequential explanations do explain, they do not emphasise the causes of events but the sequence in which they occur ...
>
> ...they cover events which are "visible" to humans both over time and space and therefore open to our immediate scrutiny (Veel, in press a:117-118).

Examples of sequential explanations are naturally occurring phenomena such as the life cycle of plants or animals and also human-made processes such as the modus operandi of

machinery and technology in processes such as the formation of new glass from old and the making of sugar (Veel, in press a:117).

On the other hand, explaining why is said to subsume explaining how and hence

> link events together both as a sequence and as a set of cause and effect relationships (Veel, in press a:135).

Illustrations of such explanations included texts dealing with ice movement, why we get sea breezes and why sewage pollutes waterways. In discussing these explanations, the covariation between experiential and logical meanings is again made clear:

> Causal explanations generally deal with either abstract entities and properties, or describe events that are generally not accessible to immediate observation or experience, and so the cause and effect relationships between events need to be made explicit and emphasised (Veel, in press a:135).

On this basis one would expect texts explaining why to include both temporal and causal conjunctive relations with the division of labour giving emphasis to causal relations in some way. The commentary on such a division of labour is however, quite equivocal:

> Each phase in an explanation sequence can be a point in the chain of events which links a preceding cause to a subsequent event ...
>
> Alternatively a phase may be just another "step" in the chain of events in the explanation sequence, similar to a sequential explanation (Veel, in press a:138).

So although "the explanation sequence in causal explanations is often quite different from that found in sequential explanations" (Veel, in press a:138), it may also be quite similar. Although sequential explanations address how and causal explanations address both how and why, this hardly means that sequential explanations do not include any causal relations and that any inclusion (albeit minimal) significantly shifts the orientation to explaining why. What is needed is further investigation of the division of labour between temporal and consequential conjunction and a more detailed account of how the relative deployment of temporal and causal relations aligns with variation in the relative technicality of experiential meanings associated with explaining how and explaining why. The first question we need to ask here is:

> *How does the division of labour between temporal and consequential conjunction vary with Field and level of schooling?*

It is then possible to incorporate the issue of the relative deployment of logical metaphor, raised previously, and then ask the question:

> *How does the deployment, and diversification in the realisation of conjunction relate to the relative construction of technicality and/or "depth" of explanation of the phenomenon?*

But before this question can be dealt with we need to examine the parameters of technicality and "depth" of explanation.

2.2.4 Relative "depth" and technicality of explanation

2.2.4.1 Relative "depth" of explanation: Variation in meanings within elements of schematic structure

The notion of "depth" of treatment of a topic is used by Veel (in press a) as equivalent to relative technicality. This is evident in the claim that Causal explanations were less frequent than Sequential explanations because

> Junior secondary science frequently introduces a number of areas of scientific enquiry to students without going into any topic in great depth .....so the need for causal explanations does not arise as often .....(Veel, in press a:145).

and earlier it had been argued that

> Causal explanations rely on technical scientific knowledge much more than sequential explanations (Veel, in press a:136).

An alternative perspective on this notion of "depth" can be developed through a critical examination of the application by Cross (1992) of Hasan's (1984) distinction between nuclear and elaborative meanings. In fact this distinction was mentioned by Veel but not developed further:

> Each phase consists of an **object** linked to a **main event** ..... a phase may also contain a number of **elaborating events** which give more detail about the process being described but do not actually move the explanation sequence any further toward its end point (Veel, in press a:121).

This alternative notion of "depth" rests on distinguishing core or nuclear meanings as well as a range of non-core or elaborative meanings and separating this kind of semantic distinction from the lexicogrammatical realisation of these meanings as technical or non-technical. Hasan (1984) argued that any account of the realisation of elements of schematic

structure must at once focus both on variance and invariance, and, in her view, this is best approached by initially establishing the essential attributes of the structurally important units of any text type in semantic terms.

> Experience in textual analysis will bear out the hypothesis that the invariant aspects of the realisation of story - or for that matter any text type - can be handled better by appeal to semantic properties. Thereafter, a semantically motivated model of language description will provide specification of the range of lexicogrammatical patterns which are capable of realising these specific semantic properties (Hasan, 1984:83).

Since the specific function of each element in the schematic structure endows it with particular semantic properties, there are certain core meanings, common across texts, which define each element. These were referred to by Hasan (1984:88), in her account of the nursery tale genre, as nuclear meanings. Additional meanings in each stage of the schematic structure were referred to as elaborative meanings. The difference between the two is that at least some selection from the nuclear meanings is essential to the movement of the text whereas the text can progress without any selection from the elaborative meanings. This distinction was used by Cross (1992) in her investigation of explanatory "cycle" texts. For example, a nuclear meaning in the summarise strategy in the ORIENTATION of the water cycle texts was continuity of the water cycle, for which the following text segment provides an elaborative meaning:

> in some desert regions where fresh water is in short supply, seawater is desalinated to make fresh water (Cross, 1992:211).

It is very clear that this elaborative meaning is not central to the implication sequences which constitute the water cycle. However Cross did not extend her investigation to the nuclear and elaborative meanings in the elements of schematic structure dealing with the PROCESS stage of the cycle texts. Here what is elaborative and non-essential to the progression of the explanation depends on the explanation's "delicacy of focus". This issue is addressed by Paris and McKeown (1987) in their semantic mapping of the knowledge base from which to generate explanations of the functioning of technology like loudspeakers and telephone dialling mechanisms etc. Their strategy maps a sequence of events in the knowledge base (called the main path) and

> this chain of events describes the object's function from the beginning (start state) to the end (goal state), thus providing an explanation of the process .....
>
> In a complex knowledge base we can expect to have many links branching out of the main path. These links include both side links and sub-steps. To keep the process explanation coherent, a process trace cannot follow every causal link base that may branch out of the main path (Paris and McKeown, 1987:100).

A side link may be "an enabling condition to an event on the main path" and relations between events such as cause (called "control links") can be broken up into sub-steps. The nuclear meanings then, would be those constructing the main path and sub-steps and side links would be elaborative meanings. However, the example above from Cross (1992) about the desalination of seawater in the water cycle text, indicates that some of the elaborative meanings may not be sub-steps or side links but meanings that are peripheral to the main path. On this reasoning then, some recontextualizations of explanations may be confined fairly closely to the "main path", adopting a relatively indelicate focus. Such explanations would include nuclear meanings but are likely to include fewer elaborative meanings or "enabling condition(s) to an event on the main path", and perhaps also fewer peripheral meanings. Where the topic was treated in greater depth, more elaborative meanings would be included. Although Cross analysed only the meanings in the ORIENTATE element, she found that what she defined as elaborative meanings tended to be distributed in texts suitable for more experienced learners (Cross, 1992:240). By undertaking semantic analyses to categorise the meanings in each element of structure as nuclear, elaborative or peripheral it will be possible to address the question:

> *How do texts vary within and across Fields and levels of schooling in their depth of treatment of the Field?*

The extent to which these meanings are realised lexicogrammatically as technical can then be considered separately. But there is an intermediate issue. That is the extent to which the meanings are accessible literally in the text or though inference.

2.2.4.2 Representing categories of reader access to meanings

The nuclear and elaborative meanings which construct the elements of schematic structure vary not only in their distribution across texts, but also in the means by which they are accessible to the reader. The categories of meaning-access are summarised in the form of a network as shown in Figure 2.8. Each of the categories is illustrated and discussed below.

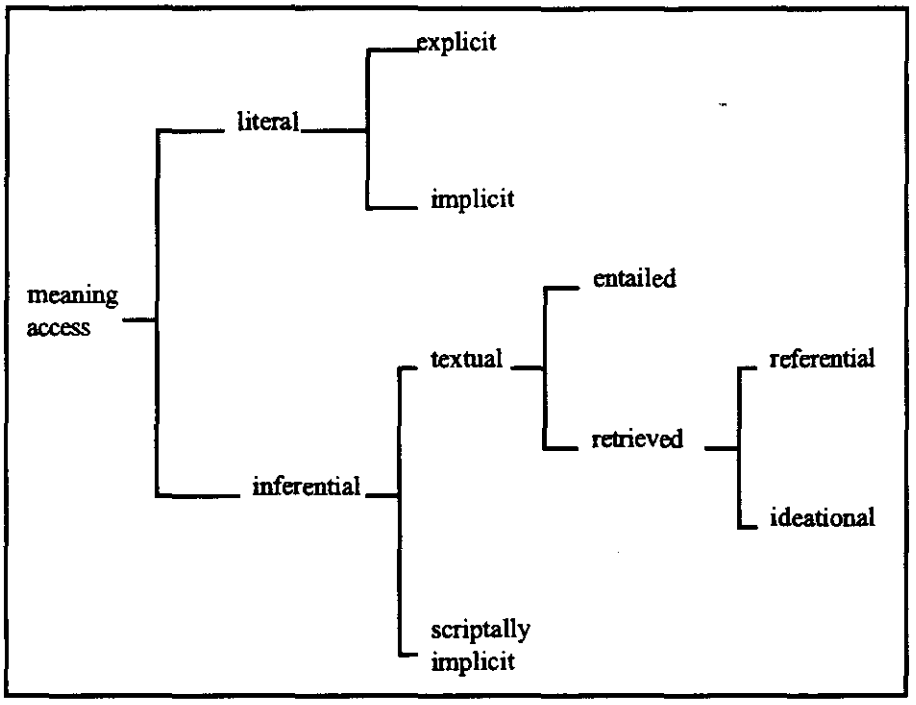


Figure 2.8 Diversification of meaning-access in written texts

The main distinction here is between literal meanings, which are directly stated in the text, and inferential meanings, which are not directly stated but which can be inferred from information in the text or from the reader's prior knowledge of the field. Literal meanings may be explicit or implicit. For example, the meaning *dead*, in *dead plant material*, can be accessed literally in both of the nominal groups: "dead plant leaves and stems" and "plant remains". But in the former it is explicit, while in the latter it is implicit.

Inferential meanings may be available via textual information, or, in the absence of this, they may rely on readers' prior knowledge of the field. The latter are referred to as "scriptally implicit" meanings (Pearson and Johnson, 1978; Armbruster et al, 1991). An example is found in the following text:

2 In ancient forests << 2.1>> layers of dead trees and other plants built up on the forest floor
2.1 <<which were warm and humid>>
3 before they could rot.
(De Vreeze et al, 1992:131)

If one has knowledge of the effects of warmth and humidity on plant growth, it is possible to infer from clause 2.1 the reason that the dead trees etc build up before they could rot i.e. *plants grow and die rapidly so dead plants accumulate rapidly*. These meanings are scriptally implicit.

Inferential meanings that can be accessed via textual information may rely on the retrieval of information from elsewhere in the text or it may be that the inferred meanings are entailed in the immediate textual information. An example of the category "entailed" is found in the clause marked "8" below. Here the meaning *compress* is entailed in the meanings realised in the following clause:

8 Over millions of years the weight of the sediments and high temperatures removed much of the water from the plant remains.
(De Vreeze et al, 1992:131)

The weight of the sediments removing the water from the plant remains entails the weight of the sediments compressing the plant remains.

Inferential meanings that are retrieved from textual information may be referential or ideational. The meaning "dead" is retrieved referentially in the following text:

4 As the land sank
5 these layers of vegetation were covered with water
(De Vreeze et al, 1992:131)

The demonstrative "these" refers to "layers of dead trees and other plants" in the prior text segment. An example of ideational retrieval can be also be seen in the explanation of coal formation by DeVreeze et al (1992:131). The meaning *dead* is literal and implicit in the ORIENTATION element of this text:

1 Coal was formed from the remains of plants buried by sediments.

In the following CONDITIONS element the meaning *dead* is retrieved ideationally from the literal implicit meaning in the ORIENTATION element so that "plant material" subsumes the meaning *dead*:

3 << if plant material is left on the ground in contact with the air (oxygen)>>
.....
6 if the plant material accumulates in a swamp (SCOAL2)

An examination of the ideational meanings in the explanation from this perspective is a significant aspect of the way in which the relative "depth" of treatment of the topic is constructed in the text. Only in the study by Cross (1992) was this aspect addressed, albeit in a less delicate manner. Cross distinguished between explicit and implicative

articulation of meanings. The following segment of her data illustrates explicit articulation of the meaning cyclicity:

> The water cycle brings a regular supply of fresh water to land areas (Cross, 1992:180).

The meaning cyclicity is articulated implicatively in the following text:

> The waters of the earth move continuously from the oceans, to the air, to the land, and back to the oceans again (Cross, 1992:181).

Although Cross examined meanings in the ORIENTATE element only, she did find that there was a tendency to use implicative articulation of the contextualize strategy in texts judged as suitable for "low novices" and either explicit articulation or a combination of explicit and implicative articulation in texts for "medium" and "high" novices (Cross, 1992:239). Further investigation of this dimension of variation is clearly warranted.

2.2.4.3 Technicality and grammatical metaphor

As indicated in chapter one, scientific discourse is a technical one in that it builds up an uncommonsense interpretation of the world, taking commonsense as a starting point and "translating" it into specialised knowledge. The construction of this technicality involves naming and defining phenomena as technical terms according to uncommonsense criteria, setting up taxonomic relations among the technical terms and explaining relationships among them and how they came into being. Explanations construct technicality through their definition, classification and decomposition of *processes* (Martin, 1993c:177-79). This involves the introduction of technical terms that are defined by implication sequences and may involve the use of technical terms that have been defined previously (Shea, 1988:76). The range of linguistic resources for defining and classifying technical terms in science has been documented in previous systemic linguistic studies (Wignell et al, 1987; Shea, 1988; Martin, 1993d). What is of interest here is the extent of selection across that range in defining technical terms in explanations. There has been no indication of this in previous work. Shea concluded from her data that

> The process of definition is thus quite similar in explanations and taxonomizing texts (Shea, 1988:78-79).

Shea did note that technical terms were frequently nominalisations which were summaries of implication sequences. Martin (1993c:179) noted that the definition of a term referring to a process is usually much longer than is typical when things are being defined, and, as discussed in Chapter one (1.3.2), indicated the essential role of grammatical metaphor in

realising what is to be defined by the technical term as a Thing - even if semantically it is a process (Martin, 1993b:225). In documenting the nominal group structure of technical terms in junior secondary school geography books, Wignell et al (1987) concluded

> there's a kind of progression here, away from discrete physical objects, towards more complex phenomena being turned into things (Wignell et al, 1987:146).

It seems likely then, that definitions of technical terms in explanations will make more use of grammatical metaphor and hence these would be less accessible than definitions referring to things in taxonomizing texts. It may also be that the relative deployment of such resources for defining technical terms depends on Field. The explanation of abstract phenomena involving invisible implication sequences, such as sound waves, may require greater use of metaphor in constructing technicality than explanations of more "concrete" phenomena such as the formation of coal. To appreciate the nature of the differences in technicality in explanations, it is necessary to be able to describe the differences in the linguistic resources deployed in its construction and also the extent to which undefined technical terms are included. As a basis for this, the relevant resources will be reviewed below.

There are a number of resources for naming and defining technical terms, most of which involve the semantic notion of elaboration (Martin, 1993b:225-226), where one element

> elaborates on the meaning of another by further specifying or describing it ... restating it, refining it, or adding a descriptive attribute or comment (Halliday, 1994a:225).

Resources at group rank and clause rank will be noted first, then those utilising logico-semantic relations between clauses and finally those drawing on the systems at the level of discourse semantics (Unless otherwise indicated, the categories and examples below are from Wignell et al, 1987 and Shea, 1988. Grammatical categories are those of Halliday (1985; 1994a)).

Group rank.

1. Nominal group parataxis (Halliday, 1994a:275)
   protozoa (single celled animals)
   lactose (sugar in milk)
   lignite or brown coal

2. Verbal group parataxis (Halliday, 1994a:275)
   moving to an fro (vibrating)
   carry or conduct electric currents
   squashes or compresses the surrounding air

3. Embedded clauses (defining relative clauses) (Halliday, 1994a:188)

When water vapour evaporates it changes into an invisible gas called water vapour.

Initially the plant matter rotted down into a brown, fibrous substance called peat.

Clause rank

4. Relational: identifying clause (Halliday, 1994a:122-138)

Thus sound is a compression wave that can be heard.

The diffusion of water across a semi-permeable membrane is known as osmosis.

5. Relational: possessive: attributive clause (Halliday, 1994a:132-138)

This kind of definition was noted by Wignell et al (1993:152) as not involving the same kind of Token/Value relationship as other forms, but rather defining a phenomenon by the accumulation of attributes.

(A desert has):
-lack of water
-very low humidity
-long drought followed by deluge
-minimum cloud and maximum sunshine
-very hot days and very cold nights
-a great daily range of temperatures

Clause complex

6. Projection

When the air cannot hold any more water at a particular temperature, we say that the air is saturated ..

7. Paratactic elaborating clauses

.... we say that the air is saturated or that it has a relative humidity of 100%

Discourse semantics

8. Reference

You have probably learned the meaning of the term transpiration in you science lessons. In this process, plants lose water in the form of vapour through their leaves, this water is replaced with water containing plant food collected by the plant roots ...

Here, the anaphoric referent "this" stands for the technical term "transpiration". Reference is used to establish a relationship between a technical term and the activity sequence which produced it. The implicit Token/Value relationship can be brought out when this is reworded as: Transpiration is when ....(Wignell et al, 1993:151).

Discourse semantics and lexicogrammar

9. Reference and relational identifying clause

> ....until eventually all the species of plants and animals in the eco-system live in a balanced state. This means that they depend upon one another and live in harmony unless disturbed.

"This" refers to "balanced state" in the previous clause and is the Token in its own Relational: identifying clause related to the Value which is the embedded clause "that they depend ....".

The principal function of technical terms in explanations, and the linguistic resources for defining them, have been described by Martin using the metaphor of distillation.

> Technical language both *compacts* and *changes the nature of* everyday words - just as a vat of whisky is both less voluminous and different in kind from the ingredients that went to make it up (Martin, 1993c:172).

This distillation is most dramatic in explanations, where the focus is on the technicalising of processes. In the following example from Martin et al (1986:154-155) several clauses are reduced into a single term in this way.

> As air is moved upward away from the land-water surface or downward toward it, very important changes occur in air temperature. Air moving upward away from the surface comes under lower pressure because there is less weight of atmosphere upon it, so it stretches and expands. Air moving downward toward the surface from higher elevations encounters higher pressures and shrinks in volume. Even when there is no addition or withdrawal of heat from surrounding sources, the temperature of the upward or downward moving air changes because of its expansion or contraction. This type of temperature change which results from internal processes alone is called adiabatic change.

This text makes the whole process of adiabatic change available for further discourse in its "distilled" form as a single technical term without the need for cumbersome reiteration of what has already been dealt with.

Where implication sequences in explanations are distilled as technical terms, the resources of the reference system combined with the grammatical choices for Relational: identifying clauses are required e.g.

> This is called the water cycle.

Relational: identifying clauses in explanations are more likely to include grammatical metaphor in achieving such distillation. In the following clause, for example, the technical term "cellulose" as the Token, certainly compacts and changes the meaning of the Value.

Cellulose is the main chemical in the walls of plant cells.

However to achieve a similar effect in an explanation of osmosis, the Token must be related to its Value, which is in fact a process metaphorized as a participant.

The diffusion of water across a semi-permeable membrane is known as osmosis.

Definitions may involve other kinds of grammatical metaphor in distilling information. In the following example (quoted in Martin, 1993c:191) the process "melt" is metaphorized as a Classifier in a nominal group, but there is not the same "shift to Thing" through nominalisation as in the osmosis example.

When molten material is forced out on to the Earth's surface it is called **lava**.

Hence an understanding of the relative technicality of explanations within and across Fields and levels of schooling will require a complementary analysis of the deployment of different types of grammatical metaphor. Thus we can frame a further specific research question:

> *How does the deployment of grammatical metaphor in the construction of technicality vary?*

Another aspect of technicality is classification. Although this is mainly achieved through taxonomizing texts called reports, classification may also occur in the context of explanatory texts where phenomena are classified according to the processes that give rise to them.

> ...When the smaller reports focus on processes, either to classify them or use them as criteria for classifying things, another genre, the explanation is used (Martin, 1993c:191).

The resources for constructing technical taxonomies have been described by Wignell et al (1987) and Shea (1988). These are outlined below using examples from Wignell et al (1987) and Shea (1988).

Group rank

1. Pre-Classifier
   realised as types of, kinds of, sorts of (e.g., types of environment)

2. Pre-Deictic
   realised as parts of, elements of, aspects of (e.g., parts of the ecosystem)

3. Classifier ^ Thing
   (e.g., biotic environment and physical environment are related by superordination to environment)

4. Possessive-Deictic ^ Thing
   (e.g., the rainforest's canopy)

Clause rank

5. Relational: intensive: attributive clauses

Sound waves	are	longitudinal waves
Sub-class	Process	Class

6. Relational: circumstantial attributive clauses

The sting of bees and wasps	is	on the abdomen
Part	Process	Whole

7. Relational: possessive: attributive clauses

Desert landforms	consist mainly of	those due to erosion and those due to deposition
Class	Process: possessive	Sub-classes

8. Relational: possessive: identifying clauses

The head	contains	the antennae, eyes and mouthparts
Whole	Process	Parts

9. Existential clauses

At the end of the abdomen	are	the reproductive organs
Whole	Process	Part

10. Material clauses

Atoms	may be divided into	three distinct types of particle; 1. The electron...2. The proton...3. The neutron...
Whole	Process	Part

Discourse semantics

11. Reference

    Except for cellulose, all the carbohydrates may be used by man as a source of energy. The sugars are sweeteners mostly obtained from plants.

The reference chain progresses from all the carbohydrates and a source of energy directly to the sugars. The Deictic element the and the generic plural indicate that this nominal group refers back to all the carbohydrates (Shea, 1988:62).

It is clear then that sugars is a hyponym of carbohydrates.

12. Conjunction

> As far as the ability to carry electricity is concerned, we can place most substances into one of two main groups. The first group contains materials with many electrons that are free to move. These materials are called conductors because they readily carry or conduct electric currents. Conductors are mostly metals but also include graphite (Figure 10.3). The second group contains materials with very few electrons that are free to move. These materials are called nonconductors and are very poor conductors of electricity.

In this example, the reference in the nominal groups the first group and the second group is an incongruent realisation of explicit simple internal spatio-temporal conjunction (Shea, 1988:64).

The subclassification of the superordinate is the basis for the conjunctive relation.

2.2.4.4 Relative technicality

By determining the relative use of undefined, or previously defined, technical terms, as well as the nature and extent of resources for naming and defining these technical terms, a basis for comparing the technicality of explanations within and across fields can be established. It is then possible to address the question:

> *How do texts vary within and across Fields and levels of schooling in their linguistic construction of the Field as technical?*

2.2.5 Organisation of research questions

The strategy for the development of research questions was to begin with a general question dealing with the central educational linguistic purpose of the study. This was reformulated in more "operational" terms as a global research question concerning the range of functional linguistic choices in the realisation of alternative recontextualizations of explanations for different levels of schooling and dealing with different phenomena. Then the results of previous studies were reviewed to determine specific research questions dealing with each of the relevant dimensions of linguistic variation identified. Some of the specific questions so generated now need to be re-ordered to facilitate systematic enquiry. For example, the last question listed above clearly needs to be dealt with before one can address *how the deployment, and diversification in the realisation of conjunction relate to the relative construction of technicality and/or "depth" of explanation of the phenomenon?* In addition the specific research questions need to be addressed in turn to explanations of

one phenomenon across sample texts for each level of schooling, then the results can be compared across levels, and finally the procedure can be repeated for texts dealing with different phenomena. The development of the research questions from the central educational linguistic purpose to the global research question to the specific research questions and their strategic ordering is shown in Figure 2.9.

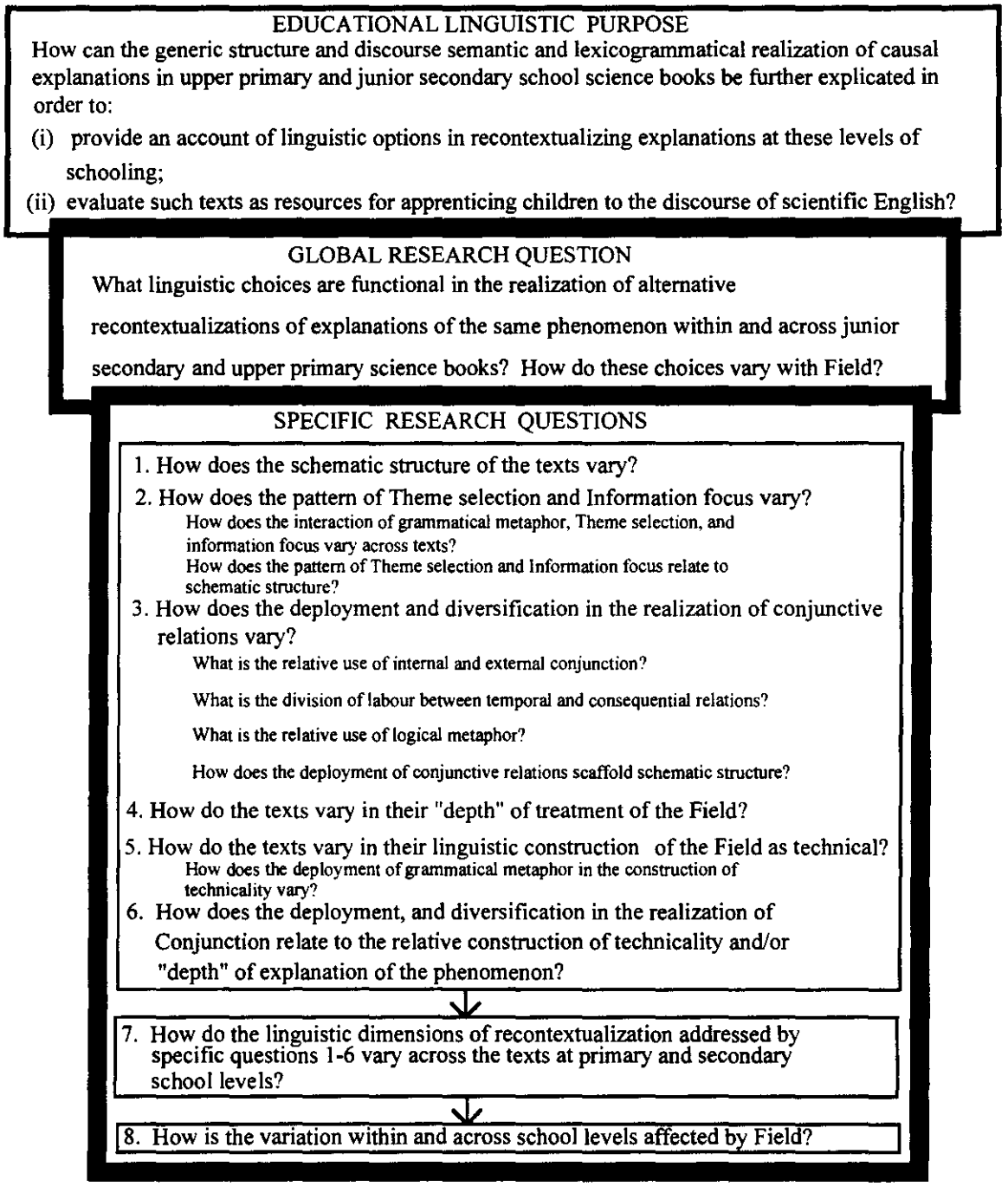


Figure 2.9 Organisation of research questions

2.3 Methodology

2.3.1 Data selection

There were two basic criteria for the selection of texts. The first was their educational relevance. This meant that the books chosen were from those in current use in New South Wales primary and secondary schools. It also meant the selection of explanations on topics that were common to both the primary and secondary books. The second criterion was the relevance of the texts to further exploration of the effect of Field and school level on the relative orientation to explaining why or explaining how. As noted in chapter one, the work of Veel (in press a) proposed that explaining how was achieved by Sequential Explanations while Causal Explanations explained both how and why. However, while the prototypical Sequential Explanations showed consistency in patterns of choices in lexicogrammar and discourse semantics and in their schematic structure, Causal Explanations seem to have been adopted as a category which remains at a very broad level of delicacy, with 'purely' Causal Explanations rarely occurring, and embracing what appear to be quite different types of explanation of a wider range of phenomena than those dealt with in Sequential Explanations. The explanatory texts chosen were selected so that phenomena they dealt with met the criteria for categorisation as causal explanations as proposed by Veel:

> Causal explanations generally deal with either abstract entities and properties, or describe events that are generally not accessible to immediate observation or experience
> .....
> .....causal explanations are often used to account for phenomena that cannot be explained through observation with the naked eye at one time and in one place. (Veel, in press a: 135).

It was also noted that a major distinction, albeit somewhat inconsistent, between these Causal Explanations and Sequential Explanations was the temporal linking of implication sequences in the latter and the consequential linking of implication sequences in the former. However, explanations in different fields within the broad category of causal explanation are likely to show different patterns of selection of logico-semantic relations to organise both the events and rhetorical structure of the texts. For example, explanations of the formation of natural phenomena such as a river, a glacier, sedimentary rock, a star etc. involve a progression of implication sequences in each of which certain material undergoes changes to be transformed into a different kind of material. What is involved is tracking several series of cause/effect relations over time. This is likely to involve a particular patterning of external temporal/successive and causal relations. On the other hand, explanations of abstract concepts such as forces, sound waves, heat etc involve the

contemporaneous reconstrual of observable phenomena in terms of unobservable, theorised, constituent, technical implication sequences. Relations of simultaneity then, will relate events at one level of abstraction (eg sound travelling through the air) to commonsense observable events (such as the vibration of a tuning fork) and events at a technical, theorised level (such as air molecules being compressed). Furthermore, the events at the latter level are being construed as the cause of the abstract events. There is then, a sense in which causal and temporal/simultaneous relations are likely to be conflated and, of course, events in the technical, theorised event sequences are likely to be organised by temporal/successive and/or causal relations. In any case the pattern of logical relations is likely to be quite different from that which organises the events leading to the formation of natural phenomena such as coal or rivers or stars etc.

There may well be other patterns. For example, explanations of the tides, seasons, phases of the moon etc. may well involve deductive reasoning which relates implication sequences in one "domain" to implication sequences in another. In the case of explaining the tides, one has to deal with the inter-relationship among at least three such domains: the earth's orbit around the sun, the moon as a satellite of the earth and the consequent variation in the relative positioning of the sun and the moon with respect to the earth; the concept of gravitational force; and the movement of the tides. This may mean more elaborated internal conjunctive relations compared with the other kinds of explanations indicated above.

On this basis, three topics were chosen: *the formation of coal*; *sound waves*; and *the seasons*. Then three secondary school science books currently used in New South Wales schools were selected. The nine texts forming the data set at the secondary level were the explanations that appeared in those three books dealing with the three specified topics. In fact, in one of the books (De Vreeze et al, 1992) there was no explanatory text on how sound travels. An explanation from a fourth book was included on this topic.

Nine primary school explanations were chosen, as far as possible on the same basis for selection as the secondary texts. However, science books are not used as class texts in primary schools in New South Wales so the books were selected from those currently on sale in Sydney bookshops and listed in the Faculty of Education Curriculum Resources Library of the University of Sydney. The explanations of the various topics are usually published in separate books each dealing with one particular field of science only and forming part of a series. These series do not all cover the same topic range, hence eight books by five different authors had to be used. The sources for the selection of the data set are summarised in Table 2.2.

	SECONDARY SCIENCE BOOKS		PRIMARY SCIENCE BOOKS	
HOW COAL IS FORMED	Chapman, B., Perry, L., & Stead, K. (1989). Science 9. Milton, Queensland: Brooks Waterloo. (127)	SCOAL1	Carter, C., Nitert, R. Ritchie, I. (1990c) Rocks and Minerals. Melbourne: Macmillan. (15)	PCOAL1
	De Vreeze, D., Lofts, G., Preuss, P., & Gilbert, K. (1992). Jacaranda science and technology (Vol. 1). Brisbane: The Jacaranda Press. (131)	SCOAL2	Taylor, B. (1990). Science starters: Energy and power. London: Franklin Watts. (22)	PCOAL2
	Hefferman, D., & Learmonth, M. (1988). The World of science (2nd ed., Vol. 1). Melbourne: Longman Cheshire. (58 & 70)	SCOAL3	Pettigrew, M. (1986a). Simply science:Planet Earth. London: Franklin Watts. (16-17)	PCOAL3
WHY DO SEASONS HAPPEN?	Chapman, B., Perry, L., Russell, D., & Stead, K. (1989). Science 8. Milton, Queensland: Brooks Waterloo. (138-140)	SSEAS1	Branwell, M. (1987). Earth science library: Planet Earth. London: Franklin Watts. (9)	PSEAS1
	De Vreeze, D., Lofts, G., Preuss, P., & Gilbert, K. (1992). Jacaranda science and technology (Vol. 1). Brisbane: The Jacaranda Press. (149-150)	SSEAS2	Flint, D. (1991). Hands on geography: Weather and climate. London: Franklin Watts. (24-25)	PSEAS2
	Hefferman, D., & Learmonth, M. (1989). The World of science (2nd ed., Vol. 2). Melbourne: Longman Cheshire. (21)	SSEAS5	Pettigrew, M. (1986a). Simply science:Planet Earth. London: Franklin Watts. (20)	PSEAS3
HOW DOES SOUND TRAVEL?	Chapman, B., Perry, L., & Stead, K. (1989). Science 9. Milton, Queensland: Brooks Waterloo. (280-81)	SSND1	Carter, C., Nitert, R., & Ritchie, I. (1990a). Sound. Melbourne: Macmillan. (5)	PSND1
	Olsen, R., & Olsen, M. (1986). The sciences. Richmond: Heinemann. (82)	SSND2	Taylor, B. (1991). Science starters: Sound and music. London: Franklin Watts. (8)	PSND2
	Hefferman, D., & Learmonth, M. (1990). The World of science (2nd ed., Vol. 3). Melbourne: Longman Cheshire. (145)	SSND3	Pettigrew, M. (1986b) Music and sound. London: Franklin Watts. (12)	PSND3

Table 2.2 Summary of sources for data set

The extent of the data set represents a balance between the range of data necessary to address the purpose of the study and the practicality of the amount and variety of analysis necessary to address the specific research questions. School science books for the junior secondary and upper primary levels are well defined in publication conventions and in school usage, so the selection of texts at both levels was not problematic. Since the variation in Causal Explanations with Field was a major parameter of the study, at least three Fields of school science needed to be included. In order to examine variation within Fields at the same level of schooling, at least three examples of explanation of the same phenomenon were considered necessary. The broad purposes of the study then, required a minimum data set of eighteen texts. The subsequent section will indicate that exploration of the specific research questions required each text be analysed in terms of Schematic Structure, Theme selection, Conjunction, Semantic mapping of ideational meanings, Transitivity and Grammatical Metaphor. The quantity of analysis involved and the need to inter-relate the results across Fields and school levels meant that the data set had to be restricted to the eighteen sample texts.

2.3.2 Organisation of data analysis to address research questions

2.3.2.1 The macro-design of the study

The within-Field variation across texts will be explored first by addressing each of the first seven specific research questions dealing with the sample texts from each Field in turn. Each Field will be dealt with separately in successive chapters:

Ch 3 The formation of coal;

Ch 4 Sound waves;

Ch 5 The seasons.

In each chapter the secondary school texts will be examined first and then the primary texts in relation to the first six specific research questions. The results will then be compared across levels for the particular Field to address research question seven. The organisation of these three chapters is indicated in Figure 2.10.

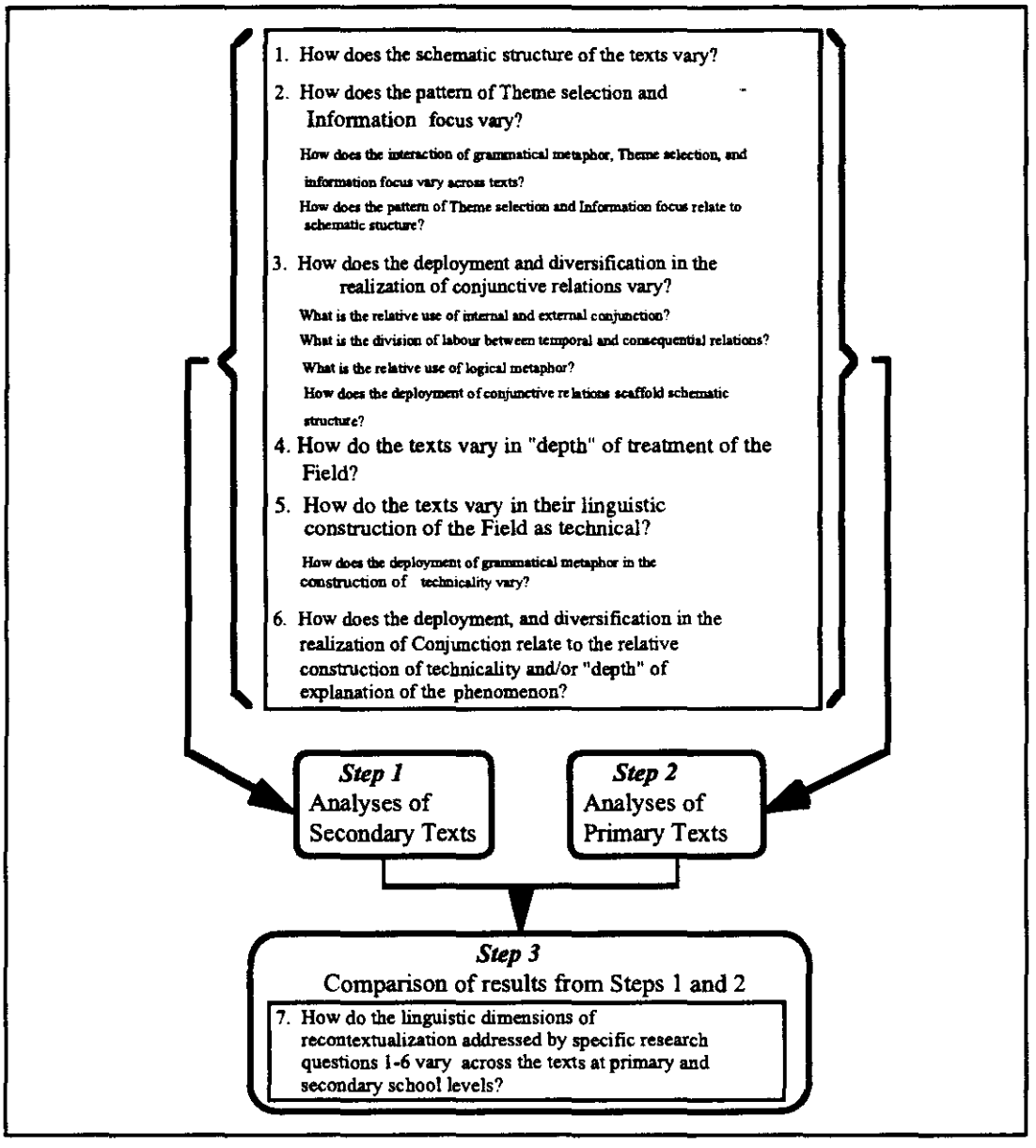


Figure 2.10 Steps in addressing research questions within Field and across school levels

The across-Field variation, addressed by research question eight, will be discussed in chapter six. This will involve a comparison of the results of the previous three chapters in which the various dimensions of recontextualization will be compared across Fields at both primary and secondary levels. The overall design is shown in Figure 2.11

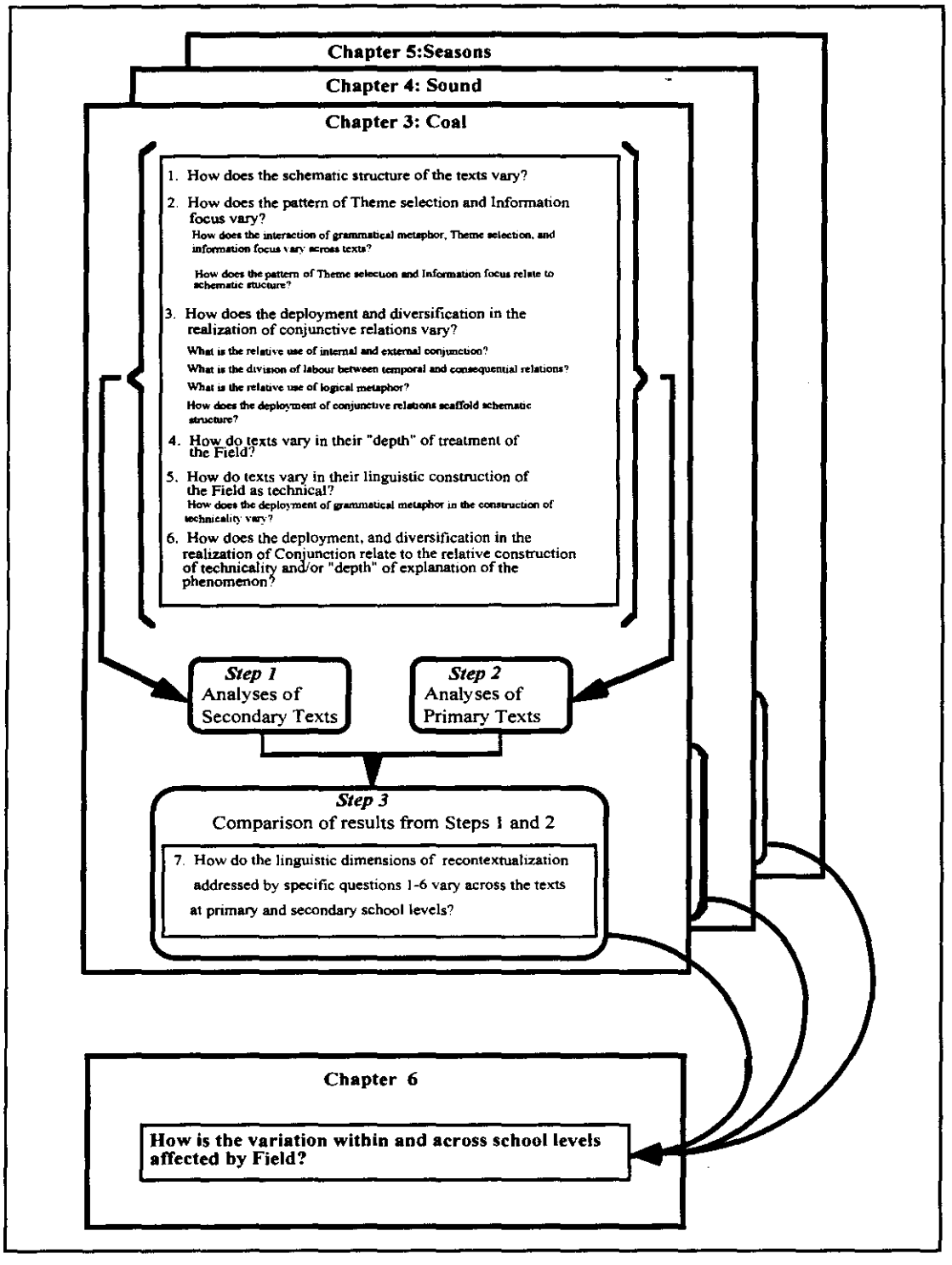


Figure 2.11 Organisation of comparisons within and across school levels and Fields

2.3.2.2 The deployment of analyses to address specific research questions

As evident in the generation of the specific research questions in the review section (2.2), the exploration of each question requires information from a range of linguistic analyses. The relationship between the research questions and the analyses undertaken is summarised in Figure 2.12.

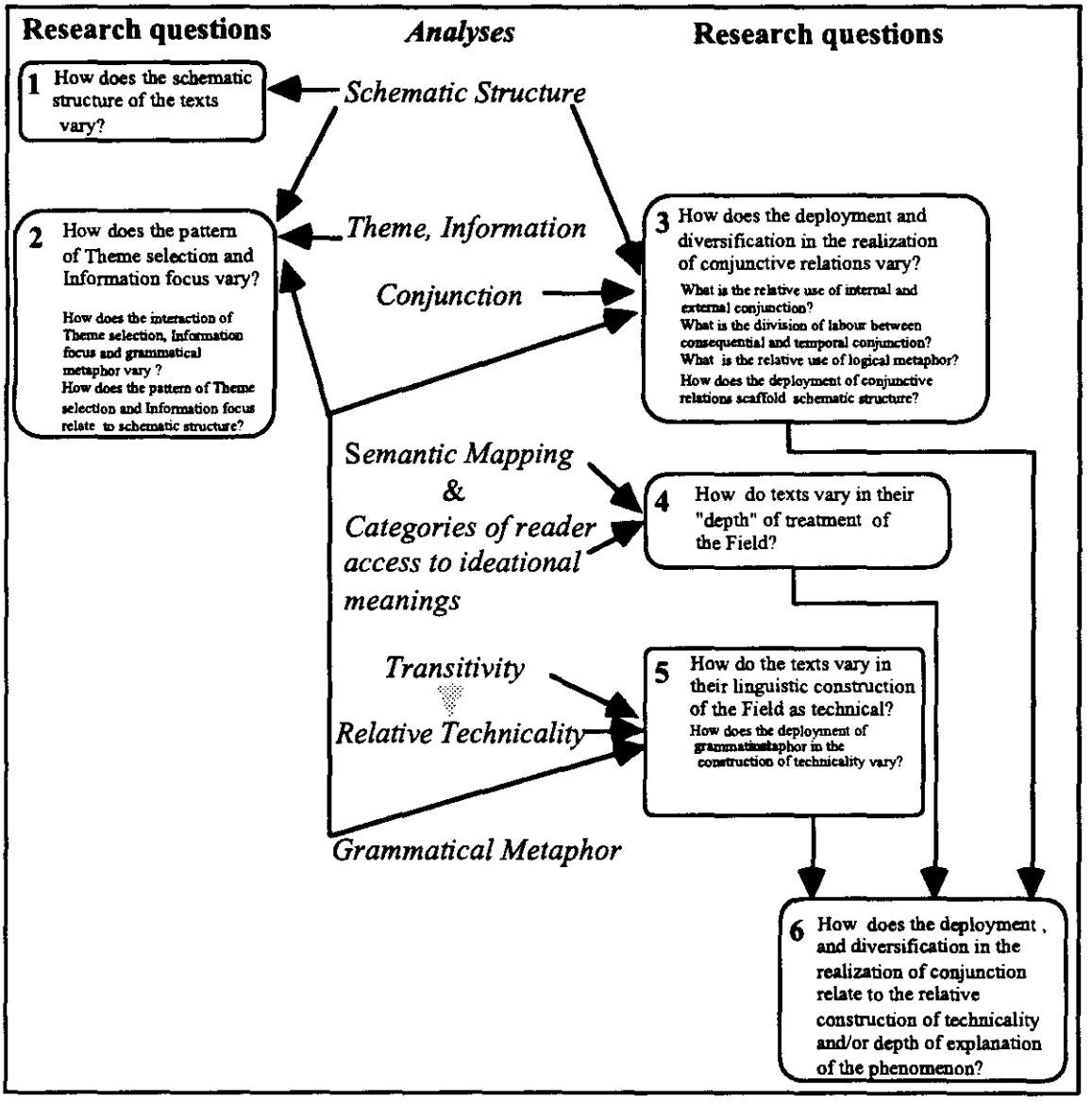


Figure 2.12 Relationship between research questions and analyses

The first question concerning variation in schematic structure involves the identification and specification of elements of structure, based initially on very global descriptions of the organisation of meanings in different parts of the text, reflecting its functional staging. This

initial description of schematic structure can be subsequently confirmed or modified on the basis of more delicate analyses.

The second question dealing with variation in Theme selection and Information focus needs to be related to its "scaffolding" of schematic structure. In so doing the analyses need to take into account not only patterns of marked and unmarked Topical Themes, but also the weaving of lexical strings through Theme and New and the use of Grammatical Metaphor in achieving this.

The third question examines variation in the deployment and diversification in the realisation of conjunction. The last two subsidiary questions here also need to be related respectively to the analysis of grammatical metaphor and the analysis of schematic structure.

The fourth question concerns variation in the "depth" of explanation. The relative distribution of ideational meanings categorised as nuclear, elaborative or peripheral is one means by which a semantic mapping analysis can address the issue of "depth". A further aspect of depth is whether the meanings are available to a reader literally or whether they are inferred, and the analysis of categories of reader access examines each of these options at greater delicacy.

The fifth question of the relative technicality in the realisation of common nuclear and elaborative meanings is dealt with in a number of stages of subsequent analysis. Firstly, an analysis of transitivity shows the grammatical realisation of experiential meanings directly available in the text. This enables the second stage, which is an analysis of the relative deployment of grammatical resources for constructing technicality. The final stage is an analysis of grammatical metaphor to determine the extent to which the grammatical construction of technicality relies on metaphorical realisation.

Research question six is addressed by relating the results of research questions three and four and five.

2.3.3 Analytic Procedures

2.3.3.1 The analysis of schematic structure

A structural element within a text is defined by the job it does within the text. The particular semantic function served by each element of structure endows it with particular semantic properties. By describing, at a very global level, the organisation of meanings in different parts of the text and by a process of successive analyses and comparison of sample texts, tentative hypotheses about the identification and classification of elements of schematic structure can be made. For example, Cross (1992:82-83) initiated her proposed schematic structure of cycle texts by comparing two accounts of the water cycle to tentatively identify and label elements of structure. An adapted summary of the results of this initial procedure is shown in Table 2.3:

Stage	Text 1	Text 2
ORIENTATION		Water can change from one form to another easily. That is why we always have fresh supply of water.
TRANSFORMATION	As the sun shines on the sea, lots of water turns to vapour and goes into the air. As the air moves over the land it may have to rise over hills and mountains. The higher the air goes, the cooler it gets. Some of the vapour turns to water. The little water drops form clouds in the sky. If the water drops grow bigger they fall to the ground as rain. Most of the rain that falls runs into rivers which flow into the sea.	The heat of the sun evaporates water from the oceans, seas, rivers and lakes. The heat also evaporates water from the ground and from plants and animals. Water vapour is formed. This rises and forms clouds in the air. When the clouds come near a mountain, they are forced to rise. As the clouds rise, they are cooled. The higher they rise, the more they are cooled. This causes more and more water to condense. In this way the tiny drops of water in the clouds get bigger and bigger until they are heavy enough to fall to the Earth as rain. Some rain water which falls on the Earth is again evaporated by the sun's heat. Some of it sinks into the ground. It may be used up by thirsty plants. It may well reach a well or a spring. Most of the water goes back to the rivers, seas and oceans.
CONCLUSION		This process then starts all over again. This process is called the water cycle.

Table 2.3 Example of an initial stage of analysis of schematic structure

This suggested the ORIENTATION and CONCLUSION stages were optional and that the TRANSFORMATION was the obligatory stage. Subsequent finer analysis of the organisation of meanings enabled a more delicate differentiation of the TRANSFORMATION element as indicated in Table 2.4:

TRANSFORMATION	Text 1	Text 2
EVAPORATION	As the sun shines on the sea, lots of water turns to vapour and goes into the air.	The heat of the sun evaporates water from the oceans, seas, rivers and lakes. The heat also evaporates water from the ground and from plants and animals. Water vapour is formed.
CONDENSATION	As the air moves over the land it may have to rise over hills and mountains. The higher the air goes, the cooler it gets. Some of the vapour turns to water. The little water drops form clouds in the sky.	This rises and forms clouds in the air. When the clouds come near a mountain, they are forced to rise. As the clouds rise, they are cooled. The higher they rise, the more they are cooled. This causes more and more water to condense.
PRECIPITATION	If the water drops grow bigger they fall to the ground as rain.	In this way the tiny drops of water in the clouds get bigger and bigger until they are heavy enough to fall to the Earth as rain.
RETURN TO SEA	Most of the rain that falls runs into rivers which flow into the sea.	Some rain water which falls on the Earth is again evaporated by the sun's heat. Some of it sinks into the ground. It may be used up by thirsty plants. It may well reach a well or a spring. Most of the water goes back to the rivers, seas and oceans.

Table 2.4 Example of a more delicate analysis of elements of schematic structure

The work by Martin (1992:244; 436-444; 1993b: 233-241) relating the interaction of Theme and conjunction in scaffolding schematic structure provides a further analytic basis for confirmation or modification of proposed schematic structures. The procedures for the analysis of Theme and conjunction are given in the next two sections and an adapted example from Martin (1993b:233-235; 246-247) relating these analyses to schematic structure is included.

2.3.3.2 Theme and Information focus

In the analysis of Theme at the clause level (Halliday, 1994a:38-64) the first element realising experiential meaning (i.e. Participant, Process or Circumstance) is labelled as Topical Theme. Elements which are not the Subject (such as Complements and Adjuncts) in Theme position are regarded as Marked Themes. Where the Topical Theme is preceded by a Modal Adjunct (Halliday, 1994a:49-50), this is also considered part of the Theme and labelled as an Interpersonal Theme. Conjunctions linking clauses within a clause complex are Textual Themes and if Conjunctive Adjuncts (Halliday, 1994a:49-51), which link clauses cohesively and not structurally, are in clause initial position, they are also Textual Themes. Relatives function as Topical Themes in the clauses they introduce. "Wh" elements in clause initial position in interrogatives conflate the roles of Topical and Interpersonal Theme and in yes/no questions, the clause initial Finite is the interpersonal Theme and the Subject is the Topical Theme. Unless the Subject and/or Finite are made

explicit in Imperatives, they are considered to consist of Rheme only. Theme analysis at the clause level is illustrated in Figure 2.13 .

	TEXTUAL	INTERPERSONAL	TOPICAL THEME	RHEME
1			Figure 3.6b	shows plant material building up in a swamp
2		Usually	dead plant leaves and stems	<<4>> are broken down
3	and			become part of the soil humus
4	<<when		when	they fall to the ground>>
5			In some swamps *(Marked Theme)*	however, it is possible that the breakdown is not complete
6	because		the plant pieces	are being produced faster than they break down
7			Layers of such plant remains	can be squeezed
8	and			changed over millions of years into the rock, coal

Figure 2.13 Example of Theme analysis within each clause in an explanation text

At the level of the explanatory text as a whole, the Theme analysis in this study investigated the "method of development" of the texts (Fries, 1983:135 quoted in Martin, 1992:434). The analysis followed the procedures outlined in Martin (1992:435 & 440). (β clauses appearing before their α are taken as marked Themes, and the Theme is not analysed in the following α. Theme is not analysed in embedded clauses, hypotactically dependent clauses nor in branched paratactic clauses with subject ellipsis.) Hyper-Themes will be identified following Martin (1992; 1993b) as discussed in section 2.2.2.1. The complementary analysis of Hyper-New (discussed in section 2.2.2.2 above) is based on the identification of New in spoken language at the clause level "as the highest ranking clause constituent (usually a ranking group or phrase) the tonic syllable falls on the final salient syllable of "(Martin, 1992:451). Here, in written texts, as in Martin (1993b:247-248), the extended New is taken as the final two experiential clause constituents. The relationship between patterns of Thematic choice, selection of News and Schematic Structure is indicated in Figure 2.14. (Themes are in italics, marked Themes are in bold italics and extended New is underlined. Schematic structure adapted from that proposed by Shea (1988) is shown on the left hand side.)

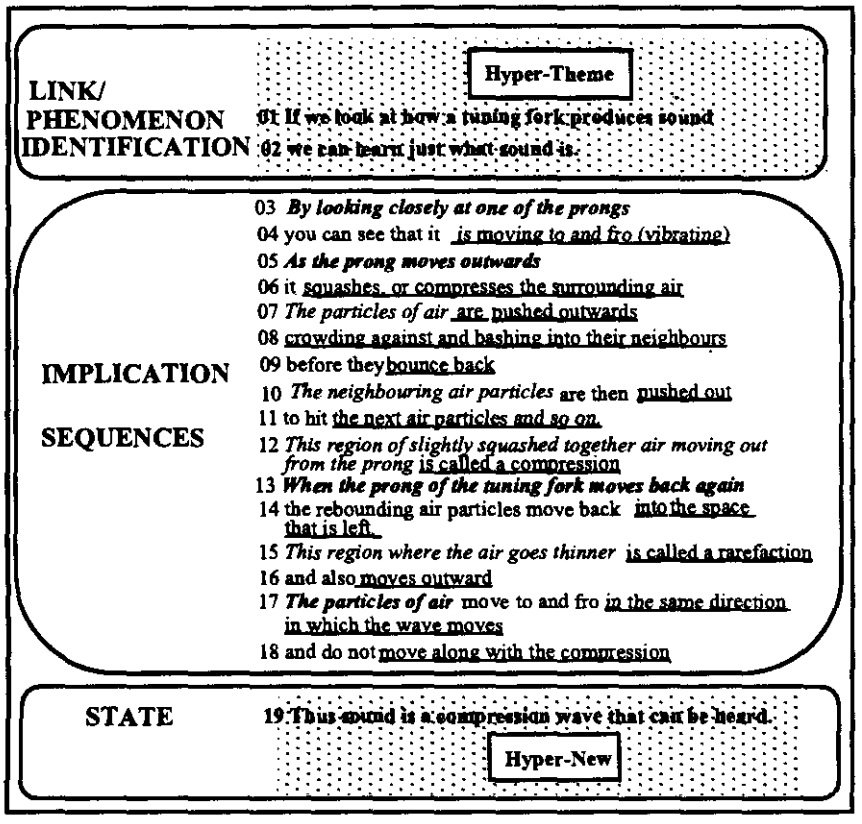


Figure 2.14 Theme, New and Schematic Structure

2.3.3.3 Conjunction

The diversification of the realisation of conjunction both within and between processes was illustrated in section 2.2.3.2 with Martin's (1992:168-170) account of temporal relations, and reference was made to the parallel account for causal relations by Halliday (1994a:398-403). The analysis of conjunction realised within processes, i.e. metaphorical realisations will be addressed through analysis of grammatical metaphor. The realisation of conjunction between processes will be analysed using procedures detailed in Martin (1992:235-243) and summarised below.

The types of logico-semantic relations between processes will be distinguished up to the points of delicacy indicated in Table 2.5. The table also indicates the notational conventions to be used and provides an example of each of the relation types to be identified.

temporal	simultaneous successive	**simul** **succ**	As the prong moves outwards, it squashes or compresses the surrounding air. ...layers of dead trees and other plants built up on the forest floor before they could rot.
consequential	manner	**man**	By looking closely at one of the prongs, you can see that it is moving to and fro (vibrating).
	consequence	**consq**	Sound waves travel through gases, liquids and solids because they all contain particles which will carry or transmit disturbances
	condition	**cond**	If we look at how a tuning fork produces sound, we can learn just what sound is
	concession	**conc**	This is what happens in a rainforest or in the compost heap of your garden,. However, decomposition is prevented if the plant material accumulates...
	purpose	**purp**	..in each case a vibration was needed (in order) to produce the sound
comparative	similarity	**simil**	Similarly, the Earth's surface is most brightly lit where the sun's rays strike the surface perpendicularly.
	reformulation	**i.e.**	when they strike the Earth's surface perpendicularly i.e. when the sun is directly overhead
	exemplification	**e.g.**	Normally if plant material is left on the ground surface in contact with the air (oxygen) it decomposes. (For example) This is what happens in a rain forest.....
	contrast	**contr**	Large vibrations cause loud sounds. Conversely, small vibrations cause soft sounds.
additive	addition	**add**	...when they fall to the ground and become part of the soil humus
locative		**loc**	.... the Earth's surface is most brightly lit where the sun's rays strike the surface perpendicularly.

Table 2.5 Categories for conjunction analysis

Implicit relations - those not overtly marked by a conjunctive relation, but which could have been made explicit in the text under consideration - will be designated implicit (**imp**), while conjunctive relations explicitly realised between clauses will be designated explicit (**exp**). Implicit addition however, will not be noted.

The distinction was drawn in section 2.2.3.1 between external conjunction, which is oriented to Field and organises activity sequences, and internal conjunction, which is oriented to Genre and orchestrates textual sequences. The distinction between internal and external conjunction is clearest in the case of temporal relations, but in other cases it is sometimes hard to draw either because it doesn't matter, as in the case of procedural texts where text time = field time, or

> ... because certain relations, such as the concessive, are themselves interpersonal enough in orientation that they fudge the distinction being drawn between organising text and constructing field (Martin, 1992:183).

Nevertheless understanding the nature of reasoning in explanation demands that such problematic issues be investigated.

The unit of analysis is the "message" where this is realised as a ranking clause that is neither a projection, nor a hypotactically dependent elaborating clause. This means that locutions and ideas, elaborating β clauses and all embedded clauses are treated as parts of

messages rather than as conjunctively related units in their own right (Martin, 1992:235). The layout of the analysis is described by Martin as follows:

> Messages will be numbered and listed vertically down the centre of the page in the order they appear in the text under consideration. External relations will be modelled down the right hand side of this "event line" and internal relations down the left - except that external additives will be modelled down the centre of the message line, between messages (Martin, 1992:236).

The following example of conjunction analysis in Figure 2.15 indicates how succeeding moves are shown to depend on preceding ones with the arrow pointing to the information presumed by the message containing the conjunction.

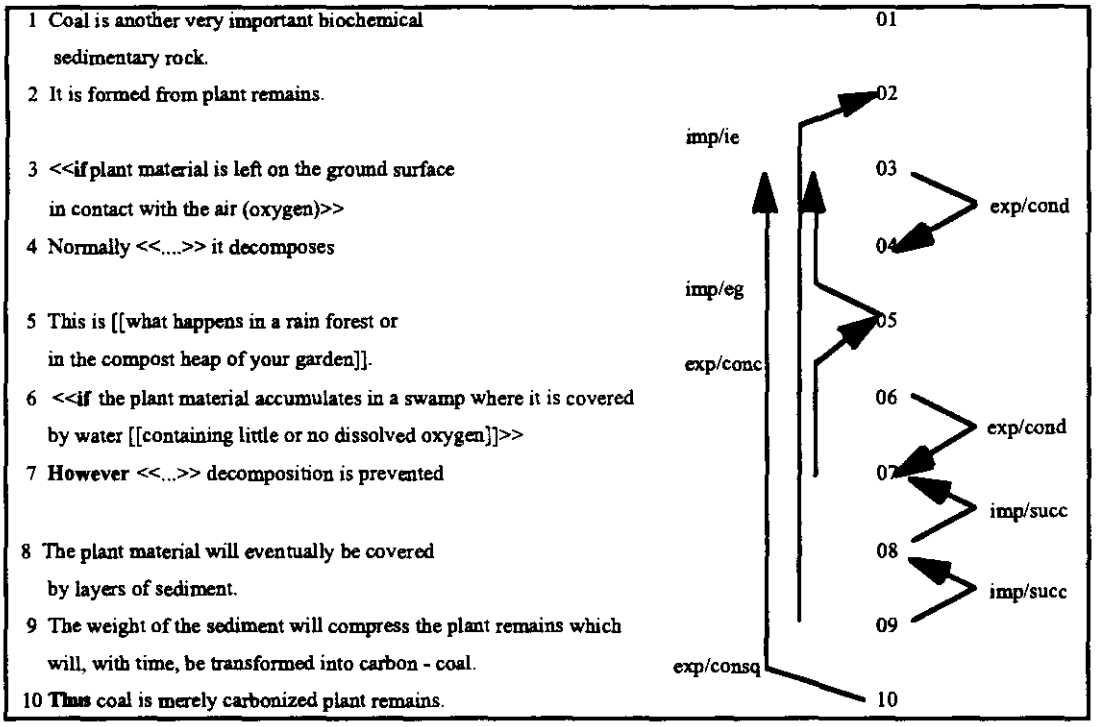


Figure 2.15 Example of conjunction analysis

The only context in which messages (conjunctively related units) can be prospectively dependent without being retrospectively depended on at the same time is in hypotactic clause complexes in which a dependent clause functions as a marked Theme as shown in Figure 2.16 below.

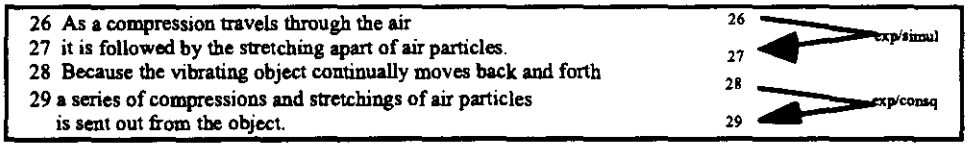


Figure 2.16 Prospectively dependent messages

The relationship between conjunction and schematic structure can be seen in Figure 2.17 showing the "sandwich" structure described by Martin (1993b:233-235), in which the Link/Phenomenon Identification is reformulated by the implicit internal conjunctive relation as the subsequent clauses 03 - 18, constituting the Implication Sequences. These are in turn related by the explicit internal consequential conjunctive relation of manner to the final clause 19, which constitutes the State.

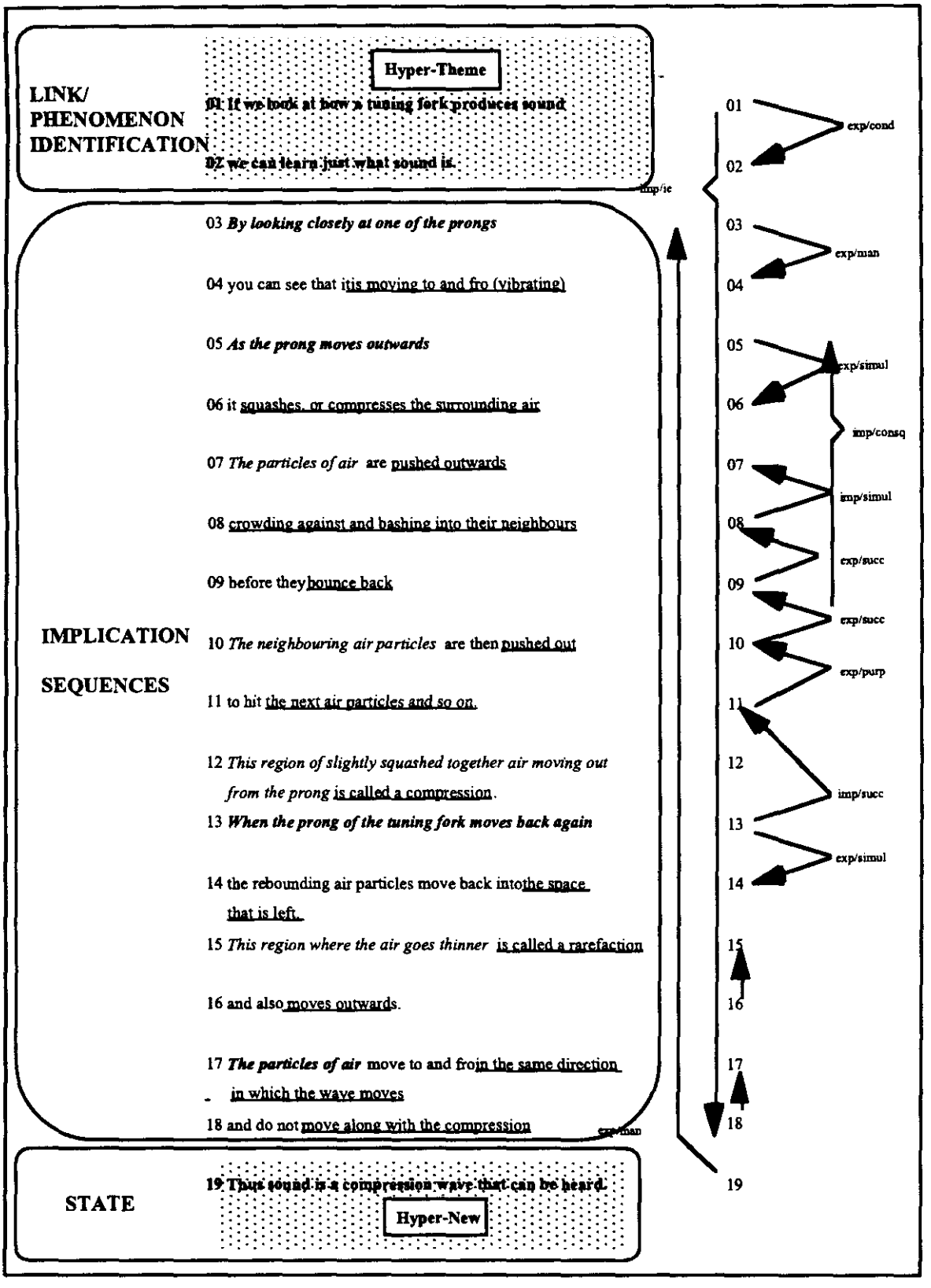


Figure 2.17 Sample analysis showing relationship between Conjunction and Schematic Structure

2.3.3.4 Semantic mapping

The method of semantic mapping used here was introduced in section 2.2.4.1 and as noted, was adapted from the method developed by Paris and McKeown (1987). Here it is used to distinguish nuclear, elaborative and peripheral meanings, which represent categories derived from the work of Hasan (1984) and (Cross, 1992). The procedures used to construct the semantic maps are detailed below, using the analysis of the secondary coal texts to illustrate.

In order to classify the meanings in the texts as nuclear, elaborative or peripheral, it is necessary to set a "delicacy of focus" as a reference from which to distinguish nuclear from elaborative meanings. Adapting from the work of Paris and McKeown (1987), a first step is to establish a semantic map of the relevant knowledge base and determine the "main path" for the process explanation - the chain of events that describes the process from beginning (start state) to the end (goal state), thus providing an explanation of the process. The knowledge base at stake is the range of meanings that are drawn upon in explaining coal formation in the context of junior secondary school science books. For the purposes of this investigation an approximation to this knowledge base is a semantic map displaying the "instantial semantics" of coal formation as evidenced in all of the sample texts. The construction of the semantic map not only permits the determination of the main path, and hence proposed nuclear meanings for each element of schematic structure, but it also permits the display of the relative commonality of meanings in the sample texts. The main path should be included in the common or core meanings across texts. The distribution of elaborative meanings across texts can be seen by projecting the meanings of each text onto the semantic map distinguishing the main path among the aggregated meanings of all sample texts.

The map is constructed in segments corresponding to the elements of schematic structure and each segment includes the meanings from all texts relevant to the corresponding element of structure. The formalism is an adaptation of that used by Paris and McKeown (1987). The components of the formalism will be introduced and illustrated referring to the ideational meanings in the TRIGGER element of SCOAL2.

4 As the land sank
5 these layers of vegetation were covered with water
6 which deposited sediments of gravel, sand, mud and silt.

Each participant is represented by a labelled box. The simplest case is represented by the participant *land* in clause 4. In fact, each box is a frame containing information about the participant but for clarity, in most cases, only the label is shown. For example, the participant realised by "sediments of gravel, sand, mud and silt" in clause six is simply labelled as *sediments*, as shown in Figure 2.18.

Figure 2.18 Example of labelling participants in a semantic map

The processes in which the participants are engaged are represented by labelled directed lines emanating from the boxes. For example "the land sank" is represented as shown in Figure 2.19.

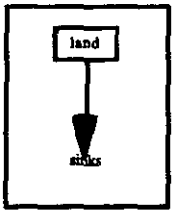


Figure 2.19 Example of representing processes in a semantic map

In grammatical terms these are middle processes and the box from which the directed line emanates has the grammatical role of Medium.

Where directed lines emanating from one box join another box, the box from which the line emanates usually has an agentive role, but may also be the Carrier or Possessor of an Attribute. The box toward which the arrow is directed is usually the participant to which the process is directed and can be thought of in grammatical terms as Medium/Goal or Range. This is shown in the representation of clause five ("these layers of vegetation were covered with water") in Figure 2.20.

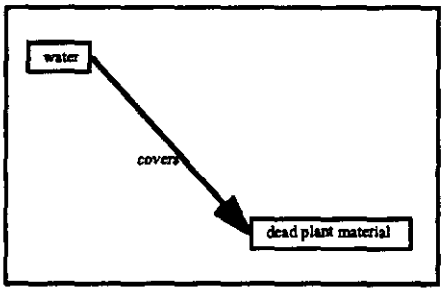


Figure 2.20 Example of representing a participant with an agentive role in a semantic map

Logical relations like cause, simultaneity or sequence etc. are represented by labelled ellipses with directed lines linking them to the relevant process lines. This can be seen in the representation of the relation of simultaneity between clauses four and five in Figure 2.21:

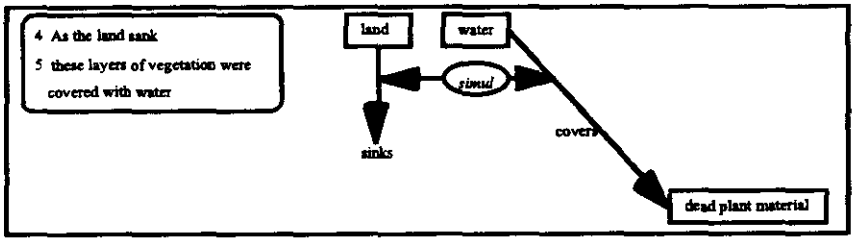


Figure 2.21 Example of representing logical relations in a semantic map

Circumstantial relations are also represented by labelled ellipses but these are linked by undirected lines to the single relevant process line. An example is the representation of the circumstance "eventually" in the complete semantic map for the TRIGGER element shown in Figure 2.22. (The representation of the circumstance *eventually* is indicated as a faint line because the meaning occurs in other texts but is not realised in SCOAL2) .

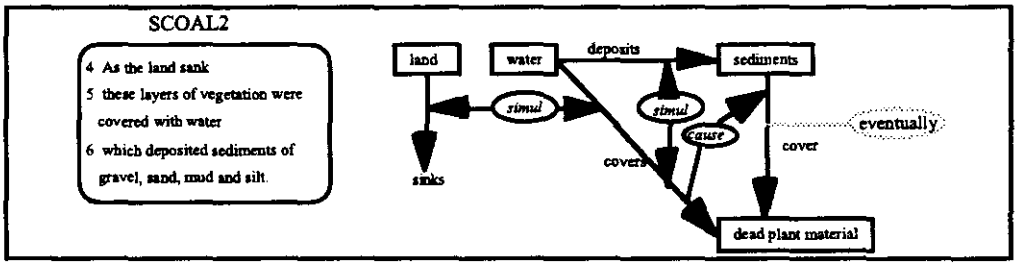


Figure 2.22 Semantic map for the TRIGGER element in SCOAL2

A main path can be determined based on an algorithm similar to that applied by Paris and McKeown (1987). This involves backtracking from the "goal state" (black coal) to the "start state" (dead plant material). It tracks from the process line directed to the goal state to the participant from which is emanates. It then picks up all process lines directed to this participant and then tracks these to the participant(s) from which they emanate. It then tracks the process lines to those participants and so on. Relation lines connecting map segments are part of the main path. The first stage of this backtracking process is illustrated in Figure 2.23 showing the semantic map for the final TRANSFORMATION element.

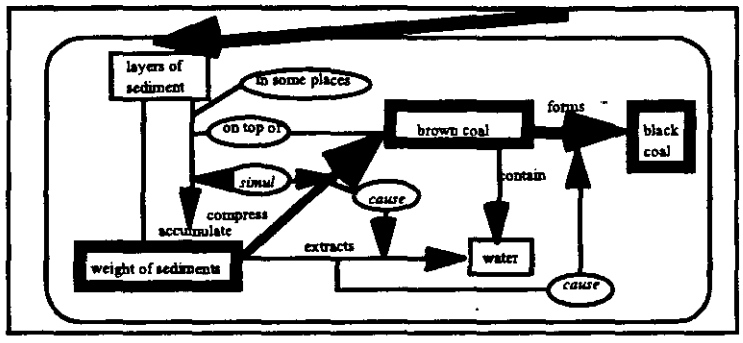


Figure 2.23 Main path in third TRANSFORMATION element

The process line directed to the goal state (*black coal*) is *forms*, and the participant from which this emanates is *brown coal.* The process line directed to this participant is *compress* and the participant from which this emanates is *weight of sediments.* There are no other process lines directed to this participant in this element so the relation line (*then*) tracks this element back to the previous TRANSFORMATION element. The algorithm is applied in this manner tracking back through all segments in the map (the ORIENTATION and CLOSURE elements are not included in the map). The relation line tracking back from the second to the first segment, links to the process line *does not decompose* rather than a participant, as shown in Figure 2.24.

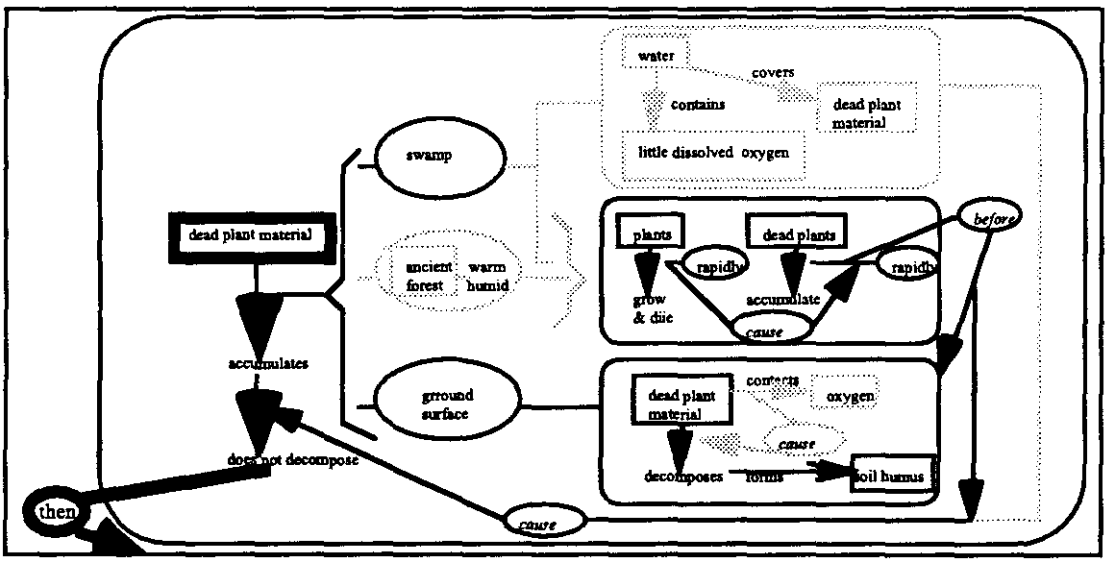


Figure 2.24 Main path in the CONDITIONS element

Tracking back this process line leads to the start state. This procedure produces the main path shown in thick lines in Figure 2.25 and the nuclear meanings are those connected by thick lines in each segment. The lighter coloured thick lines indicate those meanings in the main path that are not common to all texts. (The "PROCESS ENDS" box indicates that some texts include only one TRANSFORMATION element in which the product is coal.)

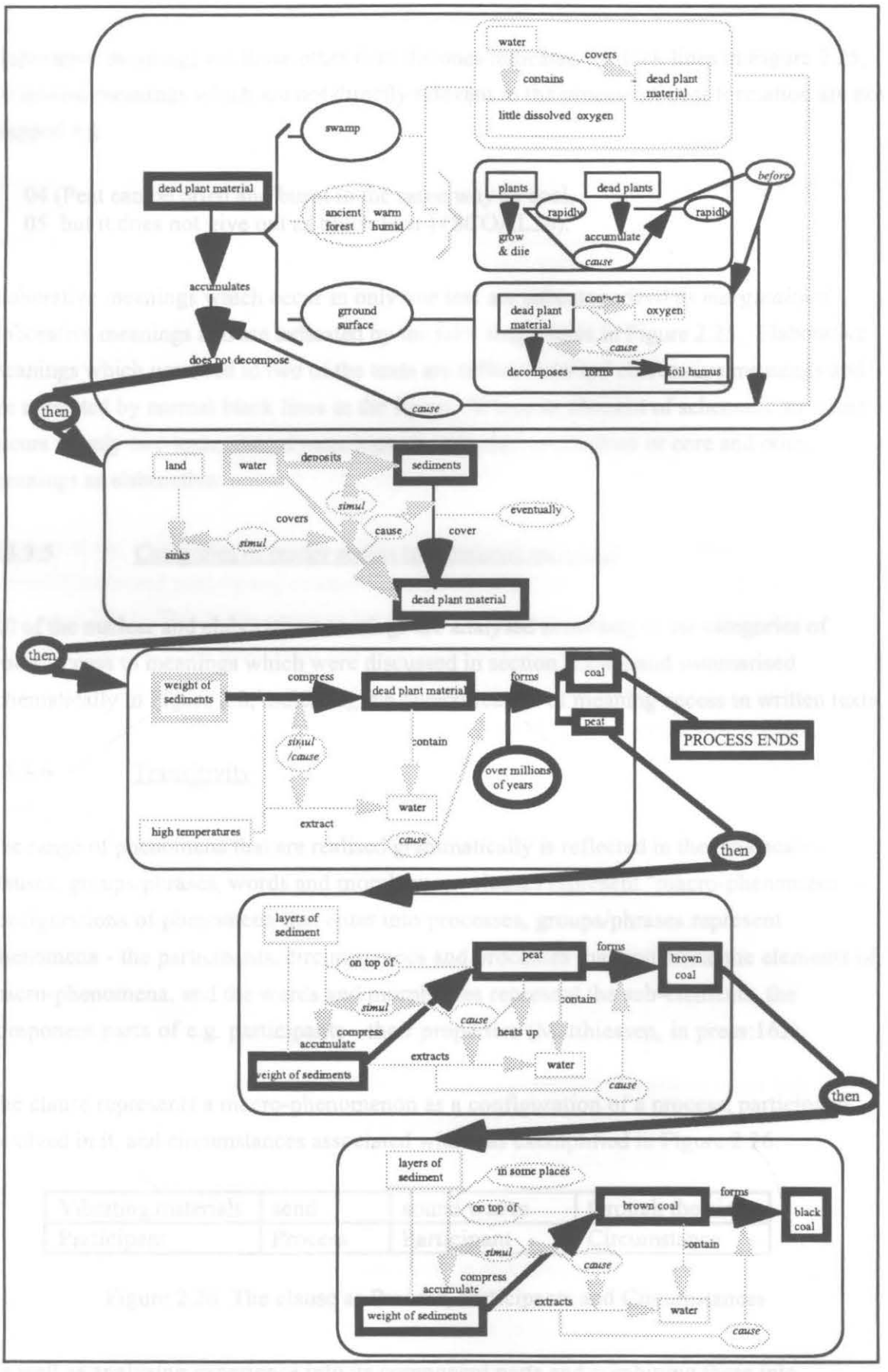


Figure 2.25 Instantial semantics of coal formation in secondary texts

Elaborative meanings are those other than the ones indicated by thick lines in Figure 2.25. Peripheral meanings which are not directly relevant to the process of coal formation are not mapped e.g.

04 (Peat can be dried and burnt in the same way as coal,
05 but it does not give out as much heat.) (SCOAL3b).

Elaborative meanings which occur in only one text are subcategorized as *marginalised* elaborative meanings and are indicated by the faint single lines in Figure 2.25. Elaborative meanings which occurred in two of the texts are called *endorsed* elaborative meanings and are indicated by normal black lines in the figure. Where an element of schematic structure occurs in only two texts, shared meanings are regarded as common or core and other meanings as elaborative.

2.3.3.5 Categories of reader access to ideational meanings

All of the nuclear and elaborative meanings are analysed according to the categories of reader access to meanings which were discussed in section 2.2.4.2 and summarised schematically in Figure 2.8, indicating the diversification of meaning access in written texts.

2.3.3.6 Transitivity

The range of phenomena that are realised grammatically is reflected in the rank scale - clauses, groups/phrases, words and morphemes: clauses represent "macro-phenomena" - configurations of phenomena that enter into processes, groups/phrases represent phenomena - the participants, circumstances and processes that constitute the elements of macro-phenomena, and the words and morphemes represent the sub-elements, the component parts of e.g. participants - their properties (Matthiessen, in press:162).

The clause represents a macro-phenomenon as a configuration of a process, participants involved in it, and circumstances associated with it as exemplified in Figure 2.26.

Vibrating materials	send	sound waves	through the air
Participant	Process	Participant	Circumstance

Figure 2.26 The clause as Process, Participants and Circumstances

As well as analysing experience into its component parts and combining these into configurations, the experiential metafunction also classifies the world into domains of

experience such as consciousness, happening and doing, and being and having. In the grammar of transitivity, the system Process Type is concerned with the particular domain of experience of processes. The following classification of process types in Table 2.6 is noted in Matthiessen (in press:168).

Domain of experience	Process type	Example
Consciousness - internal	mental	You have just seen a number of sources of sound
-external	verbal	We say the air is saturated
Doing and happening	material	As the prong moves outwards ...
Being and having	relational	Coal is another important biochemical sedimentary rock.

Table 2.6 Classification of Process Types

Agency is the option of representing the combination of Process + Medium (the most centrally involved participant) as caused by an agency external to the Medium (effective) or not (middle). This is the ergative perspective discussed by Halliday (1994a:163-172). This variable is not the traditional one concerned with the presence of an "object", distinguishing transitive from intransitive. Both middle and effective clauses can be transitive or intransitive in the traditional sense. The following examples in Table 2.7 are provided by Matthiessen (in press:175).

	middle	effective
"intransitive"	they played [non-ranged]	they hunted ('game') [goal-intransitive]
"transitive"	they played tennis [ranged]	they hunted ducks [goal-intransitive]

Table 2.7 Middle/Effective/Transitive/Intransitive paradigm

The systems dependent on Process Type and Agency interact in various ways but circumstantial systems tend to be more independent. The former systems are referred to by Matthiessen (in press) as nuclear transitivity and the latter, circumstantial transitivity. These will be considered separately.

The root of the grammar of nuclear transitivity is represented by Matthiessen (in press:171) as shown in Figure 2.27.

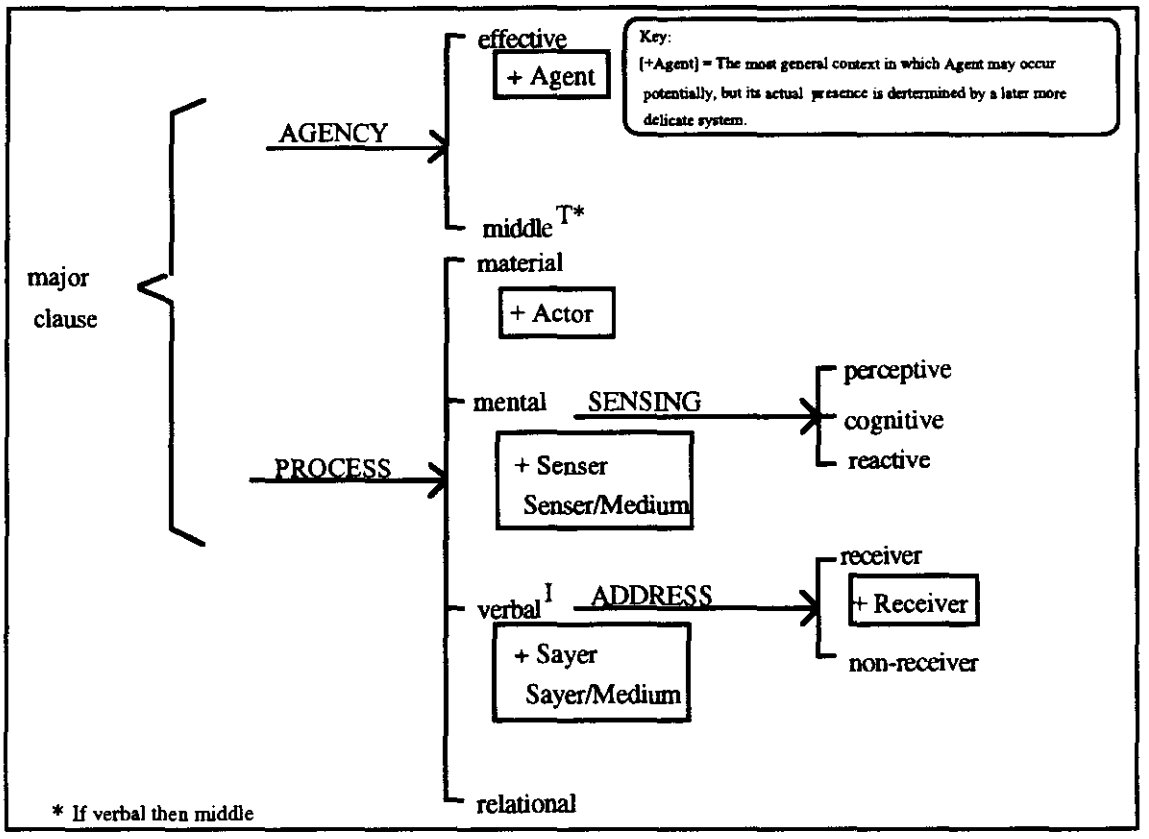


Figure 2.27 Agency, Process Type and dependent systems

There are two sets of participant functions, one generalised set including Agent and Medium, and one process-type specific set including Actor, Senser, and Sayer. The transitive and ergative equivalents of participant functions are summarised in Table 2.8 adapted from Halliday (1994a:166).

Typical preposition	Ergative Function	Transitive Function						
		Material	Behavioural	Mental	Verbal	Attributive	Identifying	Existential
PROCESS	Process							
-	Medium	Goal; *Actor	Behaver	Senser	Sayer	Carrier	Value	Existent
by	Agent	Actor [effective]		Phenomenon ('*please*')		Attributor	Token	
to, for	Beneficiary	Recipient; Client			Receiver	Beneficiary		
at, on etc	Range	Range	Behaviour	Phenomenon ('*like*')	Verbiage	Attribute		

*when the process is middle

Table 2.8 Transitive and ergative equivalents

Together Agency and Process Type define a two dimensional paradigm - effective/middle x Material/Mental/Verbal/Relational. Examples of this paradigm including general and process-type specific participant functions are shown in Table 2.9 which is a combination of examples provided in Matthiessen (in press:172-173).

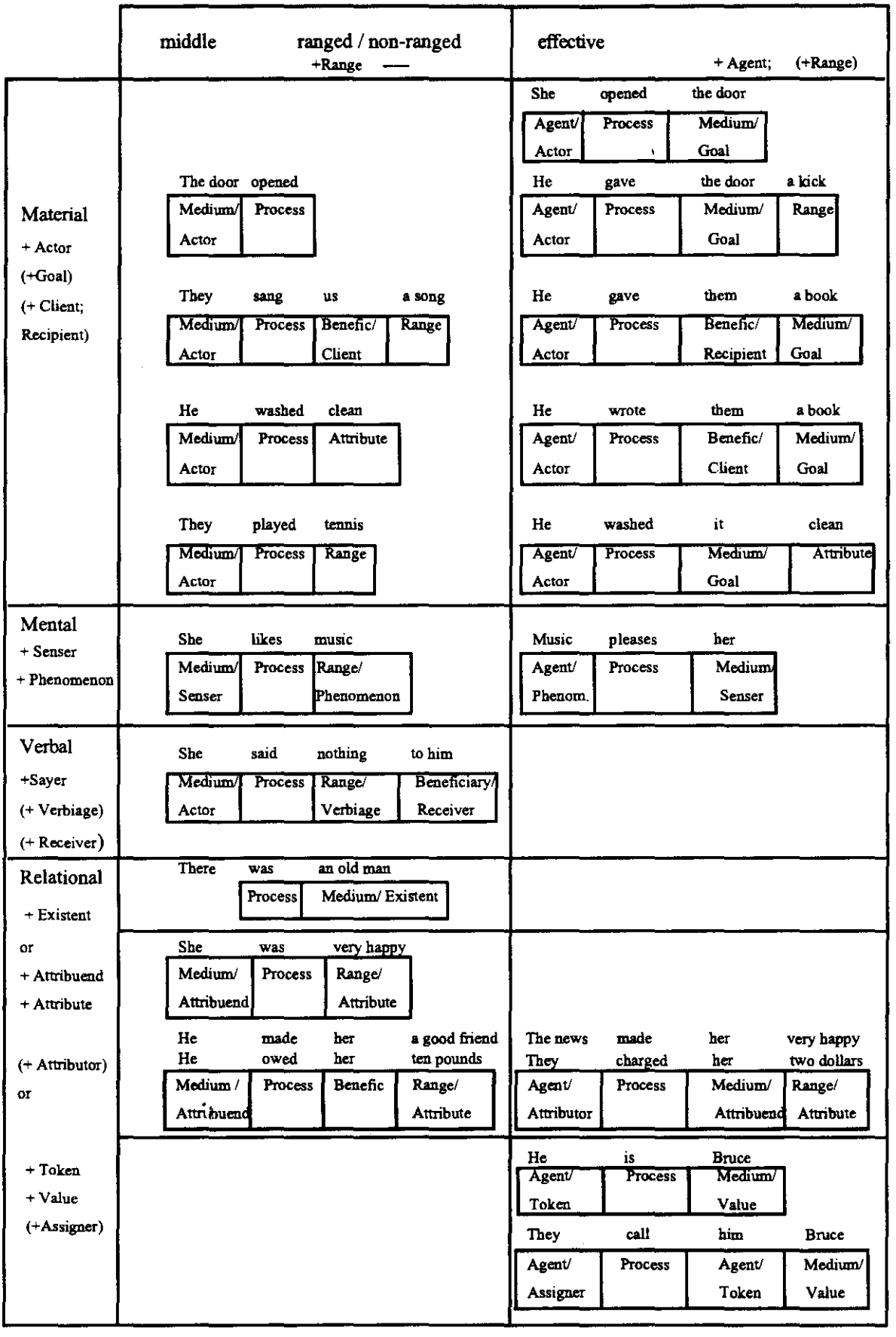


Table 2.9 Structures at the intersection of Agency and Process Type

The outline of transitivity provided is the basis of the analysis to be undertaken. It derives from more elaborated accounts of the rationale for the distinctions among process types and among the various participants roles (Halliday, 1985; 1994a) and the more delicate system networks associated with such distinctions (Matthiessen, in press). In general, these will not be pursued further here, however, the analysis of clauses involving the process type: Relational, warrants explication in somewhat greater delicacy than that sketched above. The system network in Figure 2.28 adapted from Matthiessen (in press:245) indicates the distinctions to be made in the analysis.

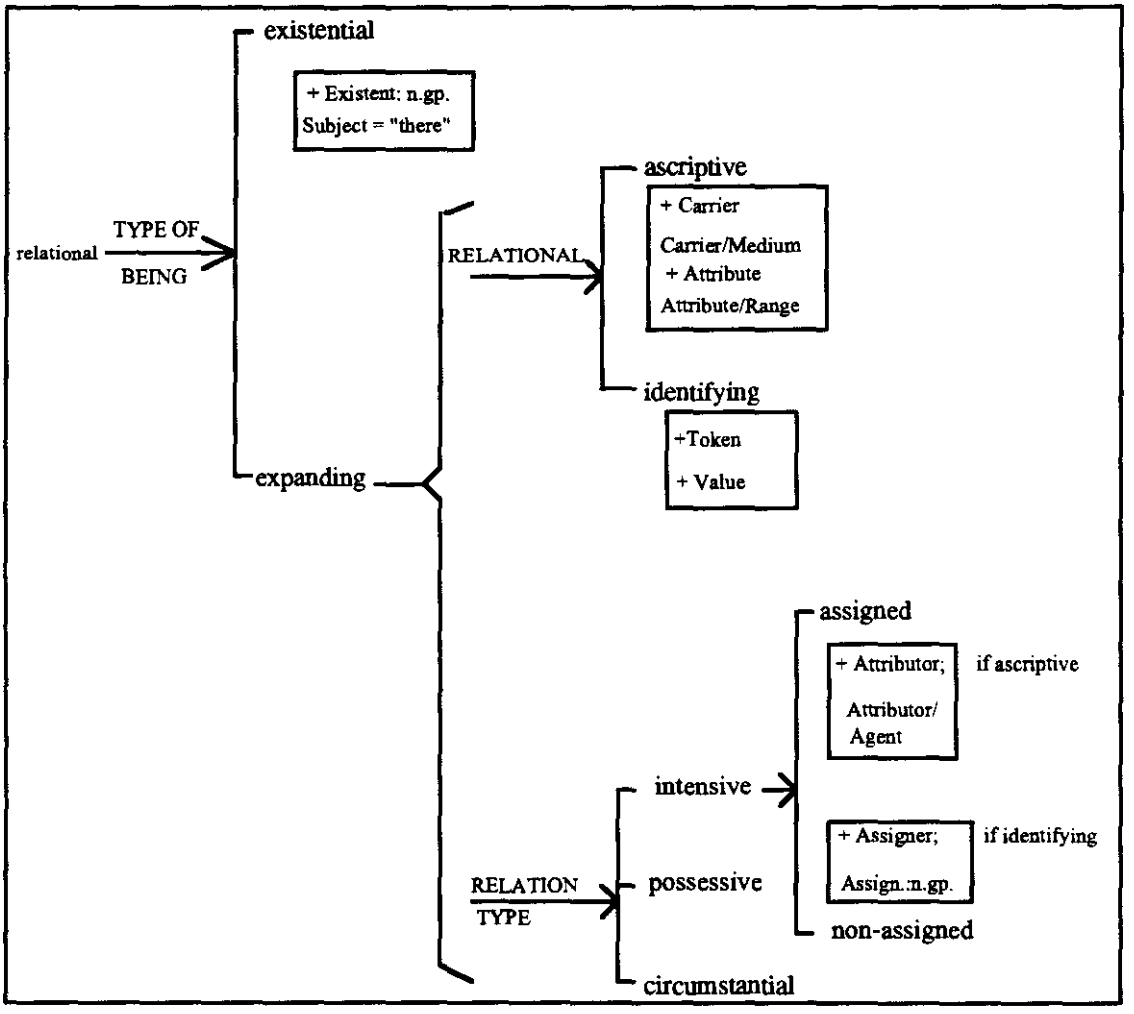


Figure 2.28 Relational transitivity

Setting aside existential clauses such as "There's a man in the moon", the cross-classification of "Relational" with "Relation Type" produces a paradigm of ascriptive (attributive)/identifying x intensive/possessive/circumstantial. Examples of this paradigm are shown in Table 2.10 adapted from Halliday (1994a:136-37).

	Attributive			Identifying		
INTENSIVE	Sarah *Carrier*	is/seems *Process*	wise *Attribute*	Sarah *Identified/Token*	is *Process*	the wise one *Identifier/Value*
	John *Carrier*	became *Process*	a plumber *Attribute*	The wise one *Identified/Value*	is *Process*	Sarah *Identifier/Token*
CIRCUMSTANTIAL	Pussy *Carrier*	is *Process*	in the well *Attribute/Circ*	by train *Identified/Token*	is *Process*	the best way *Identifier/Value/Circ*
				the best way *Identified/Value/Circ*	is *Process*	by train *Identifier/Token*
	The poem *Carrier*	concerns *Process: circ*	a fish *Attribute*	applause *Identified/Token*	followed *Process:circ*	her act *Identifier/Value*
				her act *Identified/Value*	was followed by *Process:circ*	applause *Identifier/Token*
POSSESSIVE	the piano *Carrier/Possessed*	is *Process*	Peter's *Attribute/Possession*	the piano *Token/Possession*	is *Process*	Peter's *Value/Possession*
				Peter's *Value/Possession*	is *Process*	the piano *Token/Possession*
	Peter *Carrier/Possessor*	has *Process: possession*	a piano *Attribute/Possessed*	Peter *Identified/Token*	owns *Process:possessive*	the piano *Identifier/Value*
	The piano *Carrier/Possessed*	belongs to *Process:possession*	Peter *Attribute: Possessor*	the piano *Identified/Value*	is owned by *Process/Possessive*	Peter *Identified/Token*

Table 2.10 Attributive and Identifying Relational Processes

A number of relational clauses serve as grammatical metaphors for clause complexes or cohesively related clauses, e.g. "Applause followed her act" (She finished her act and then the audience applauded) in Table 2.10 above. From this point of view it is useful to list such relational verbs according to different expansion types as shown in Table 2.11 (Matthiessen, in press: 263).

elaborating	expository	be, comprise, constitute, indicate, point to, reflect, represent, signal
	exemplifying	be, exemplify, illustrate
extending	additive	accompany, combine with, complement
	alternative	alternate with, replace, substitute for, supplant
	adversative	contrast with, distinguish
enhancing	temporal	anticipate, co-occur with, follow, greet, precede, pre-date
	causal	arise from, bring about, cause, lead to, produce, prove, result in
	conditional	apply to, be associated with, condition, correlate with, depend on
	concessive	conflict with, contradict, contravene, preclude, prevent
	comparative	approximate to, compare with, differ from, resemble, simulate

Table 2.11 Relational verbs serving as grammatical metaphors

Circumstantial transitivity is the resource for expanding the process, or combination of the process and participants, along various dimensions. The simultaneous Circumstance systems can be grouped according to logico-semantic relations of projection and expansion (Matthiessen, in press: 271) as shown in Figure 2.29, derived from the categories provided in Halliday (1994a:152-158).

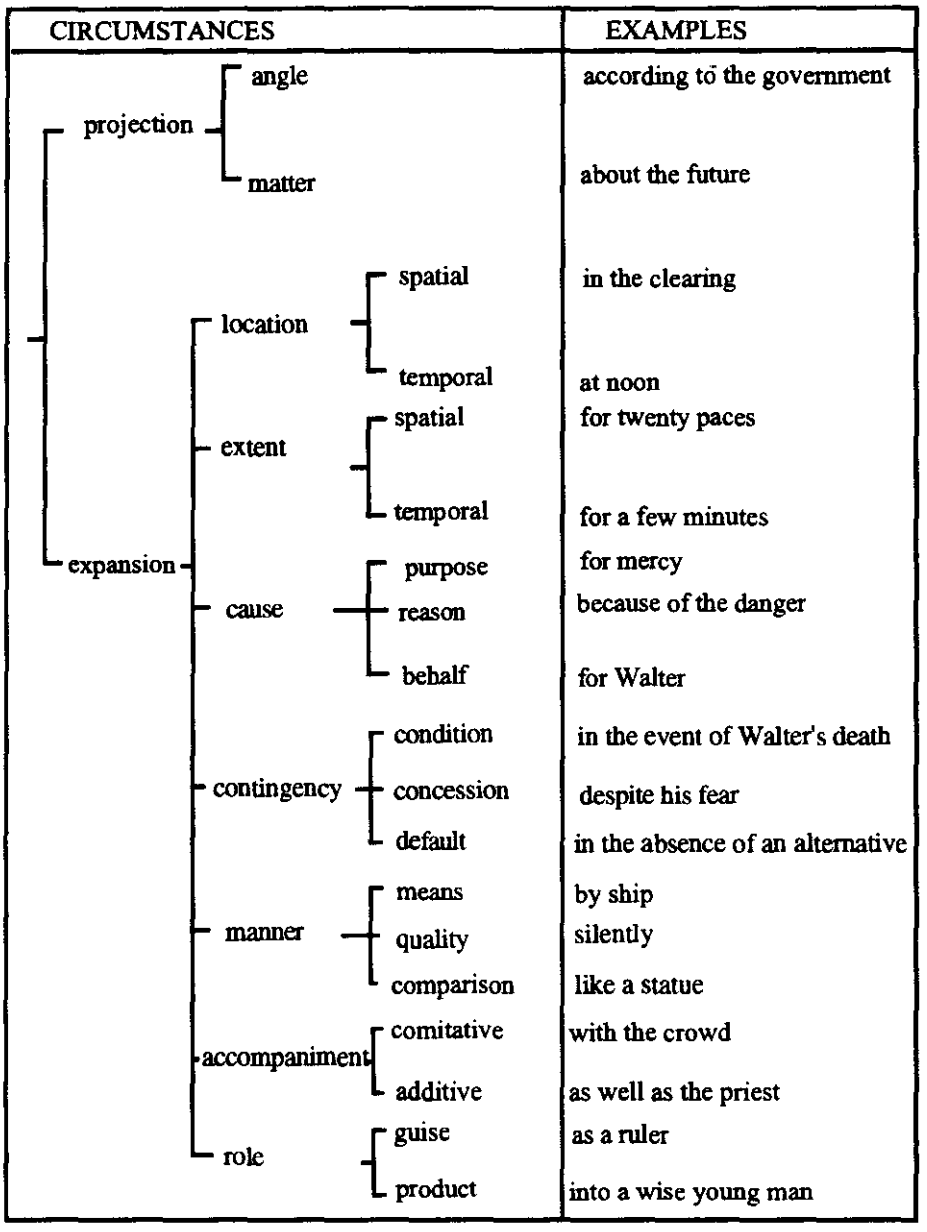


Figure 2.29 Circumstances grouped according to projection and expansion categories

The method of displaying the transitivity analysis is illustrated for the following text in Figure 2.30.

01 Figure 3.6*b* shows [[plant material building up in a *swamp*.]]
02 Usually, dead plant leaves and stems, <<04>> are broken down
03 and become part of the soil humus (see Chapter 2)
04 <<when they fall to the ground>>
05 In some swamps, however, it is possible [[that the breakdown is not complete]],
06 because the plant pieces are being produced faster [[than they break down.]]
07 Layers of such plant remains can be squeezed
08 and changed over millions of years into the rock, coal.

Generalised participant roles are indicated as column headings, process types are indicated in the relevant cells.

	AGENT	PROCESS	MEDIUM	BENEFIC/RANGE	CIRCUMSTANCE
01	Figure 3.6b	shows (RELATIONAL: IDENTIFYING)	[[plant material building up in a swamp]]		
		building up (MATERIAL)	plant material		in a swamp (SPATIAL:LOCATION)
02		are broken down (MATERIAL)	dead plant leaves and stems		
03		become (RELATIONAL: ATTRIBUTIVE)		part of the soil humus	
04		fall (MATERIAL)	they		to the ground (SPATIAL:LOCATION)
05		is (RELATIONAL: ATTRIBUTIVE)	it [[that the breakdown is not complete]]	possible	in some swamps (SPATIAL:LOCATION)
		is not (RELATIONAL: ATTRIBUTIVE)	the breakdown	complete	
06		are being produced (MATERIAL)	the plant pieces		faster [[than they break down]] (MANNER:COMPARISON)
		break down (MATERIAL)	they		
07		can be squeezed (MATERIAL)	layers of such plant material		
08		changed (MATERIAL)			into the rock - coal (ROLE:RESULT) over millions of years (TEMPORAL:EXTENT)

Figure 2.30 Sample transitivity analysis - SCOAL3a

2.3.3.7 Categories of Grammatical metaphor

Categories of experiential metaphor (Table 2.12) and logical metaphor (Table 2.13) were derived from Halliday (1994a; 1994b), Ravelli (1988), Jones (1988), Martin (1992), and Halliday and Matthiessen (in press). All texts in the data set were analysed for the occurrence of the categories of grammatical metaphor detailed below.

Grammatical Metaphor: Experiential				
Shift to Thing				
Cat	**Semantic Choice**	**Metaphorical Realisation Function/Class**	**Example**	**Congruent Realisation Class**
1a	material process	Thing/nominal group	the movement of the air	verbal group
1b	mental process	Thing/nominal group	our perception of the war	verbal group
1c	relational process	Thing/nominal group	a fairly direct relationship	verbal group
1d	verbal process	Thing/nominal group	an explanation of the	verbal group
1e	behavioural process	Thing/nominal group	act out behaviours	verbal group
1f	existential process	Thing/nominal group	the existence of coal	verbal group
1g	process:tense/phase	Thing/nominal group	the prospect of finding	verbal group
1h	process:conation	Thing/nominal group	an attempt to find coal	verbal group
1i	process+circumstance	Thing/nominal group	The earth's revolution	verbal group
1j	modality of process	Thing/nominal group	the possibility of floating	modal verb
2a	quality of process	Thing/nominal group	rate of growth	adverb
2b	quality of a Thing	Thing/nominal group	the strength to continue	adjective
2c	0 - Thing	Thing/nominal group	the phenomenon of sound	0
3	minor process	Thing/nominal group	an accompaniment of coal	preposition
4	circumstance	Thing/nominal group	the fifth day saw them ...	prepositional phrase
Shift to Quality				
5a	material process	Epithet, Classifier/ adjective	performance level	verbal group
5b	mental process	Epithet, Classifier/ adjective	the 'so-called' significant others	verbal group
5c	behavioural process	Epithet, Classifier/ adjective	a crying baby	verbal group
5d	relational process	Epithet, Classifier/ adjective	the relative weights of the objects	verbal group
5e	existential process	Epithet, Classifier/ adjective	the existing forces	verbal group
5f	process:tense/phase	Epithet, Classifier/ adjective	the initial movement	verbal group
5g	quality of process	Epithet, Classifier/ adjective	poor achievement	adverb
5h	modality of process	Epithet/adjective	in June the South Pole is in constant darkness	modal verb/adverb
6a	participant	Epithet, Classifier/ adjective	engine failure	nominal group
6b	participant	Qualifier/prepositional phrase	the vibration of the tuning fork	nominal group
6c	participant	Possessive determiner	the Earth's revolution	nominal group
7a	circumstance	Epithet, Classifier/ adjective	surface cracks	prepositional phrase
7b	circumstance	Epithet, Classifier/ adjective	a lengthy delay	prepositional phrase
Shift to Process				
8	circumstance	Process/verbal group	buoyancy concerns the forces on objects in fluids	prepositional phrase
9	participant	Process/ verbal group	computerise	nominal group
10	agency-process	Process/verbal group	impose movement on ...	causative verb
11	Ø - process	Process/verbal group	have an impact	0

Table 2.12 Categories of experiential grammatical metaphor used in analysis

Grammatical Metaphor: Logical				
Cat	**Semantic Choice**	**Metaphorical Realisation Function/Class**	**Example**	**Congruent Realisation Class**
12a	logical connection	Thing/nominal group	The result is the melting..	conjunction
12b	logical connection	Process/ verbal group	Our wait preceded our tour...	conjunction
12c	logical connection	Minor process/preposition	In times of flood silt was deposited on the plant	conjunction
12d	logical connection	Circumstance/ prepositional phase	As a result the brown coal turned into black coal	conjunction
12e	logical connection	Numerative/ adjective	Our previous tour of the ring	conjunction

Table 2.13 Categories of logical metaphor used in analysis

2.3.3.8 Analysis of relative technicality

The relative technicality of the texts will be determined by comparing the frequency of occurrence of the categories of lexicogrammatical and discourse semantic resources for defining and classifying as detailed in section 2.2.4.3, and including the proportion of undefined technical terms. This will be complemented by the analysis of grammatical metaphor indicating the extent of metaphorical realisation in the deployment of these resources.

Chapter 3

Explanations of coal formation

This chapter reports on analyses of explanations of coal formation in three secondary and three primary school science books addressing the research questions listed in Figure 3.1.

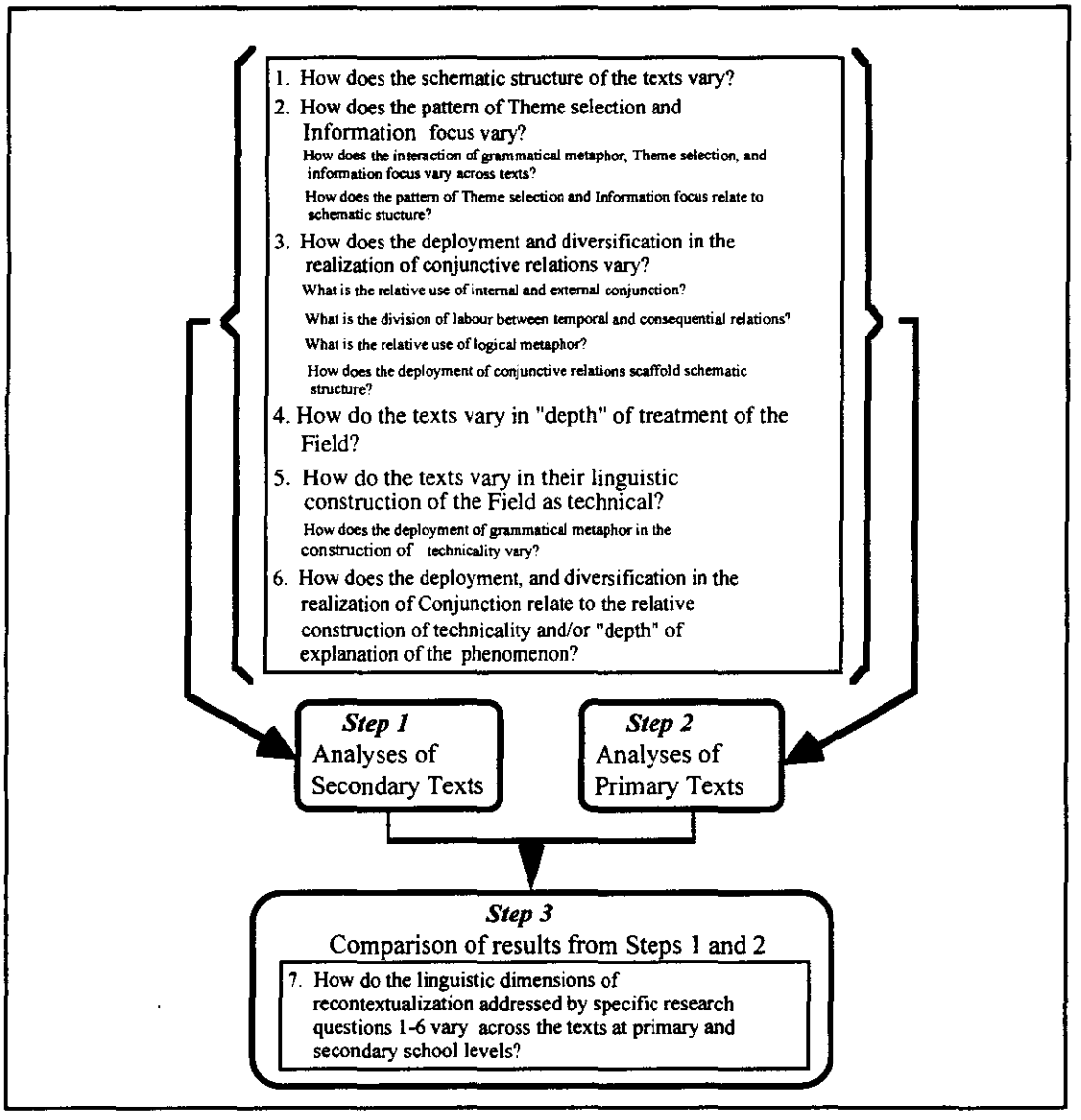


Figure 3.1 Research questions addressed in chapter three

The secondary texts are dealt with in the first section with separate sub-sections allocated to each of the research questions one through six. Then the results of the analyses of the primary texts are reported in the same manner, and including, for each research question, comparison with the corresponding results for secondary texts. Finally, these comparisons

are summarised to address research question seven, the global research question and the educational linguistic purpose of the study.

3.1 Secondary coal texts

3.1.1 Schematic structure in secondary coal texts

As previously noted a generalised schematic structure for explanatory "cycle" texts (water cycle, nitrogen cycle etc) was proposed by Cross (1992):

(ORIENTATE) ^ TRANSFORM ^ (CONCLUDE)

What is proposed for the coal texts is a similar schematic structure, with the hyper-element TRANSFORM and additional elements prerequisite to the TRANSFORMATION element proper:

(ORIENTATION) ^ CONDITIONS ^ TRIGGER ^ TRANSFORMATION ^ (CLOSURE)

However, the account of generic structure proposed here must remain tentative due to the small number of texts examined.

The ORIENTATION element has the function of preparing the reader for the text that follows. The first step is the Phenomenon Identification realised by the subheading. A further strategy is the provision of a summary or overview of the implication sequences or logical chain of events that will be detailed subsequently in the text. This incorporates the phenomenon to be explained - in this case coal - along with what is to be explained about it - in this case its formation. Other meanings central to the summarise strategy in these texts are what coal is formed from, i.e. plant remains, and some indication of what brings about the change, i.e. sedimentation. The first two secondary coal texts begin with an ORIENTATION, which at a more delicate level of analysis, revealing "layers of staging" (Martin, 1994; 1995:24), includes a Phenomenon Identification element and an Explanation Summary element:

Coal
1 Coal is another very important biochemical sedimentary rock.
2 It is formed from plant remains. (SCOAL1)

Coal
1 Coal was formed from the remains of plants buried by sediments. (SCOAL2)

A further orienting strategy is indicated in SCOAL1 by the inclusion of the comparative reference "another", relating to prior co-text. This is the Link strategy referred to by Shea (1988:108).

The ORIENTATION in SCOAL3b does not employ the summarise strategy or the link strategy. It orients the reader by using the contextualize strategy (Cross,1992:169), discussed in Chapter two. In SCOAL3b the title is not simply "Coal" but "Coal and the future". This and the first clause locate the text in the context of industrial science - knowing how coal is formed is relevant because of its implications for the industrial use of fossil fuel.

1 Coal deposits are very common in many areas of Australia. (SCOAL3b)

In SCOAL1 the Classifier "biochemical" also functions to contextualize that account of coal formation as having a biochemical perspective rather than an industrial, historical etc perspective. The ORIENTATION in these texts includes a Phenomenon Contextualization element.

There is no ORIENTATION element in SCOAL3a. This stage in the schematic structure then, may be optional and it may use, either individually or in combination, the strategies of summarise, contextualize and link, to prepare the reader for the forthcoming text.

The next three elements of structure (Conditions ^ Trigger ^ Transformation↰) explicate the process of coal formation. They represent a more delicate analysis of the stage referred to as the "explanation sequence" (Macken, 1989, Veel, in press a; in press b) or the "implication sequence" (Wignell et al, 1987; Shea, 1988). The Conditions element establishes the condition (undecomposed) of the raw material (plant remains) necessary to the formation of the phenomenon (coal). This element occurred in all texts and since the undecomposed state of the plant remains is a prerequisite to subsequent stages of coal formation, this element of schematic structure is judged to be obligatory. The Conditions may simply be stated or the implication sequences which produce the Conditions may be included. In SCOAL3b the Conditions are simply stated:

2 They all start as plant remains [[that are not fully broken down and put back into the soil.]] (SCOAL3b)

However, in SCOAL1 the chain of events producing the required condition is explained:

3 <<if plant material is left on the ground surface in contact with the air (oxygen)>>
4 Normally <<3>> it decomposes
5 This is [[what happens in a rain forest or in the compost heap of your garden]].
6 <<if the plant material accumulates in a swamp
6.1 where it is covered by water [[containing little or no dissolved oxygen]]>>
7 However <<6-6.1>> decomposition is prevented (SCOAL1)

The Trigger element introduces the event sequence which makes it possible for the raw material to be subject to processes of Transformation. In these texts it is the covering of undecomposed plant remains with sediment. This element occurs in two of the texts:

8 The plant material will eventually be covered by layers of sediment (SCOAL1)

5 As the land sank
6 these layers of vegetation were covered with water
7 which deposited sediments of gravel, sand, mud and silt. (SCOAL2)

Although the Trigger element does not occur in SCOAL3a or SCOAL3b, it will be suggested that this is nevertheless an obligatory element of the schematic structure of explanations of coal formation and that its omission partially accounts for explanatory inadequacies in SCOAL3a and SCOAL3b.

The Transformation element is iterative and deals with the step by step conversion of the raw material to the phenomenon in question. Each step in the process which results in an intermediate product constitutes a single Transformation element, the intermediate product of the first Transformation becoming the raw material for the next and so on until the final product is the phenomenon in question. This can be seen in SCOAL2, where the first Transformation element is the conversion of plant remains to peat, the second is the conversion of peat to brown coal, and the final Transformation element is the conversion of brown coal to black coal.

Transformation 1
7 Over millions of years the weight of the sediments and high temperatures removed much of the water from the plant remains.
8 These plant remains are known as peat.

Transformation 2
9 As the peat was compressed
10 and became warmer
11 moisture was driven out
12 and it became brown coal, or lignite

Transformation 3
13 In some places, more layers of sediment built up on top of the brown coal.
14 This caused more and more moisture to be driven out
15 and black coal was formed (SCOAL2)

In some texts the iterative Transformations are collapsed into a single element omitting the implication sequences resulting in intermediate products. This occurs in SCOAL1 and SCOAL3a:

9 The weight of the sediment will compress the plant remains which will, with time, be transformed into carbon - coal. (SCOAL1)

7 Layers of such plant remains can be squeezed
8 and changed over millions of years into the rock, coal. (SCOAL3a)

At least one Transformation element is obligatory.

The CLOSURE element functions to draw some conclusion to the text such that it steps outside of the detail of the processes of formation of the phenomenon. Two strategies were evident in the sample texts. The first was again a summarise strategy, re-defining the phenomenon, coal:

10 Thus coal is merely carbonized plant remains. (SCOAL1)

This is labelled as the Conclusion element.

The second strategy is comment, where the meanings concern some attribute or use of the phenomenon and do not directly relate to the account of its formation. This can be seen in the CLOSURE element of SCOAL3b and is labelled as the Comment element:

11 These two types of coal make better fuels. (SCOAL3b)

One text (SCOAL3a) does not include a CLOSURE, and where this stage does occur it can be easily seen that it is not essential to the explanation of coal formation. The CLOSURE is therefore regarded as an optional stage in the schematic structure.

The possible schematic structures in the secondary textbook explanations of coal formation can be summarised as follows:

The organisation of the secondary coal texts in terms of the proposed schematic structure is shown in Table 3.1.

	SCOAL1	SCOAL2	SCOAL3a	SCOAL3b
ORIENTATION				
Phenomenon Identification	Coal	Coal		Coal and the Future
Phenomenon Contextualization	1 Coal is another very important biochemical sedimentary rock.			1 Coal deposits are very common in many areas of Australia.
Link				
Explanation Summary	2 It is formed from plant remains.	1 Coal was formed from the remains of plants buried by sediments.		
IMPLICATION SEQUENCES				
Conditions	3 <<if plant material is left on the ground surface in contact with the air (oxygen)>> 4 Normally <<.3>> it decomposes 5 This is [[what happens in a rain forest or in the compost heap of your garden]]. 6 <<if the plant material accumulates in a swamp 6.1 where it is covered by water [[containing little or no dissolved oxygen]]>> 7 However <<.6-6.1>> decomposition is prevented	2 In ancient forests, <<.2.1>>layers of dead trees and other plants built up on the forest floor 2.1 <<which were warm and humid>> 3 before they could rot.	1 Figure 3.6 *b* shows plant material building up in a *swamp*. 2 Usually, dead plant leaves and stems, <<.3>> are broken down 3 <<when they fall to the ground>> 4 and become part of the soil humus (see Chapter 2) 5 In some swamps, however, it is possible [[that the breakdown is not complete]], 6 because the plant pieces are being produced faster [[than they break down.]]	2 They all start as plant remains [[that are not fully broken down and put back into the soil.]]
Trigger	8 The plant material will eventually be covered by layers of sediment	4 As the land sank 5 these layers of vegetation were covered with water 6 which deposited sediments of gravel, sand, mud and silt.		
Transformation	9 The weight of the sediment will compress the plant remains which will, with time, be transformed into carbon - coal.	7 Over millions of years the weight of the sediments and high temperatures removed much of the water from the plant remains. 8 These plant remains are known as peat.	7 Layers of such plant remains can be squeezed 8 and changed over millions of years into the rock, coal.	3 The first stage of the change to coal is peat, 3.1 which is a watery, spongy black mass of plant material. 4 (Peat can be dried and burnt in the same way as coal, 5 but it does not give out nearly as much heat.) 6 Large areas of peat 'bogs' may take millions of years 7 to form.
Transformation		9 As the peat was compressed 10 and became warmer 11 moisture was driven out 12 and it became brown coal, or lignite.		8 As other layers of rock are laid on top 9 the weight of these sediments squeezes the peat into brown coal,
Transformation		13 In some places, more layers of sediment built up on top of the brown coal. 14 This caused more and more moisture to be driven out 15 and black coal was formed.		10 then into black coal.
CLOSURE				
Conclusion	10 Thus coal is merely carbonized plant remains.			
Comment		16 Anthracite has the lowest moisture content of all types 17 but it is rarely found in Australia.		11 These two types of coal make better fuels.

Table 3.1 Schematic structure of secondary coal texts

Apart from the use of the Link in SCOAL1, variation in the schematic structure of the first two texts is confined to the iteration of the Transformation element and the different strategies used in the CLOSURE element. Although SCOAL3a omits the optional ORIENTATION and CLOSURE elements, the main distinction between the first two texts and SCOAL3a and SCOAL3b is the omission of the Trigger element in the latter texts. The consequence of this is that Agency is not specified in the realisation of the implication sequences in the subsequent Transformation element in these texts so a key aspect of what causes coal to form is not dealt with.

3.1.2 Theme and schematic structure in secondary coal texts

The Theme analysis investigated the "method of development" of the texts (Fries, 1983:135 quoted in Martin, 1992:434). The analysis followed the procedures outlined in Martin (1992:435 & 440). In this approach β clauses appearing before their α are taken as marked Themes, and Theme is not analysed in the following α. Theme is not analysed in embedded clauses, hypotactically dependent clauses, nor in branched paratactic clauses with subject ellipsis. The results are discussed for each text in turn and related to the proposed schematic structure.

The Theme analysis showing method of development and the schematic structure of SCOAL1 is indicated in Figure 3.2. Themes are shown on the left and Rhemes on the right. Marked Themes are shown in italics and clauses as marked Themes in bold italics.

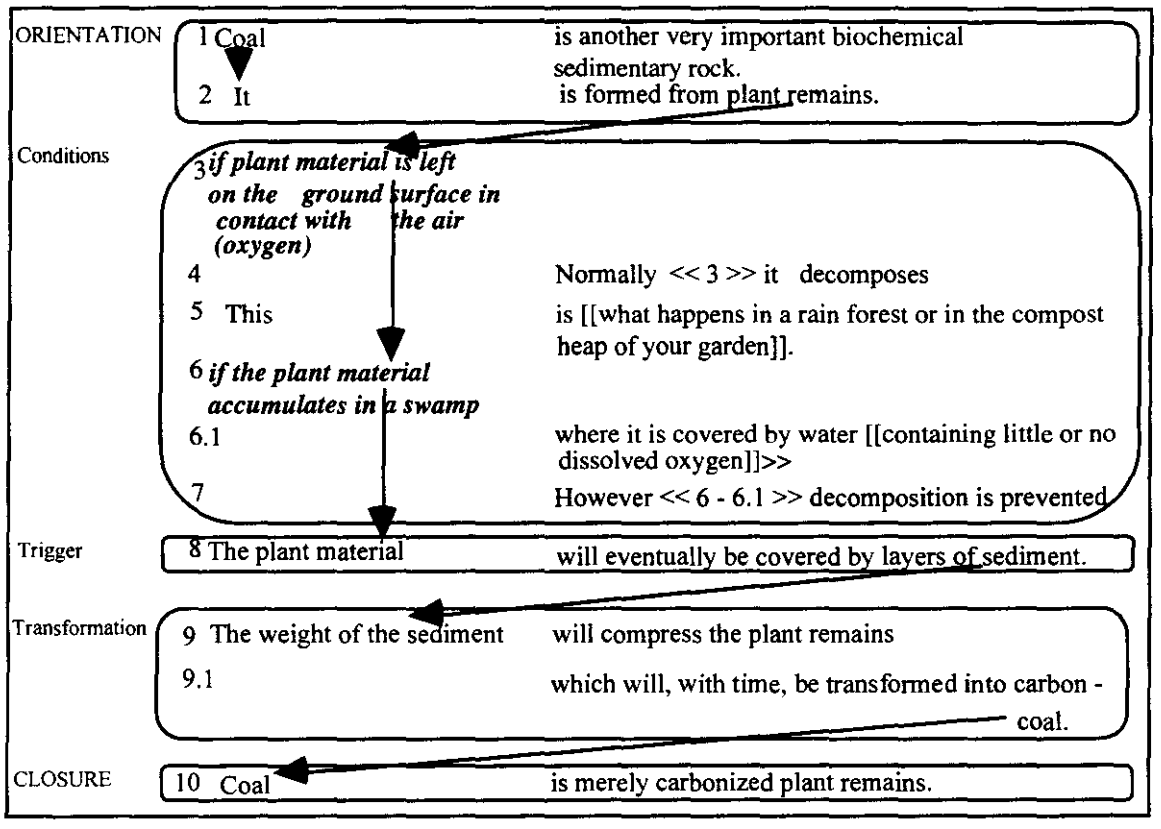


Figure 3.2 Theme and schematic structure in SCOAL1

The interaction of Theme and lexical strings is clearly related to the elements of schematic structure. Coal is Theme in the ORIENTATION and the CLOSURE, plant material is Theme in the Conditions and Trigger elements, while the weight of the sediment is Theme in the Transformation element. The Theme progression is fairly consistently from Theme → Theme within elements of schematic structure and from Rheme → Theme at the transition from one element to the next.

The ORIENTATION corresponds to the Hyper-Theme, predicting the subsequent choices of Topical Theme as indicated in Figure 3.3

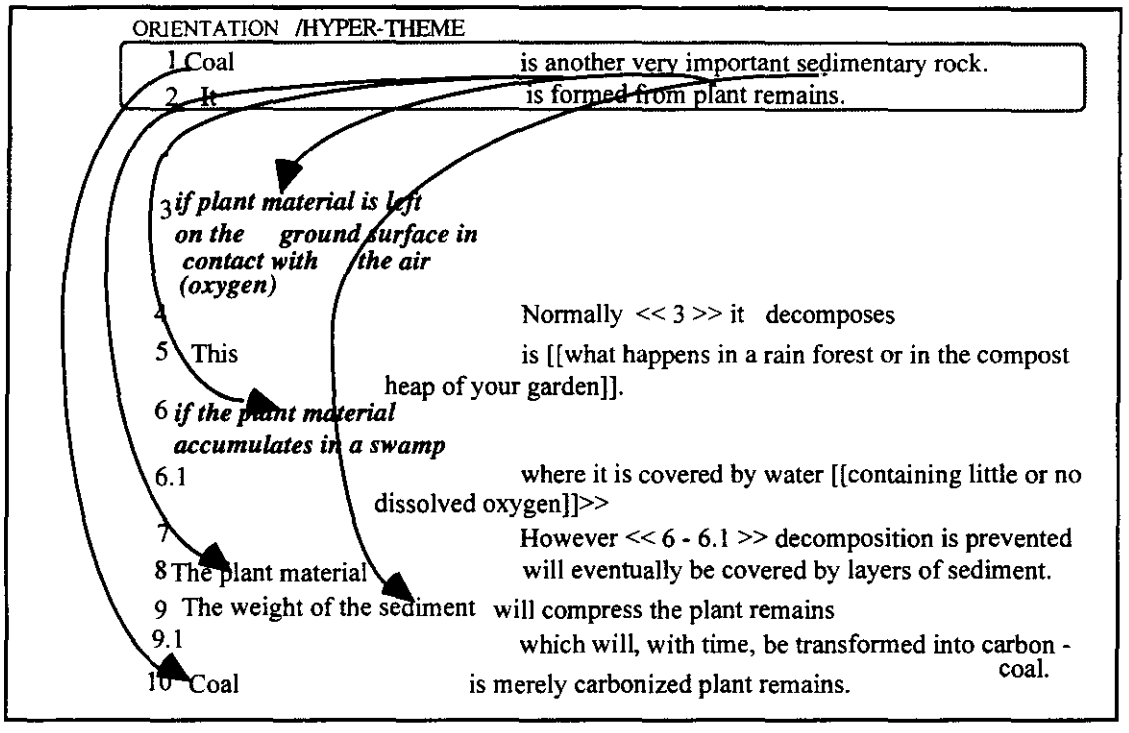


Figure 3.3 Hyper-theme in SCOAL1

The processes of coal formation introduced through the News are not clearly accumulated in a Hyper-New, although the summarise strategy in the CLOSURE in clause ten does suggest something of the function of a Hyper-New, at least compacting the most recently updated New from clause nine.

The interaction of the pattern of Theme selection and schematic structure in SCOAL2 is quite different. Here the schematic structure is scaffolded by the selection of marked topical Themes, whereas the two enhancing β clauses as marked Themes in the previous text both occurred within the Conditions element. In SCOAL2 marked Themes introduce each element in the IMPLICATION SEQUENCES stage of the schematic structure (Conditions, Trigger and Transformation) and these are the only occurrences of marked Themes in the text. The interaction pattern is shown in Figure 3.4.

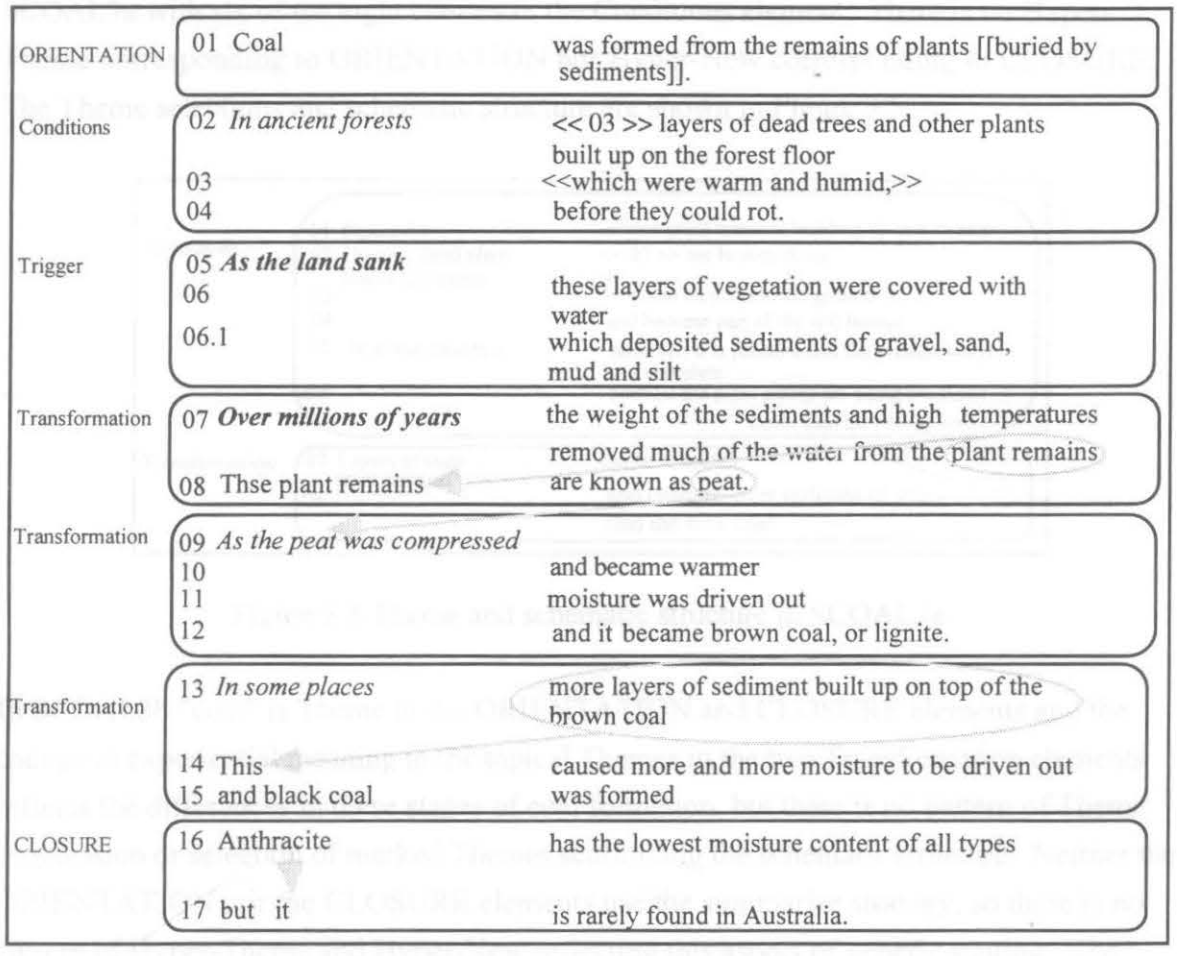


Figure 3.4 Theme and schematic structure in SCOAL2

Again "coal" is Theme in both the ORIENTATION and CLOSURE elements and the change in experiential meanings in the topical Theme with each element of schematic structure (Conditions, Trigger and the three Transformations) shows the progression in the formation of coal. However, there is only one instance of Theme → Theme progression and three Rheme → Theme progressions, two of which are within Transformation elements, so it is not the patterns of Theme progression which interact systematically with schematic structure. The first clause could be considered a Hyper-theme with "the remains of plants" predicting the topical Themes of "ancient forests" (clause 2) and "plant remains"(clause 8), perhaps "buried" predicting "As the land sank"(clause 5), and "coal" predicting "black coal" and "anthracite" in the final clauses. However, there is no accumulation of News as Hyper-New, since the CLOSURE element uses the comment rather than the summarise strategy.

While SCOAL1 and SCOAL2 showed different but systematic relationships between the pattern of Theme selection and the schematic structure, such clear relationships were not evident in SCOAL3a and SCOAL3b. Only two elements of schematic structure constitute

SCOAL3a with six of the eight clauses in the Conditions element. There is no Hyper-Theme corresponding to ORIENTATION nor Hyper-New corresponding to CLOSURE. The Theme selections and schematic structure are shown in Figure 3.5.

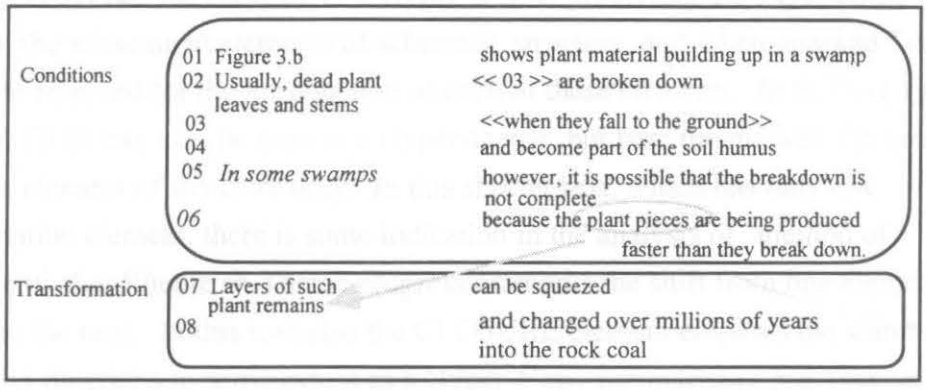


Figure 3.5 Theme and schematic structure in SCOAL3a

In SCOAL3b "coal" is Theme in the ORIENTATION and CLOSURE elements and the change in experiential meaning in the topical Themes in the two Transformation elements reflects the differences in these stages of coal formation, but there is no pattern of Theme progression or selection of marked Themes scaffolding the schematic structure. Neither the ORIENTATION nor the CLOSURE elements use the summarise strategy, so there is no pattern of Hyper-Theme and Hyper-New reflecting this aspect of generic staging. The Theme and schematic structure of SCOAL3b is shown in Figure 3.6.

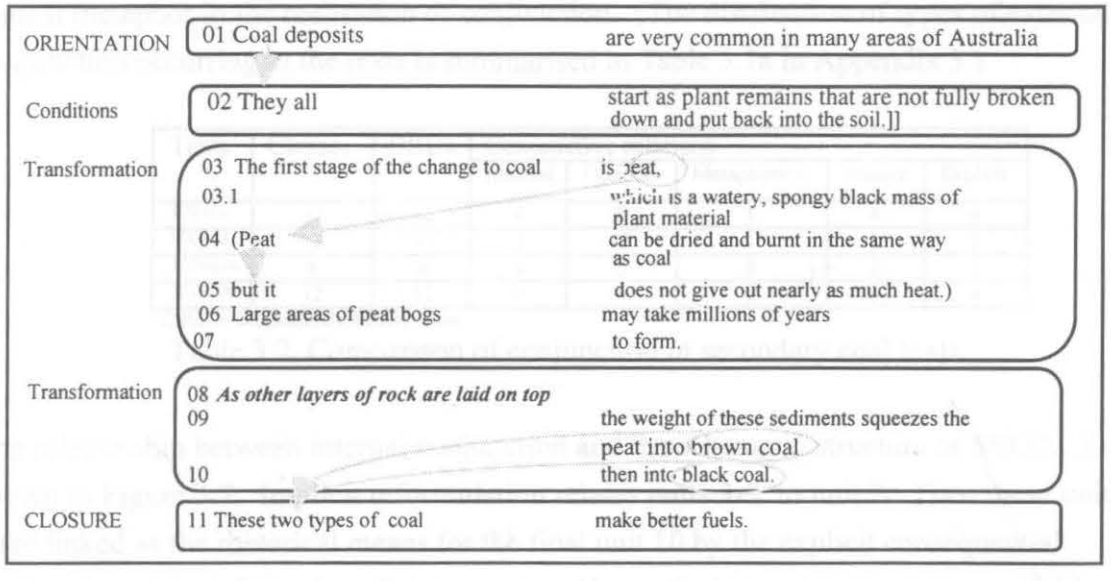


Figure 3.6 Theme and schematic structure in SCOAL3b

On the whole then, SCOAL3a and SCOAL3b do not have effective patterns of Thematic choice. On the other hand SCOAL1 and SCOAL2 show different but effective patterns of Theme selection which scaffold schematic structure. This is clearer in SCOAL2, where the ORIENTATION has the function of a Hyper-theme, predicting the experiential content of Themes in the subsequent elements of schematic structure, and where marked Topical Themes are reserved for the introduction of each of these elements. In SCOAL1 the ORIENTATION can also be seen as a Hyper-theme, but here the marked Themes occur within one element of structure only. In this shorter text, which has only one Transformation element, there is some indication in the analysis of "method of development" that Rheme → Theme progression marks the shift from one element of structure to the next. In this text also the CLOSURE element employs the summarise strategy and functions to some extent as a Hyper-New, summarising previous selections of News.

3.1.3 Conjunction in secondary coal texts

The conjunction analyses are shown in Figures 3.1a - 3.3a in Appendix 3. The deployment of internal and external conjunction as well as implicit, explicit and metaphorical realisations is summarised in Table 3.2. Internal relations were prominent only in SCOAL1 with only one occurrence in SCOAL2. External relations occurred more frequently in all texts and were most fully elaborated in SCOAL2 with 13 of the 17 units linked by external conjunction. Temporal relations were dominant in all texts and there was very little use of logical metaphor in the realisation of conjunction. (The distribution of types of external conjunction occurring in the texts is summarised in Table 3.1a in Appendix 3.)

Texts	Clauses	CRUs	Conjunctive relations				
			Internal	External	Metaphorical	Implicit	Explicit
SCOAL1	12	10	4	5	1	4	4
SCOAL2	18	17	1	13	1	8	5
SCOAL3a	8	8	0	6	0	3	3
SCOAL3b	12	11	0	6	0	3	4

CRUs = Conjunctively Related Units

Table 3.2 Comparison of conjunction in secondary coal texts

The relationship between internal conjunction and the schematic structure of SCOAL1 is shown in Figure 3.7. Implicit reformulation relates units 3-9 to unit 2. Then these units 3-9 are linked as the rhetorical means for the final unit 10 by the explicit consequential conjunctive adjunct "Thus", realising manner. Hence the internal conjunction scaffolds a rhetorical "sandwich structure" referred to by Martin (1993b:235) as commonly occurring in scientific explanations. The other instances of internal conjunction occur within the Conditions element of schematic structure, with exemplification linking unit 5 to units 3-4 and the explicit concessive relation linking 6-7 to 5.

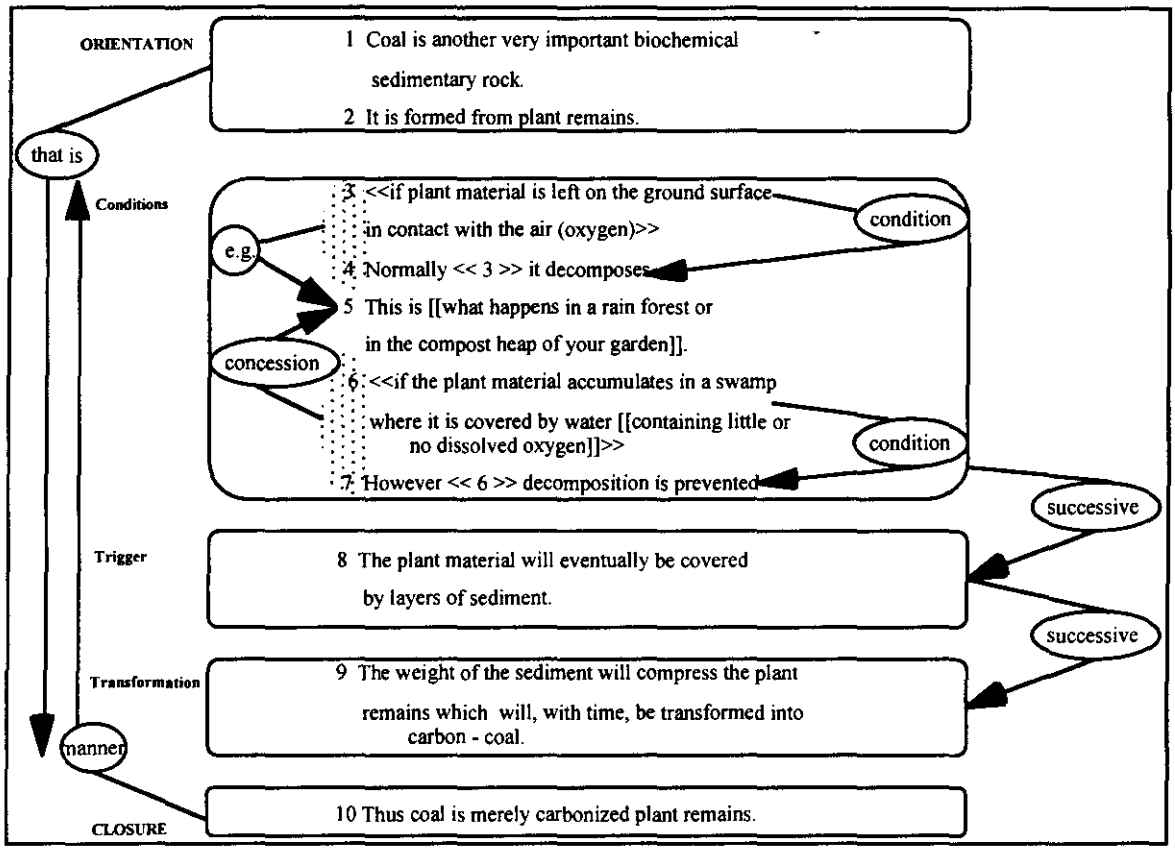


Figure 3.7 Conjunction and schematic structure in SCOAL1

It is the implicit external: temporal: successive conjunctive relations that link the elements of structure that are the "meat within the sandwich" i.e. the IMPLICATION SEQUENCES stage of coal formation - Conditions ^ Trigger ^ Transformation. Causal relations occur within these structural elements.

The relationship between conjunction and schematic structure for SCOAL2 is shown in Figure 3.8. The pattern is similar to SCOAL1 except that the CLOSURE element doesn't use the summarise strategy so there is no internal consequential relation completing the sandwich structure. Implicit external successive relations link each of the elements of the IMPLICATION SEQUENCES stage of coal formation and causal relations occur within elements of schematic structure.

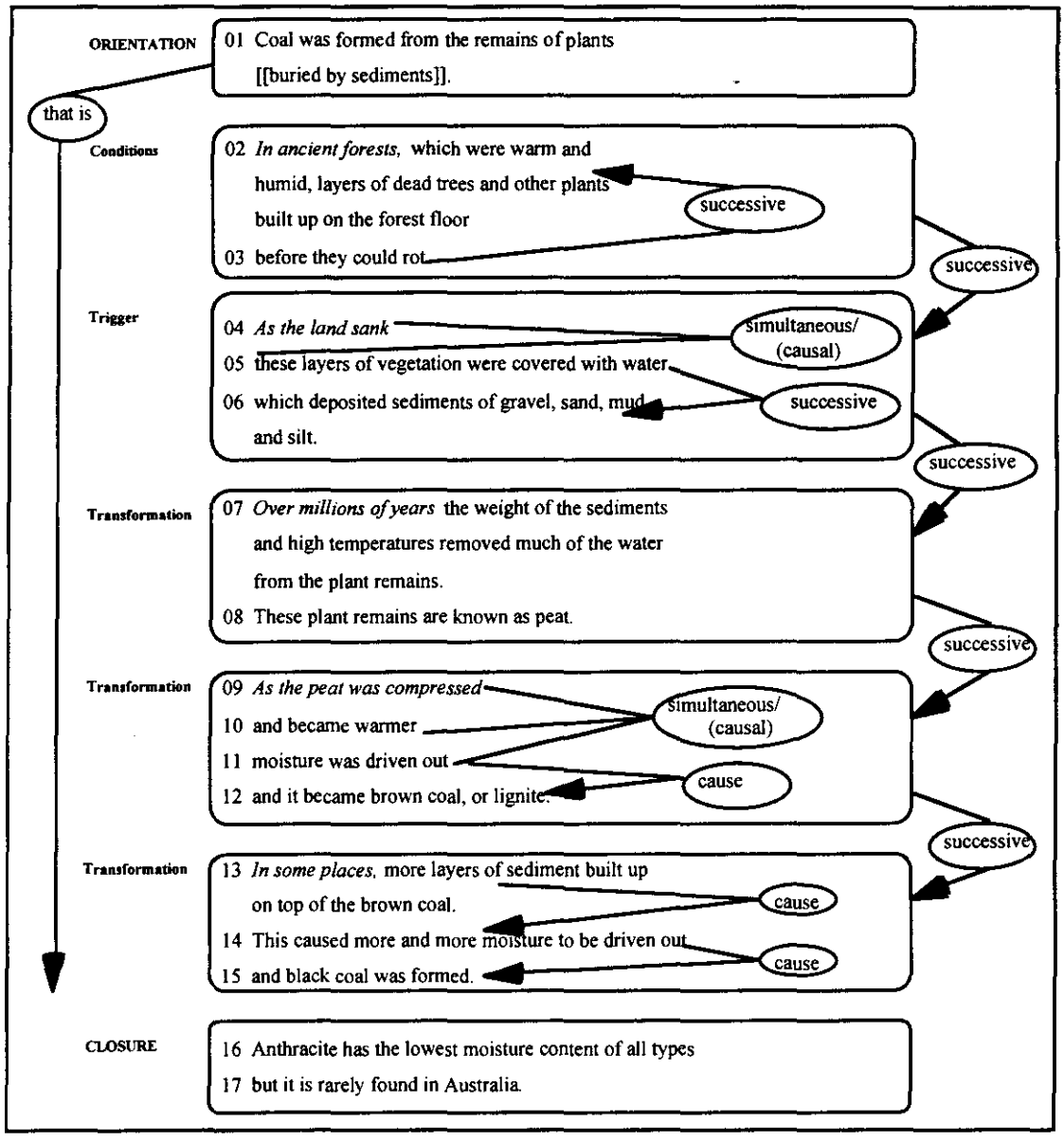


Figure 3.8 Conjunction and schematic structure in SCOAL2

The temporal: simultaneous relation realised by the initial Thematic β clauses in the Trigger and the second of the Transformation elements, also imply a causal relation. On this reading, causal relations are dominant within elements of schematic structure and are distributed in the Trigger and Transformation elements. This contrasts with SCOAL1 where the causal relations are confined to the Conditions element.

The relationship between conjunction and schematic structure for SCOAL3a and SCOAL3b is shown in Figure 3.9.

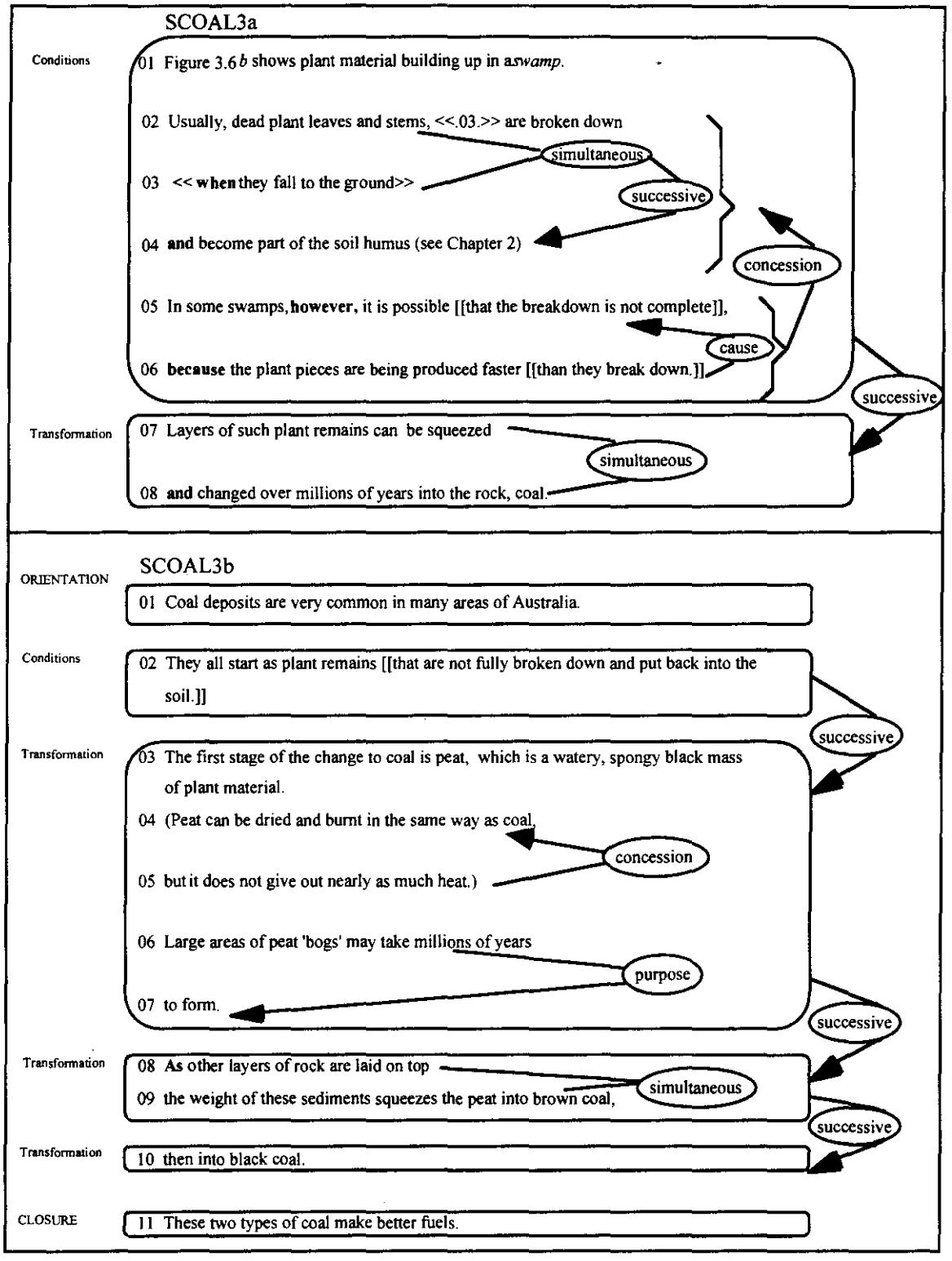


Figure 3.9 Conjunction and schematic structure in SCOAL3a and SCOAL3b

In SCOAL3a and SCOAL3b there is no internal conjunction. Again, implicit external successive relations link the Conditions and Transformation elements (the Trigger element does not occur in these texts) and causal relations occur within elements of schematic

structure. There are only two consequential relations in each text. In SCOAL 3a they occur in the Conditions element and in SCOAL3b in the first Transformation element.

The common pattern of conjunctive relations scaffolding schematic structure across the secondary texts is external temporal successive relations linking elements of schematic structure in the IMPLICATION SEQUENCES stage and, if external consequential relations are included, they occur within elements of schematic structure. Internal reformulation links the ORIENTATION element to the elements in the IMPLICATION SEQUENCES stage and if the CLOSURE element uses the summarise strategy, it is linked retrospectively to the elements in the IMPLICATION SEQUENCES stage by internal consequence:manner.

3.1.4 "Depth" of treatment and variation across texts in the selection of, and reader access to, ideational meanings.

Two aspects of variation in meaning availability were explored. The first involved the construction of semantic maps, as detailed in Chapter two (2.3.3.4), to chart the relative distribution across texts of meanings categorised as nuclear, elaborative and peripheral. The results are first discussed in relation to elements of schematic structure and then a consolidated semantic map for each text is provided to show overall variation across texts in depth of treatment from this perspective.

The second aspect of variation in meaning availability explored was the means of reader access to ideational meanings. This involved categorisation of nuclear and elaborative meanings in each element of schematic structure in each text according to the network of meaning access discussed in Chapter two (2.2.4.2).

ORIENTATION

The meanings within the ORIENTATION element are compared for SCOAL1 and SCOAL2 only, which both use the summarise strategy. There is no ORIENTATION in SCOAL3a and in this element of SCOAL3b the contextualize strategy is used:

01 Coal deposits are very common in many areas of Australia. (SCOAL3b)

The meanings here do not directly address the process of coal formation - only "deposits" is related to the process, but in a highly scriptally implicit manner and hence these meanings are regarded as "peripheral". The semantic map for the ORIENTATION element in SCOAL1 and SCOAL2 is shown in Figure 3.10.

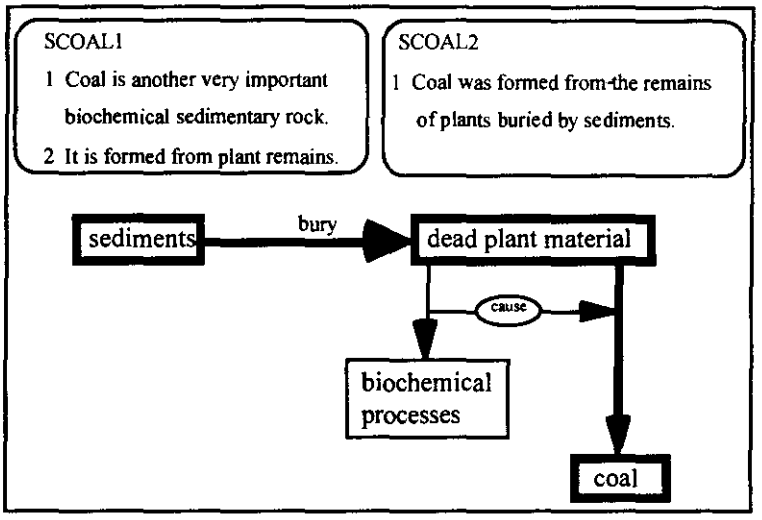


Figure 3.10 Semantic map of the ORIENTATION element of secondary coal texts

The common meanings are *sediments bury dead plant material - forms coal* and the means of reader access is indicated in Table 3.3.

	Literal								Inferential															
	Explicit				Implicit				Scriptal				Textual											
													Entailed				Retrieved							
																	Referential				Ideational			
TEXTS	1	2	3a	3b	1	2	3a	3b	1	2	3a	2b	1	2	3a	3b	1	2	3a	3b	1	2	3a	3b
ORIENTATION																								
sediments		x			x																			
bury		x							x															
dead					x	x																		
plant material	x	x																						
forms	x	x																						
coal	x	x																						

Table 3.3 Types of access to common meanings in the ORIENTATION element

All of the common meanings are literally accessible, apart from *bury* in SCOAL1, which can only be inferred from "sedimentary" if one already has knowledge of the process. The meaning *dead* is implicit in both texts. However, it is SCOAL2 in which the meanings are most directly accessible.

The only variation in meaning distribution is the elaborative meaning *biochemical processes* which partially cause the plant material to form coal. Again, these meanings are scriptally implicit. (Interpersonal meanings like "very important" are not mapped.)

Where the summarise strategy is used then, there is little variation in the elaborative meanings and some variation in the types of access to nuclear meanings.

Conditions

As a first step in exploring the variation in the meanings that define the Conditions element, the semantic maps for SCOAL1 and SCOAL2 will be compared. These are shown in Figure 3.11. The dark lines indicate the meanings included in the particular text and the faint lines indicate the remaining aggregated meanings from all of the other texts. Nuclear meanings are shown in thick lines and elaborative meanings with normal line width.

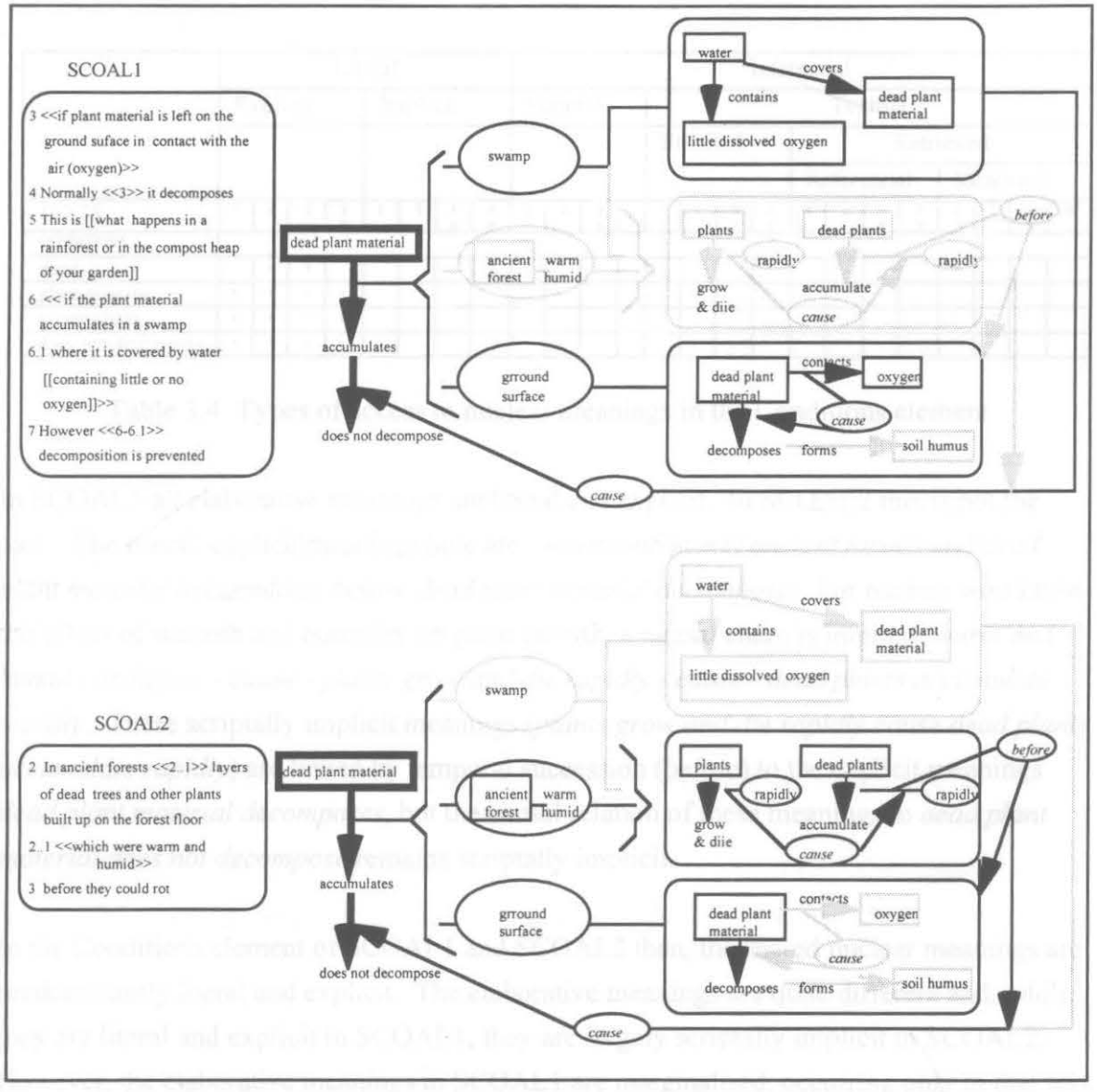


Figure 3.11 Semantic map of Conditions element in SCOAL1 and SCOAL2

The common nuclear meanings can be easily seen but the elaborative meanings in SCOAL1 and SCOAL2 show little commonality. Different causes for the prevention of decomposition of plant material are given in each text. This may be related to the different

locations of coal formation (SCOAL1 - swamp; SCOAL2 - ancient forests), but there is no acknowledgment of the alternative/complementary causes in either text.

The types of access to the nuclear meanings are summarised in Table 3.4 Meanings that are not included at all in particular texts are indicated in the table by zero. There is only one difference in reader access to nuclear meanings between SCOAL1 and SCOAL2 - the meaning *dead* is inferred ideationally from "plant remains" in the ORIENTATION element in SCOAL1.

	Literal								Inferential															
	Explicit				Implicit				Scriptal				Textual											
													Entailed				Retrieved							
																	Referential				Ideational			
TEXTS	1	2	3a	3b	1	2	3a	3b	1	2	3a		1	2	3a	3b	1	2	3a	3b	1	2	3a	3b
CONDITIONS																								
dead		x	x					x													x			
plant material	x	x	x	x																				
accumulates	x	x		0											x									
does not decompose	x	x	x	x																				

Table 3.4 Types of access to nuclear meanings in the Conditions element

In SCOAL1 all elaborative meanings are literal and explicit. In SCOAL2 this is not the case. The literal, explicit meanings here are: *warm and humid ancient forests* and *dead plant material accumulates before dead plant material decomposes*. For readers who know the effect of warmth and humidity on plant growth, a causal chain is implied: *warm and humid conditions - cause - plants grow and die rapidly - cause - dead plants accumulate rapidly*. These scriptally implicit meanings (*plants grow and die rapidly cause dead plants accumulate rapidly*) are linked by temporal succession (before) to the explicit meanings *dead plant material decomposes*, but the causal relation of these meanings to *dead plant material does not decompose* remains scriptally implicit.

In the Conditions element of SCOAL1 and SCOAL2 then, the shared nuclear meanings are predominantly literal and explicit. The elaborative meanings are quite different and, while they are literal and explicit in SCOAL1, they are largely scriptally implicit in SCOAL2. However, the elaborative meanings in SCOAL1 are marginalised, occurring only in that text, while a number of the elaborative meanings in SCOAL2 are endorsed, also occurring in SCOAL3a.

The semantic maps for SCOAL3a and SCOAL3b are shown in Figure 3.12.

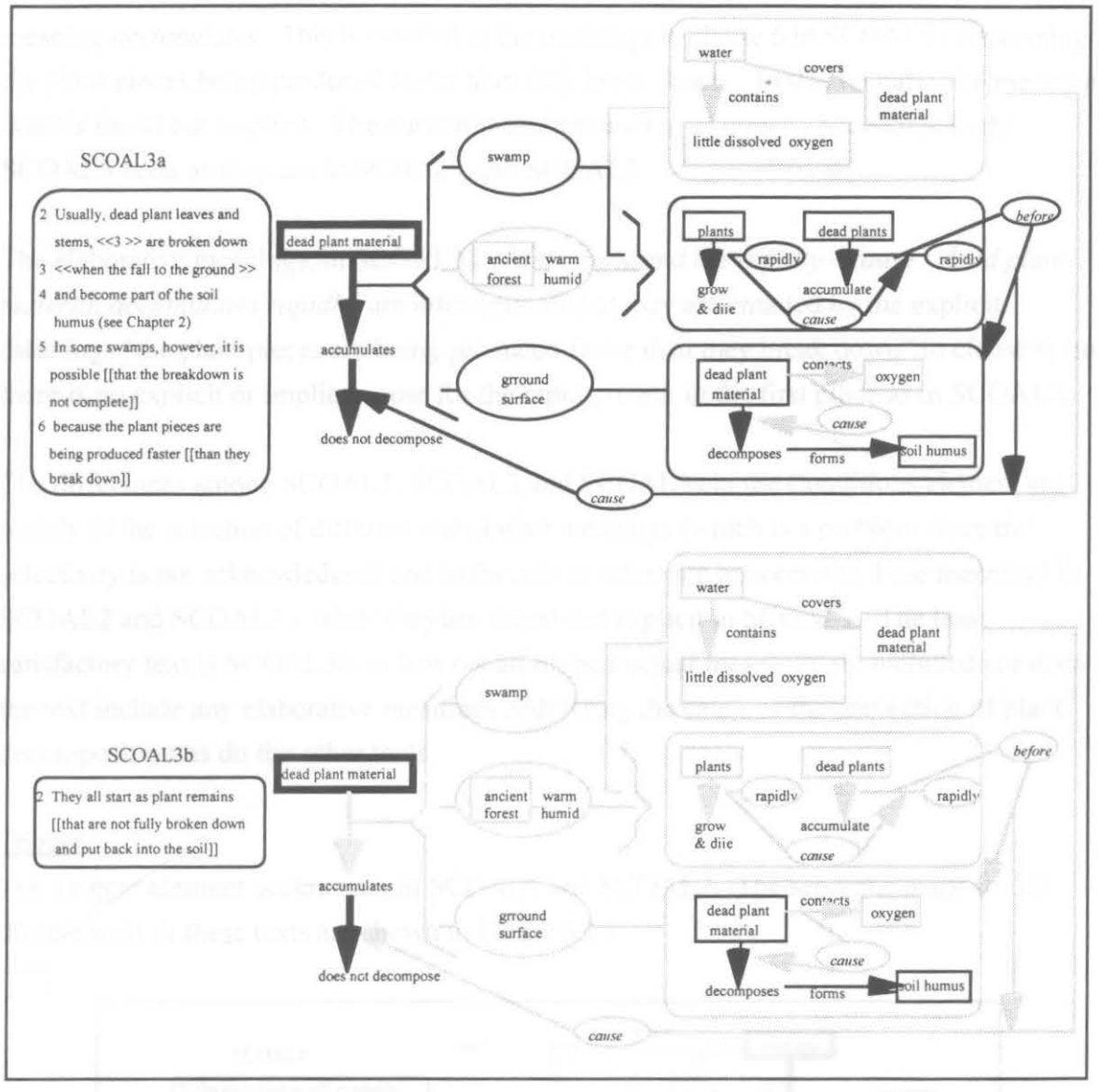


Figure 3.12 Semantic map for Conditions element of SCOAL3a and SCOAL3b

The nuclear meaning *accumulates* is not available in SCOAL3b at all. Apart from this, nuclear meanings are common across the four texts. Very few elaborative meanings occur in SCOAL3b. The elaborative meanings in SCOAL3a are similar to those in SCOAL2. This confounds the alignment suggested above between the location of the accumulation of dead plant material and the reason for its not decomposing. In SCOAL3a the location is "swamp", as in SCOAL1, but there is no mention of oxygen deprivation preventing decomposition, as in SCOAL1. Either or both suggested causes of the prevention of decomposition may be valid but again the basis of the selectivity of meanings in these texts is not acknowledged.

As shown in Table 3.4 above, the main difference with respect to reader access to nuclear meanings in SCOAL3a and SCOAL3b compared with SCOAL1 and SCOAL2, is the

meaning *accumulates*. This is entailed in the meanings in clause 6 in SCOAL3a concerning the plant pieces being produced faster than they break down. In this text also the meaning *dead* is literal but implicit. The nuclear meanings are not as directly accessible in the SCOAL3 texts as they are in SCOAL1 and SCOAL2.

The elaborative meanings, in SCOAL3a, *plants grow and die rapidly - cause - dead plant material accumulates rapidly*, are inferential in that they are entailed by the explicit meanings "the plant pieces are being produced faster than they break down" in clause 6, but there is no explicit or implied cause for the rapid growth in the first place as in SCOAL2.

The differences among SCOAL1, SCOAL2 and SCOAL3a in the Conditions element are mainly in the selection of different elaborative meanings (which is a problem since the selectivity is not acknowledged) and in the role of inference in accessing these meanings in SCOAL2 and SCOAL3a, while they are literal and explicit in SCOAL1. The least satisfactory text is SCOAL3b, in that not all of the nuclear meanings are included nor does the text include any elaborative meanings addressing the cause of the prevention of plant decomposition as do the other texts.

Trigger

The Trigger element occurs only in SCOAL1 and SCOAL2. The semantic maps for the this element of these texts are shown in Figure 3.13.

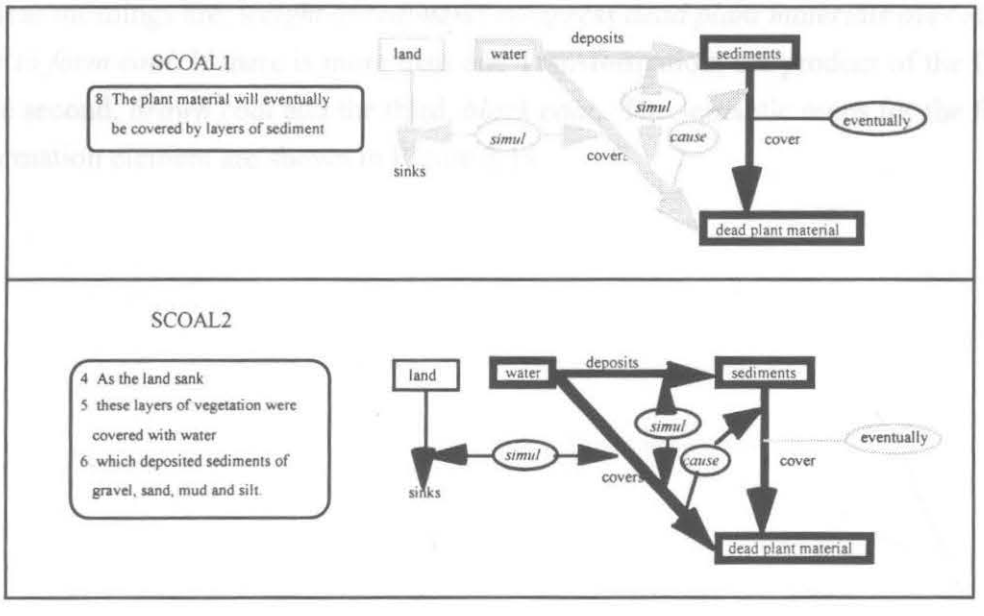


Figure 3.13 Semantic map for Trigger element in secondary coal texts

Only the "core" of the nuclear meanings, *sediments cover dead plant material*, are shared. The only elaborative meaning in SCOAL1 is a location in time - *eventually*, which does not occur in SCOAL2. The elaborative meaning in SCOAL2 is *land sinks* , which is the initiating event in the implication sequence realising the Trigger element.

The nuclear meanings *sediments* and *plant material* are literal and explicit in both texts. The meaning *cover* is explicit in SCOAL1, but inferential in SCOAL2 in that it is entailed in the meanings realised in clause 6 dealing with the water depositing sediments. It could be argued that the meanings *water deposits* are scriptally implicit in SCOAL1, since these meanings would be available to a reader who had prior knowledge of *sediments*. The meaning *dead* is inferred through the demonstrative reference to "dead trees and other plants" in the Conditions element in SCOAL2, but inferred ideationally from *plant remains* in the ORIENTATION in SCOAL1. The elaborative meanings in both texts are literal and explicit.

The main difference between the two texts is the inclusion of "core" nuclear meanings only in SCOAL1, whereas the remainder of the nuclear meanings in SCOAL2 provide the causal chain of events which result in the core meanings - *sediments cover dead plant material.*

Transformation 1

In the Transformation element the nuclear meanings are minimal and depend on whether there is one or more such elements in the text. If there is only one Transformation element, the nuclear meanings are: *weight of sediments compress dead plant materials over millions of years to form coal.* If there is more than one Transformation, the product of the first is *peat*, the second, *brown coal* and the third, *black coal.* The semantic maps for the first Transformation element are shown in Figure 3.14.

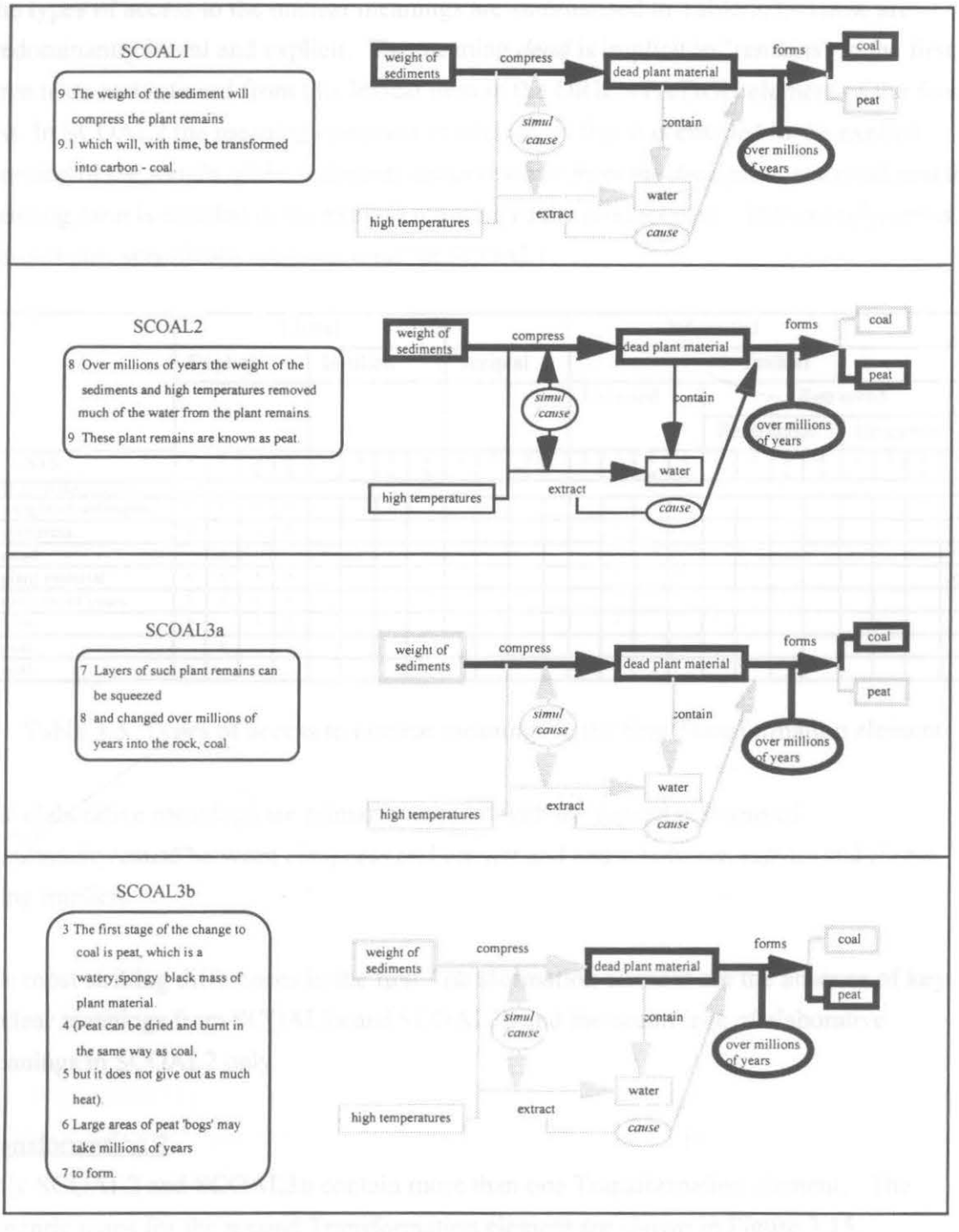


Figure 3.14 Semantic map for first Transformation element in secondary coal texts

A major difference among these texts is the absence of key nuclear meanings from SCOAL3a and SCOAL3b. The meaning *the weight of sediments* is absent from both texts and the meaning *compress* is absent from SCOAL3b. The elaborative meanings are all marginalised, occurring in SCOAL2 only. This is the only text that mentions the removal of moisture from plant remains as part of the process of coal formation.

The types of access to the nuclear meanings are summarised in Table 3.5. These are predominantly literal and explicit. The meaning *dead* is implicit in "remains" in the first three texts and inferred from this lexical item in the ORIENTATION element of the fourth text. In SCOAL2 the meaning *compress* is inferred, in that it is entailed in the explicit meaning of *the weight of the sediments extracts water from the dead plant material*, and the meaning *form* is entailed in the explicit meaning of the product *peat*. *Millions of years* is realised non-specifically as "with time" in SCOAL1.

	Literal								Inferential															
	Explicit				Implicit				Scriptal				Textual											
													Entailed				Retrieved							
																	Referential				Ideational			
TEXTS	1	2	3a	3b	1	2	3a	3b	1	2	3a		1	2	3a	3b	1	2	3a	3b	1	2	3a	3b
TRANSFORMATION 1																								
weight of sediments	x	x	0	0																				
compress	x		x	0										x										
dead					x	x	x																	x
plant material	x	x	x	x																				x
millions of years	0	x	x	x																				
form	x		x	x										x										
peat		x		x																				
coal	x		x																					

Table 3.5 Types of access to nuclear meanings in the first Transformation element

The elaborative meanings are primarily explicit with the logical relations of simultaneity/cause between *compress* and *extract* and cause between *extract* and *forms*, being implicit.

The most striking differences in the first Transformation element are the absence of key nuclear meanings from SCOAL3a and SCOAL3b and the occurrence of elaborative meanings in SCOAL2 only.

Transformation 2

Only SCOAL2 and SCOAL3b contain more than one Transformation element. The semantic maps for the second Transformation element are shown in Figure 3.15.

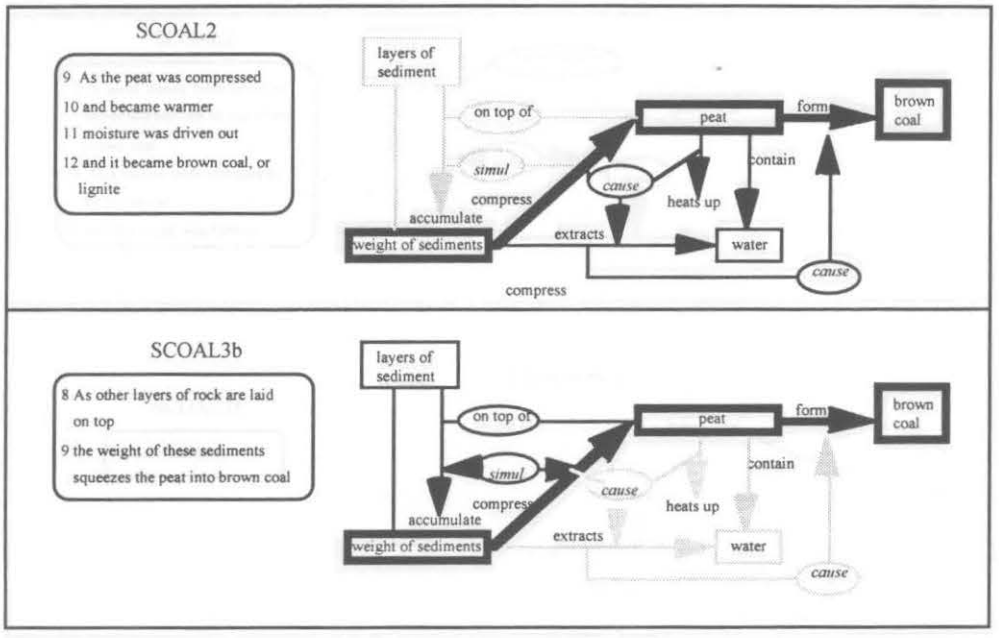


Figure 3.15 Semantic map: second Transformation element in secondary coal texts

The nuclear meanings here are common, but the selection of elaborative meanings is very different. Those in SCOAL2 indicate that it is the removal of moisture from peat that results in brown coal, but this is ignored in SCOAL3b. While the elaborative meanings in SCOAL3b indicate that additional sedimentation causes the further compression of peat to form brown coal, the omission of these from SCOAL2 suggests that it was the passage of time that resulted in the further compression of peat to form brown coal. Either or both accounts may be valid, but each occurs in only one of the sample texts. So the different elaborative meanings are marginalised and the alternative or competing version is not acknowledged in either text.

The nuclear meanings are predominantly literal and explicit. The exceptions are in SCOAL2 where *the weight of the sediments* is inferred ideationally from textual information in the first Transformation element, and the meaning *form* is literally implicit in the process "became". In both texts the elaborative meanings are literal and explicit. It is the different selection of these elaborative meanings that marks a significant difference across the texts in this element of schematic structure.

Transformation 3

The final Transformation element again occurs only in SCOAL2 and SCOAL3a. The semantic map for this element is shown in Figure 3.16.

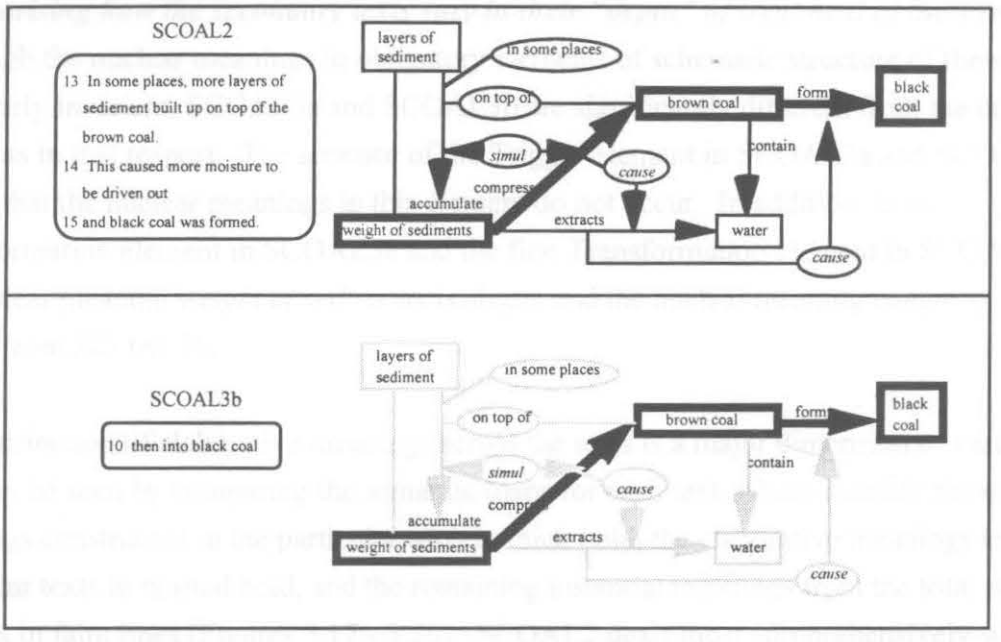


Figure 3.16 Semantic map: Third Transformation element in secondary coal texts

The obvious difference between these texts is that in SCOAL3b all nuclear meanings apart from *black coal* are inferred textually via ellipsis, while in SCOAL2 , the meaning *weight of sediment* is inferred from textual information in the first Transformation element, and the meaning *compresses* is inferred, in that it is entailed in the explicit meaning of extracting more water from the brown coal, but the remaining nuclear meanings in SCOAL2 are literal and explicit.

All of the elaborative meanings are supplied by SCOAL2 and all are literal and explicit.

CLOSURE

Semantic maps were not drawn for the CLOSURE element because the almost total lack of shared meanings in this element was very obvious. In fact the only shared meaning was *coal*. The three CLOSURE elements are indicated below:

10 Thus coal is merely carbonized plant remains. (SCOAL1)

16 Anthracite has the lowest moisture content of all types
17 but is rarely found in Australia. (SCOAL2)

11 These two types of coal make better fuels. (SCOAL3b)

Summarising how the secondary texts vary in their "depth" of treatment of the Field

Although the nuclear meanings in obligatory elements of schematic structure of these texts are largely invariant, SCOAL3a and SCOAL3b are significantly different from the other two texts in this respect. The absence of the Trigger element in SCOAL3a and SCOAL3b means that the nuclear meanings in this element do not occur. In addition, in the Transformation element in SCOAL3a and the first Transformation element in SCOAL3b, the nuclear meaning *weight of sediments* is absent and the nuclear meaning *compress* is absent from SCOAL3b.

The distribution of elaborative meanings across the texts is a major dimension of variation. This can be seen by comparing the semantic maps for each text, which indicate the nuclear meanings constructed in the particular texts in thick bold, the elaborative meanings in the particular texts in normal bold, and the remaining instantial meanings from the total range in all texts in faint lines (Figures 3.17 - 3.20). SCOAL2 deals most comprehensively with the range of nuclear and elaborative meanings evidenced in the total range of instantial meanings in the sample texts. However, a more extensive detailing of elaborative meanings in the Conditions element occurs in SCOAL1. SCOAL3a and SCOAL3b provide very few elaborative meanings. However, it is not the case that some texts simply provide more elaborative detail and others don't. Most of the elaborative meanings are marginalised, occurring in one text only. Different details occur in different texts and this selectivity is not acknowledged.

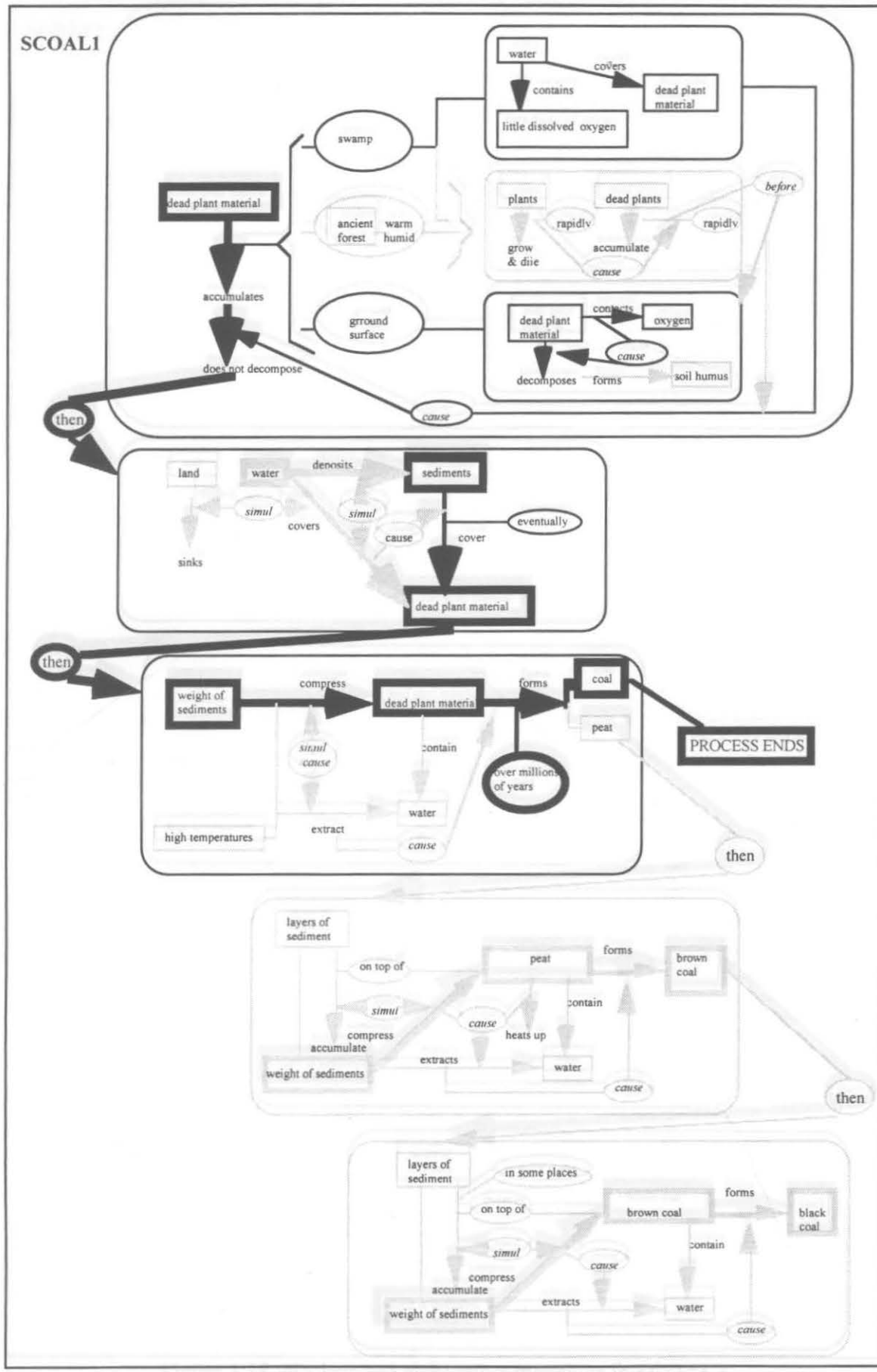


Figure 3.17 Nuclear and elaborative meanings in SCOAL1

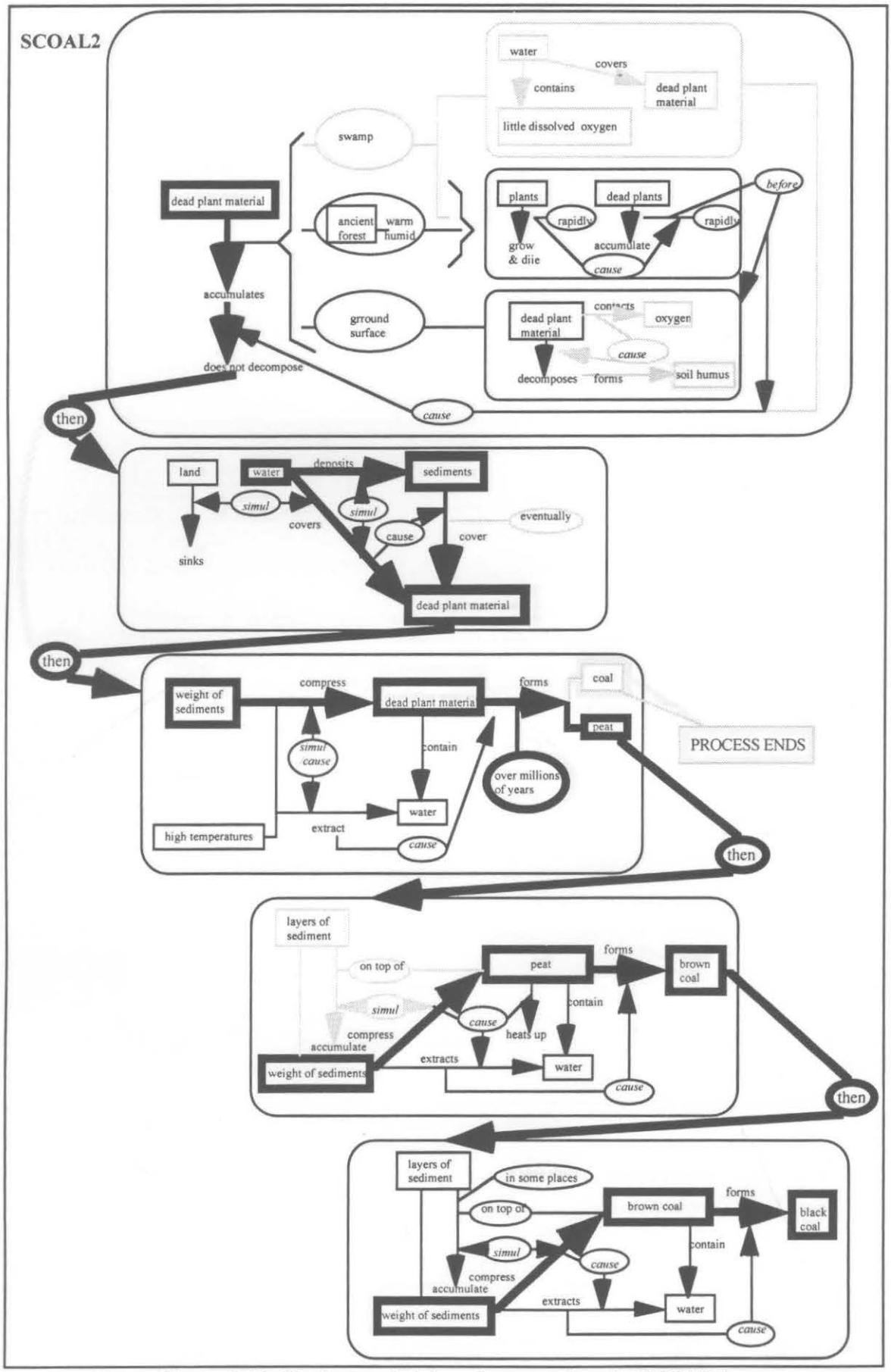


Figure 3.18 Nuclear and elaborative meanings in SCOAL2

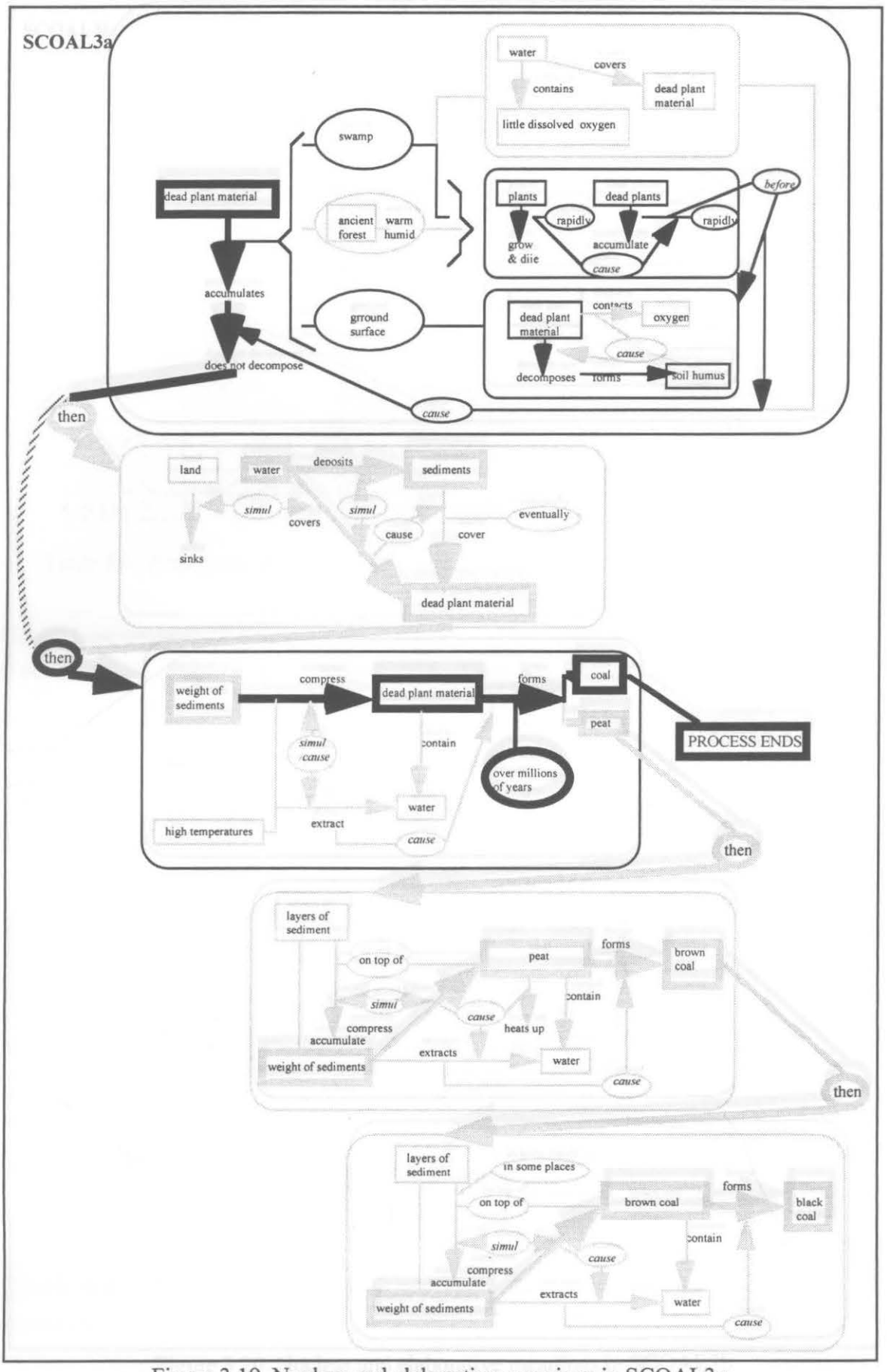


Figure 3.19 Nuclear and elaborative meanings in SCOAL3a

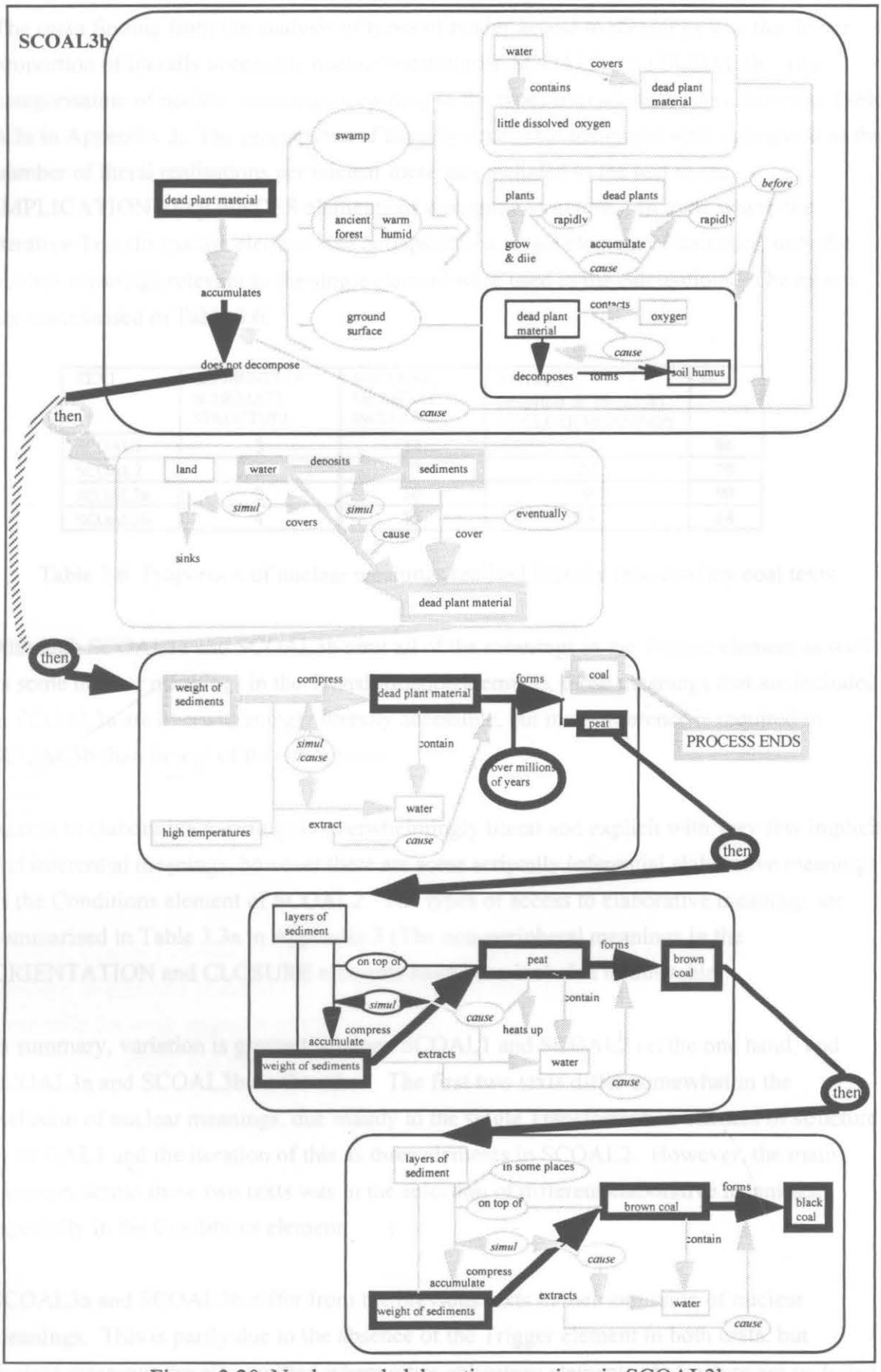


Figure 3.20 Nuclear and elaborative meanings in SCOAL3b

The main finding from the analysis of types of reader access to meanings was the lower proportion of literally accessible nuclear meanings in SCOAL3a and SCOAL3b. The categorisation of nuclear meanings according to the types of reader access is shown in Table 3.2a in Appendix 3. The proportions of literally accessible meanings were calculated as the number of literal realisations per nuclear meanings included in the text in the IMPLICATION SEQUENCES elements of schematic structure. In texts where the iterative Transformation element was collapsed as a single element of structure, only the nuclear meanings relevant to the single element were used in the calculations. The results are summarised in Table 3.6.

TEXT	ELEMENTS OF SCHEMATIC STRUCTURE	NUCLEAR MEANINGS INCLUDED	LITERAL (explicit & implicit) NUCLEAR MEANINGS	%
SCOAL1	3	14	12	**86**
SCOAL2	5	27	20	**75**
SCOAL3a	2	10	9	**90**
SCOAL3b	4	19	13	**68**

Table 3.6 Proportion of nuclear meanings realised literally in secondary coal texts

Although SCOAL3a and SCOAL3b omit all of the meanings in the Trigger element as well as some nuclear meanings in the Transformation elements, those meanings that are included in SCOAL3a are overwhelmingly literally accessible, but more inference is required in SCOAL3b than in any of the other texts.

Access to elaborative meanings is overwhelmingly literal and explicit with very few implicit and inferential meanings, however there are some scriptally inferential elaborative meanings in the Conditions element of SCOAL2. The types of access to elaborative meanings are summarised in Table 3.3a in Appendix 3 (The non-peripheral meanings in the ORIENTATION and CLOSURE elements have been included in this table).

In summary, variation is greatest between SCOAL1 and SCOAL2 on the one hand, and SCOAL3a and SCOAL3b on the other. The first two texts differ somewhat in the inclusion of nuclear meanings, due mainly to the single Transformation element of structure in SCOAL1 and the iteration of this as three elements in SCOAL2. However, the main variation across these two texts was in the selection of different elaborative meanings, especially in the Conditions element.

SCOAL3a and SCOAL3b differ from the previous texts in their omission of nuclear meanings. This is partly due to the absence of the Trigger element in both texts, but nuclear meanings are also omitted where other obligatory elements of structure are included.

This occurs to a greater extent in SCOAL3b. Also in contrast to the first two texts, SCOAL3a and SCOAL3b include very few elaborative meanings.

3.1.5 Variation in the linguistic construction of technicality in secondary coal texts

3.1.5.1 Transitivity

The transitivity analyses are shown in Figures 3.4a - 3.7a in Appendix 3. The selection of process types is summarised in Table 3.7.

TEXT	CLAUSES	Material		Relational	
		Effective	Middle	Identifying	Attributive
SCOAL1	12	6 (expl.agt. 2)	3	4	1
SCOAL2	18	10 (expl. agt. 5)	4	1	4
SCOAL3a	8	4 (expl. agt. 0)	3	1	3
SCOAL3b	12	6 (expl. agt. 2)	2	1	4

Table 3.7 Comparison of process types in secondary coal texts

In all of the texts Material processes dominate and most of these are effective. Relatively few of the effective Material clauses have an explicit Agent. "The weight of the sediments" occurs as Agent in texts SCOAL1, SCOAL2 and SCOAL3b. In addition, in SCOAL1, "layers of sediment" is agentive and in SCOAL2 "high temperatures" and "water" (twice) as well as the text reference item "This" occur as Agents. In fact SCOAL2 has the highest proportion of explicitly realised Agents in effective Material clauses. In addition, it is SCOAL2 that has the greatest range of meanings selected as Mediums (7) in effective Material clauses followed by text 3b (3), while in texts 1 and 3a all of the selections for Medium in effective Material clauses involve plant materials/remains. The latter texts deal more with the early stages of coal formation, having more elaborative meanings in the Conditions element and including only one Transformation element. On the other hand SCOAL2 and SCOAL3b include three Transformation elements. The more comprehensive and explicit realisation of the nuclear and elaborative meanings in these elements in SCOAL2 is reflected in the greater proportion of effective Material clauses with explicit agency as well as the wider range of meanings realised as Medium within them.

A comparison across texts of the lexical items realising "corresponding" processes in each text, indicates the more technical choices in texts SCOAL1 and SCOAL2 compared with SCOAL3a and SCOAL3b. This can be seen in Table 3.8.

SCOAL 1	SCOAL2	SCOAL3a	SCOAL3b
PROCESS	PROCESS	PROCESS	PROCESS
is formed	was formed was formed		
decomposes	could rot	are broken down	are broken down
		break down	
accumulates	built up	building up	
will be covered by	buried **deposited** built up		are laid
will compress	**was compressed**	can be squeezed	squeezes
will be transformed		changed	

Table 3.8 Lexical items realising "corresponding" processes across texts

Variation in the selection of participant roles associated with Material processes and their realisation at group rank indicates the greater technical orientation of SCOAL1. For example, in the Conditions element, the meaning *(dead) plant material* has the transitivity role of Medium in all texts, but there is significant variation in its realisation at the level of the nominal group:

06 <<if the plant material accumulates in a swamp>> (SCOAL1)

02 In ancient forests <<2.1>> layers of dead trees and plants built up on the forest floor (SCOAL2)

In SCOAL2 this meaning is realised as a nominal group complex in which lexical items realising concrete participants are related hyponymically ("layers of dead trees and other plants"). However, in SCOAL1 the realisation is with "plant" as Classifier and the Thing as the generalised superordinate participant "material".

Variation in the realisation of common nuclear meanings in the Trigger element reflects the assumption of prior technical knowledge in SCOAL1. In this text the nuclear meanings which occur only in SCOAL2 (shown in faint thick lines in Figure 3.21) are assumed.

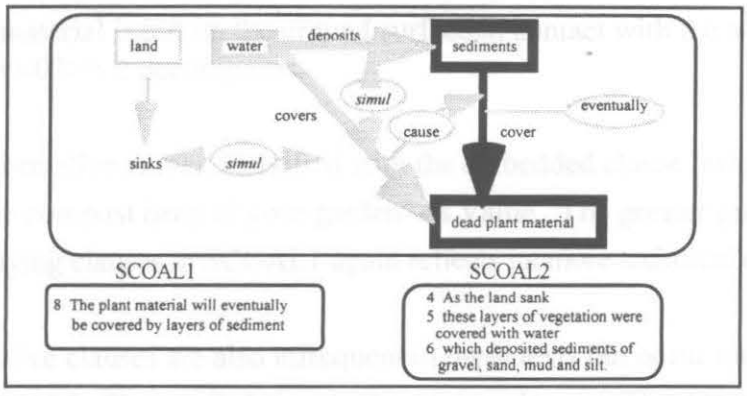


Figure 3.21 Semantic map for Trigger element in SCOAL1 and SCOAL2

This assumption is indicated by the nominal group structure realising the meaning *sediments*. In SCOAL1 the nominal group structure is Pre-numerative^Thing ("layers of sediment") whereas in SCOAL2 it is Thing^Qualifier ("sediments of gravel, sand, mud and silt"). The new technical term, "sediment", is linked to commonsense in SCOAL2 by the Qualifier listing lexical items which are hyponyms of the technical term. In SCOAL1 the technical term "sediment" is assumed by the writer to be familiar to the readers and hence it would not be considered necessary to detail how the sediments come to cover the plant material. SCOAL2 does not make this assumption and hence realises the meaning *sediment* in the role of Medium in an effective material clause with "water" as the Agent and "deposits" as the Process. However, SCOAL1 realises the meaning *sediment* as Agent with "covers" as the Process and "plant material" as Medium. While these meanings are explicitly grammaticalised in SCOAL1, they are entailed in SCOAL2 in the explicit realisation of the water covering the layers of vegetation and water depositing sediments, and can be easily inferred from this information.

Relational: identifying clauses occur very infrequently. They are used on four occasions only to define coal (twice in SCOAL1) and peat (SCOAL2; SCOAL3b) as technical terms. In SCOAL1 a further Relational: identifying clause is used to link technical meanings to commonsense. The Relational: intensive: identifying clause 5 in SCOAL1 links technical meanings (about plant material on the ground surface decomposing upon contact with oxygen) to more commonsense experience.

05 This is [[what happens in a rain forest or in the compost heap of your garden]]

Here the text reference "This" as Token, compacts the technical information in clauses three and four:

03 <<if plant material is left on the ground surface in contact with the air (oxygen)>>
04 Normally <<03>> it decomposes.

This technical information is then identified with the embedded clause "what happens in a rainforest or in the compost heap of your garden" as Value. The greater proportion of Relational: identifying clauses in SCOAL1 again reflects its more technical orientation.

Relational: attributive clauses are also infrequent in these texts but occur more frequently in SCOAL2 and SCOAL3a/3b than Relational: identifying clauses. The Attribute in intensive clauses is either a quality ("which were warm and humid") or a resultative Attribute ("it became brown coal, or lignite").

The circumstantial transitivity is summarised in Table 3.9. In all texts the greatest number of Circumstances are of location in space. Only four Circumstances deal with extent in time. Two of these are in text 1, but they don't indicate the time frame for the formation of coal as millions of years. This is clearly indicated in texts two and three. There are two Circumstances of manner: means and two of manner:quality. Of the five Circumstances of role, four are role:result (e.g. "into brown coal") and the other is role: guise ("as plant remains...."). There is little in the circumstantial transitivity that constructs these explanations as the unfolding of events over time. There are no Circumstances of causation, although those of manner:means (e.g. "from plant remains") and role:result do signify nodes in a causal chain, and one or both of these types of Circumstance occur in each text.

TEXT	LOCATION		EXTENT		MANNER			ROLE
	Time	Space	Time	Space	Means	Quality	Comp	Role
SCOAL1	0	5	2	0	1	0	0	1
SCOAL2	0	6	1	0	1	0	0	0
SCOAL3a	0	3	1	0	0	0	1	1
SCOAL3b	0	3	0	0	0	0	1	3

Table 3.9 Comparison of Circumstances in secondary coal texts

3.1.5.1.1 *Naming and defining technical terms in secondary coal texts*

The texts were analysed for the occurrence of resources for naming and defining technical terms as detailed in Chapter two (2.2.4.3). Technical terms not defined but assumed in the text were noted as a separate category. The results are shown in Table 3.10.

Category	SCOAL1	SCOAL2	SCOAL3a; SCOAL3b
GROUP RANK			
1 Nominal group parataxis	air (oxygen) carbon - coal	brown coal, or lignite	
1.1 Thing ^ Qualifier		sediments of gravel, sand, mud and silt	
2 Verbal group parataxis			
3 Embedded clauses			
CLAUSE RANK			
4 Relational intensive identifying clause	Coal is another very important biochemical sedimentary rock. Thus coal is merely carbonized plant remains.	These plant remains are known as peat.	The first stage of the change to coal is peat.(SCOAL3b)
5 Relational possessive attributive clause		Anthracite has the lowest moisture content of all types.	
CLAUSE COMPLEX			
6 Projection			
7 Paratactic elaborating clause			
DISCOURSE SEMANTICS			
8 Reference			As other layers of rock are laid on top, the weight of these sediments squeezes the brown coal ...
DISCOURSE SEMANTICS AND LEXICOGRAMMAR			
9 Reference and relational identifying clause	Normally, if plant material is left on the ground surface in contact with the air (oxygen), it decomposes. This is [[what happens in a rain forest or in the compost heap of your garden]].		
UNDEFINED TECHNICAL TERMS	biochemical sedimentary rock sediment		soil humus (see chapter 2)

Table 3.10 Defining, naming or assuming technical terms in secondary coal texts

SCOAL3a and SCOAL3b make the least use of resources for naming and defining technical terms. Although the proportionate deployment per clause is highest in SCOAL1, it has more undefined terms than SCOAL2.

3.1.5.2 Grammatical metaphor in secondary coal texts

The texts were analysed using the categories of grammatical metaphor summarised in Tables 2.12 and 2.13 in Chapter two (These analyses are shown in Tables 3.5a - 3.7a in Appendix 3). The categories of experiential grammatical metaphor and logical metaphor found in the texts are listed and illustrated in Table 3.11 and Table 3.12.

Grammatical Metaphor: Experiential				
Shift to Thing				
Cat	**Semantic Choice**	**Metaphorical Realisation Function/Class**	**Example**	**Congruent Realisation Class**
1a	material process	Thing/nominal group	It is formed from plant remains SCOAL1	verbal group
2a	quality of process	Thing/nominal group	... give out nearly as much heat SCOAL3b	adverb
Shift to Quality				
5a	material process	Epithet, Classifier/ adjective	...little or no dissolved oxygen SCOAL1	verbal group
6a	participant	Epithet, Classifier/ adjective	It is formed from plant remains SCOAL1	nominal group

Table 3.11 Categories of experiential grammatical metaphor in secondary coal texts

Grammatical Metaphor: Logical				
Cat	**Semantic Choice**	**Metaphorical Realisation Function/Class**	**Example**	**Congruent Realisation Class**
12a	logical connection	Thing/nominal group	The first stage of the change to coal is peat. SCOAL3b	conjunction
12b	logical connection	Process/ verbal group	This caused more and more moisture to be driven out SCOAL2	conjunction
12d	logical connection	Circumstance/ prepositional phrase	Peat can be dried and burnt in the same way as coal, SCOAL3b	conjunction

Table 3.12 Categories of logical metaphor in secondary coal texts

Table 3.13 compares the categories of grammatical and logical metaphor across the secondary coal texts. The final column indicates the density of metaphor per clause in each text.

Text	Clauses	Type of Metaphor								Density
		1a	1c	2a	5a	**6a**	12a	12b	12c	
SCOAL1	12	**5**	0	0	2	**3**	0	0	0	0.83
SCOAL2	18	**3**	1	0	0	**3**	0	1	0	0.44
SCOAL3a	8	**2**	0	0	0	**1**	0	0	0	0.38
SCOAL3b	12	**2**	1	1	0	**2**	1	0	1	0.67

Table 3.13 Categories of grammatical and logical metaphor in secondary coal texts.

The most frequently occurring types of metaphor are the Material Process realised as Thing (1a) and the Participant realised as Classifier (6a). It is the greater density in SCOAL1 of the first category that results in the greater density of metaphor in that text overall. The Classifier in the nominal group "plant remains" accounts for seven of the nine occurrences of the category 6a (The other two instances of Participant→Classifier are "moisture content" - SCOAL2 and "coal deposits" - SCOAL3b). The Thing in the nominal

group "plant remains" accounts for eight of the twelve occurrences of category 1a across all texts. The only other nominalisations are "contact" and "decomposition" in SCOAL1, "breakdown" in SCOAL3a and "(coal) deposits" in SCOAL3b. In the case of "decomposition" and "breakdown" the metaphorical forms occur subsequent to congruent realisations:

04 Normally, <<3>> it decomposes
...
07 However, <<6-6.1>> decomposition is prevented
(SCOAL1)

02 Usually, dead plant leaves and stems <<3>> are broken down
....
05 ....[[that the breakdown is not complete]]
(SCOAL3a)

Both of these metaphors involve the shift to Thing, but the underived verbal noun "breakdown" is closer to a commonsense orientation to Field and the nominalisation "decomposition" indicates a more technical orientation. However, as noted above (3.1.5.1) textual reference and relational transitivity are used in this text to bridge from this technicality back to commonsense.

When it is noted that two of the grammatical metaphors in SCOAL3b occur in the realisation of peripheral meanings concerned with the burning of peat (clauses 04-05) and two are logical metaphors, it can be seen that the relative density of grammatical metaphor reflects the relative technicality of the explanations.

Summarising realisational variation in the construction of technicality

There was a much greater technical orientation in SCOAL1 and SCOAL2 than in SCOAL3a and SCOAL3b. This is reflected in the incidence of technical lexis, the transitivity choices and the deployment of grammatical metaphor. SCOAL1 included more technical lexis, greater use of resources for naming and defining technical terms and a greater proportion of undefined technical terms. SCOAL2 was somewhat less technical, but while SCOAL1 focussed mainly on the Conditions element of schematic structure and collapsed the stages of coal formation into a single Transformation element, SCOAL2 dealt with the three Transformation stages in coal formation. In the realisation of the meanings in these stages SCOAL2 included technical lexis like "peat", "lignite" and "anthracite", which did not occur in SCOAL1, and SCOAL2 was also grammatically differentiated by its higher proportion of effective Material processes with explicit agency and the widest range of meanings realised as Mediums with these processes. The higher density of grammatical metaphor in SCOAL1 was also shown to reflect its relatively higher technicality.

3.1.6 The relationship between causal conjunction, "depth" of explanation and relative technicality of the texts

The notion of the "depth" of treatment of a topic in an explanation is constructed through the interaction of choices at a number of levels of semiosis. At the level of genre in these coal texts, it may be influenced by the choice of a single or iterated Transformation element. At the level of semantics it may be influenced by the extent of the inclusion of elaborated meanings to complement nuclear meanings within the various elements of schematic structure. At the level of lexicogrammar the relative "depth" may be influenced by the extent to which these meanings are realised as technical terms. The question is whether the choices that construct greater "depth" of treatment entail a greater orientation to reasoning based on causal rather than sequential relations.

At all levels SCOAL3a and SCOAL3b have been shown to deal in much less "depth" with the formation of coal than SCOAL1 and SCOAL2. The former texts omit the integral Trigger element of schematic structure entirely and also nuclear meanings from other elements of structure. They have also been shown to provide the least technical account of coal formation. It is difficult to make a general comparison of depth of treatment between SCOAL1 and SCOAL2. At the level of genre SCOAL2 includes more of the structure potential. This text also includes a more comprehensive treatment of the nuclear meanings at each stage of coal formation. However, SCOAL1 includes more elaborative meanings in the CONDITIONS element and constructs a somewhat more technical account than SCOAL2. Despite these very substantial differences across the secondary texts, there is very little difference in the proportion of consequential relations per conjunctively related unit (except marginally for SCOAL3b) as shown in Table 3.14. The most technical text, SCOAL1 has the lowest proportion of external consequential conjunctive relations and the proportion in SCOAL2 is very similar to that in SCOAL3a, which deals with the Field in much less depth on all dimensions.

TEXTS	External conjunction per Conjunctively related unit	
	Temporal	Consequential
SCOAL1	0.30	0.20
SCOAL2	0.53	0.24
SCOAL3a	0.50	0.25
SCOAL3b	0.38	0.18

Table 3.14 Technicality and external conjunctive relations in secondary coal texts

There does not seem to be any simple relationship between the relative deployment of temporal and consequential relations and the relative depth of treatment of the Field.

It has been shown that the consequential conjunctive relations occur within elements of schematic structure and do not link across them. It can also be shown that within these elements, the consequential relations occur in the realisation of elaborative meanings and in relating elaborative to nuclear meanings. For example, the two external consequential relations in SCOAL1 both occur in the Conditions element. The first links clauses realising elaborative meanings. The second involves the causal relation between the elaborative and nuclear meanings. This can be seen in Figure 3.22 showing the semantic map (nuclear meanings in thick bold lines and elaborative meanings in thin bold lines) and conjunctive relations analyses for the Conditions element of SCOAL1.

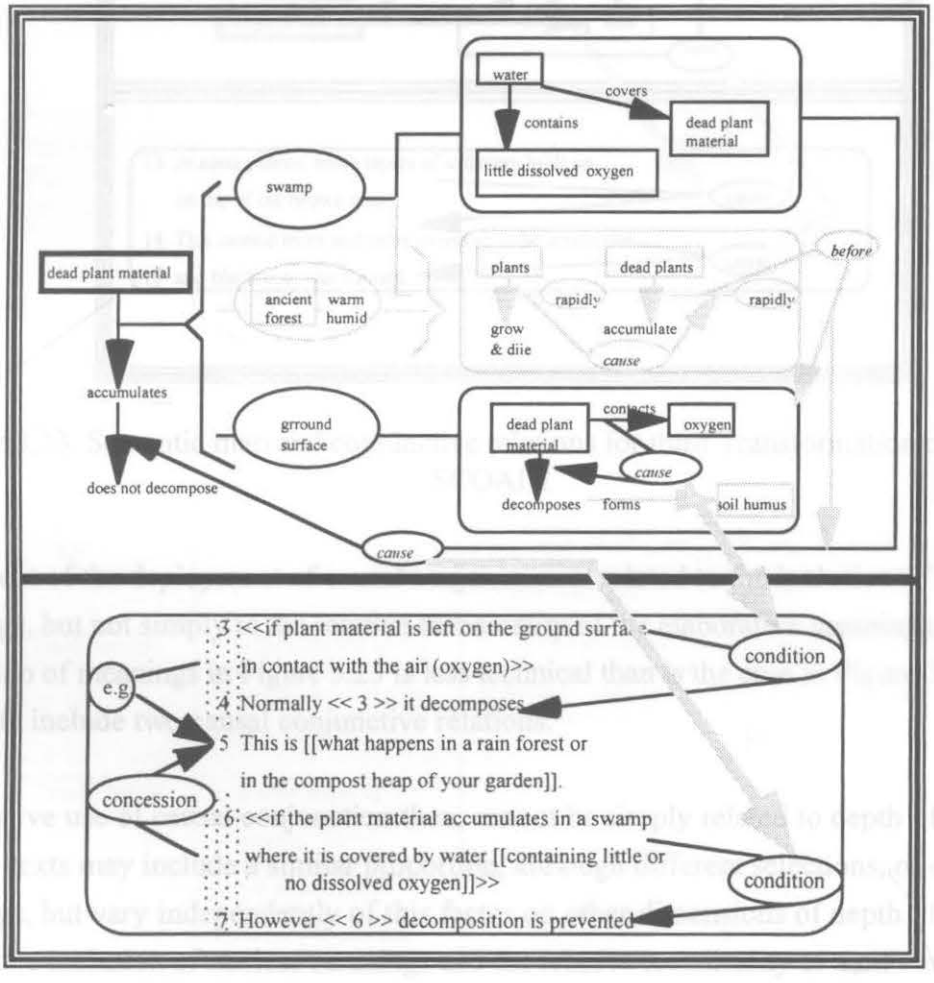


Figure 3.22 Semantic map and conjunctive relations for Conditions element in SCOAL1

The external consequential relations in these explanations of coal formation then, construct consequential relations within elaborative meanings or make causal links between elaborative and nuclear meanings within elements of schematic structure. The relative use

of causal or temporal conjunction is related to the inclusion of elaborative meanings. However different texts include elaborative meanings in some elements and not in others. For example, SCOAL1 includes extensive elaborative meanings in the Conditions element but not in the single Transformation element. On the other hand SCOAL2 does include elaborative meanings in Transformation elements and hence consequential conjunctive relations occur here. The semantic map and conjunctive relations analysis of the second Transformation element in SCOAL2 are shown in Figure 3.23.

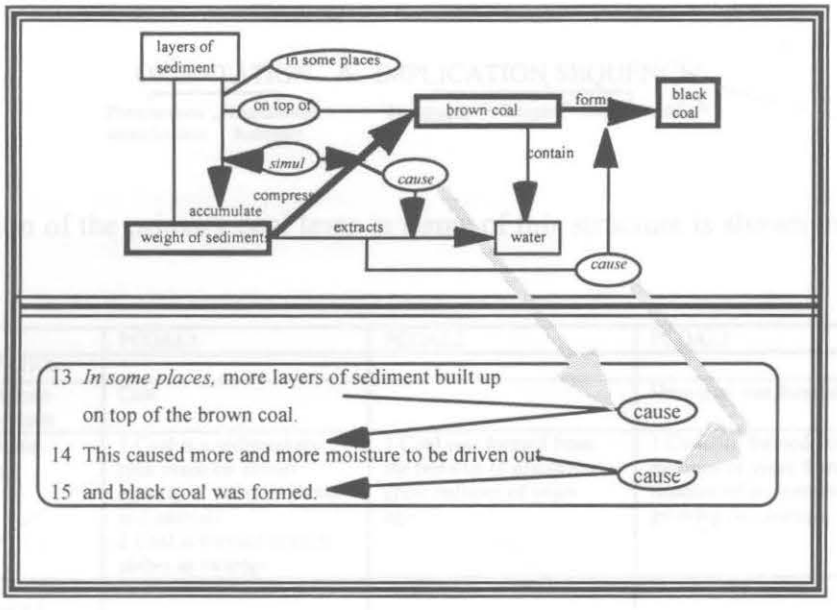


Figure 3.23 Semantic map and conjunctive relations for third Transformation element in SCOAL2

The extent of the deployment of causal conjunction is related to the inclusion of elaborative meanings, but not simply to the relative technicality of the elaborative meanings. The realisation of meanings in Figure 3.23 is less technical than is the case in Figure 3.22 and yet they both include two causal conjunctive relations.

The relative use of causal conjunction then, cannot be simply related to depth of treatment because texts may include a similar proportion, although different selections, of elaborative meanings, but vary independently of this factor on other dimensions of depth of treatment such as the inclusion of nuclear meanings and the relative technicality of their realisation.

3.2 Comparing primary and secondary coal texts

3.2.1 Schematic structure in primary and secondary coal texts

The schematic structure of the primary texts is similar to that of the secondary texts, except that none of the primary texts have a CLOSURE stage and none include the Link or Phenomenon Contextualization elements in the ORIENTATION. The proposed schematic structure is as follows:

The organisation of the primary coal texts in terms of this structure is shown in Table 3.15.

	PCOAL1	PCOAL2	PCOAL3
ORIENTATION			
Phenomenon Identification	Coal		How coal was formed
Explanation Summary	1 Coal is a sedimentary rock made up almost entirely of decayed plants and animals. 2 Coal is formed in such places as swamps	1 Coal was formed from the remains of plants that grew millions of years ago.	1 Coal has formed over millions of years from the remains of ancient forests growing on swamps.
IMPLICATION SEQUENCES			
Conditions		2 When these plants died	2 As forest trees and plants died 3 they fell into swamps 4 forming layers of dead vegetation
Trigger		3 they were buried under layers of mud and sand 4 which eventually became rocks	5 Later, sedimentary rocks formed on top of these layers.
Transformation	3 As the plant and animal matter that falls into the swamp decomposes over time 4 it is turned into peat	5 Over vast periods of time, heat and the pressure of the rocks gradually changed the plants into coal	6 The pressure caused by the rocks made the layers of vegetation denser and harder 7 and formed them into the solid rock - coal.
Transformation	5 As more layers of material are added on top of the peat 6 greater pressure is placed on the layers underneath. 7 It is this pressure that turns peat into coal.		

Table 3.15 Schematic structure of primary coal texts

The ORIENTATION includes a Phenomenon Identification, which is discrete in PCOAL1 and PCOAL3, but conflated with the Explanation Summary in PCOAL2. All three texts

employ the "summarise" strategy, providing at least a partial overview of the event sequences to be detailed subsequently. Central concepts in this summary included in all texts are the phenomenon to be explained - coal; what is to be explained about it - its formation; and the material from which it is formed - plant remains. A further meaning central to the summarise strategy is some indication of what brings about the change, i.e. sedimentation. This occurs in PCOAL1 only, and indirectly in the form of the Classifier "sedimentary".

A significant inaccuracy in the account of coal formation is introduced in the ORIENTATION element of PCOAL1. The inaccuracy is in the use of the Classifier "decayed". All of the sample secondary texts, and several others which were consulted (Messel, 1964:53-9; Heading et al, 1982:301; Chapman et al, 1984:200; Jones et al, 1991: 432), note that coal was formed from dead plant material that did ***not*** decompose before it was buried by sediments (in addition none of these sources mentions animal remains).

The Conditions element establishes the Conditions of the raw material (plant remains) necessary to the formation of the phenomenon (coal). One of the conditions, as noted above in the secondary texts, is that the plant remains are not decomposed. However, this is not included in any of the primary texts, and the inaccurate account in PCOAL1 constructs decomposition of plant and animal remains as part of the first Transformation element. In fact there is no clear Conditions stage in this text. The embedded clause as Qualifier of "plant and animal matter" in clause three in the Transformation element ("that falls into the swamp") could be construed as a condition for the decomposition (sic!) but it is not differentiated as a separate element of schematic structure. The grounds for distinguishing clause 2 in PCOAL2 as a separate Conditions stage are also minimal. In fact the plants must die before they can be buried by sediments, but the conjunctive relation of simultaneity between clauses 2 and 3 tends to reconstrue this condition as part of the event sequence in the Trigger element. Only PCOAL3 then, has a clear CONDITIONS element, establishing the accumulation of dead plants as prerequisite to coal formation:

2 As forest trees and plants died
3 they fell into swamps
4 forming layers of dead vegetation (PCOAL3).

The Trigger element introduces the event sequence which makes it possible for the raw material to be subject to processes of Transformation - the covering of plant remains with sediment. This element of schematic structure does not occur in PCOAL1.

The Transformation element is potentially iterative, dealing with the step by step conversion of the plant remains to peat, then to brown coal and then to black coal. In PCOAL1 two Transformation elements are included, the first dealing with transformation to peat and the second with the conversion of peat to coal without differentiating an intermediate transformation to brown coal. The first Transformation maintains the inaccuracy in the ORIENTATION, wrongly indicating the process of conversion to peat involving the decomposition of plant and animal remains over time. In PCOAL2 and PCOAL3 conversion processes are collapsed into a single Transformation element where plant remains are transformed into coal.

PCOAL1 is an unacceptable explanation of coal formation. It lacks both the Conditions and the Trigger elements of schematic structure and contains grossly inaccurate information in the ORIENTATION and Transformation elements. The schematic structure of PCOAL2 and PCOAL3 on the other hand is similar to that of the most effective secondary texts (SCOAL1 and SCOAL2), except that the optional CLOSURE element is not included in the primary texts.

Comparing primary and secondary texts

A comparison of the elements of schematic structure across primary and secondary texts is shown in Table 3.16. Two secondary texts and one primary text do not include obligatory elements of structure. Further unsatisfactory dimensions of these texts will be indicated in subsequent sections. SCOAL2 has the most elaborated schematic structure. PCOAL2 and PCOAL3 resemble SCOAL1 schematically, since these texts include all obligatory elements, collapsing the Transformation stage as a single element (The primary texts, as noted above, do not include the optional CLOSURE element).

ELEMENTS OF SCHEMATIC STRUCTURE		Texts						
		Secondary				Primary		
		SCOAL1	SCOAL2	SCOAL3a	SCOAL3b	PCOAL1	PCOAL2	PCOAL3
ORIENTATION	Phenomenon Id	■	■		■	■	■	■
	Phen. Context.	■			■			
	Link	■						
	Explan. Summ.	■	■			■	■	■
IMPLICATION SEQUENCES	Conditions	■	■	■	■		■	■
	Trigger	■	■				■	■
	Transformation	■	■	■	■	■	■	■
	Transformation		■		■	■		
	Transformation		■		■			
CLOSURE		■	■		■			

Table 3.16 Comparison of schematic structure in primary and secondary coal texts

3.2.2 Theme and schematic structure in primary and secondary coal texts

The primary texts were analysed in the same way as the secondary texts, again following the procedures outlined in Martin (1992: 435&440). The results of this analysis are discussed for each of the primary texts in turn. The analysis for PCOAL1 is shown in Figure 3.24. Topical Themes are shown on the left and Rhemes on the right. Marked Themes are shown in italics and clauses as marked Themes in bold italics.

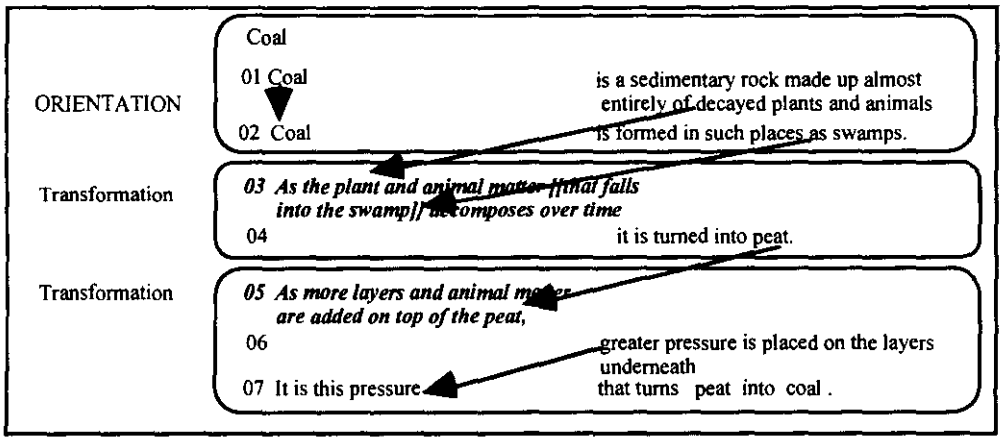


Figure 3.24 Method of development in PCOAL1

Clauses 1 and 2 are a Hyper-theme, predicting the topical thematic content of the β clauses taken as marked Themes. These thematic β clauses introduce the two main elements of schematic structure in the IMPLICATION SEQUENCES stage of the explanation sequence and in each element maintain the textual ordering of events as iconic with the ordering of events in the material world. The predicated Theme in clause seven picks up the Rheme in the previous clause. On this analysis the Theme progression seems to be mainly from Rheme → Theme.

The analysis for PCOAL2 is shown in Figure 3.25.

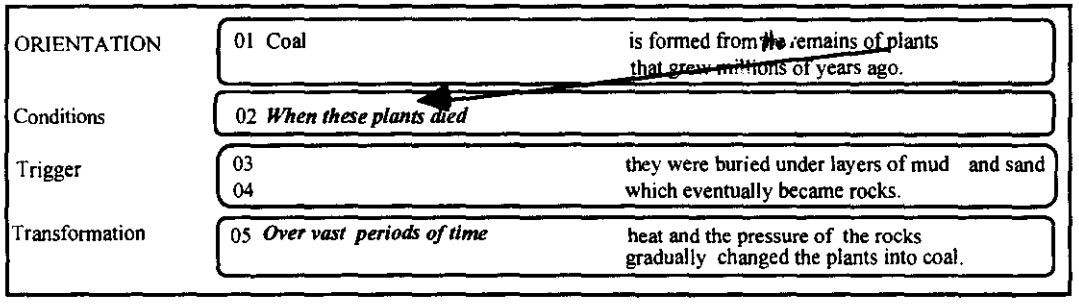


Figure 3.25 Method of development in PCOAL2

What is similar to the preceding text is that marked Themes again introduce two of the elements of schematic structure. As noted in the section on schematic structure, the evidence for distinguishing Conditions as a distinct stage in this text is not strong and the role of marked Themes in scaffolding the schematic structure, which was so clear in SCOAL2 and seems to be a feature of the primary texts, is further evidence that the Conditions and Trigger elements are conflated in PCOAL2.

The analysis for PCOAL3 (Figure 3.26) again shows that two of the elements of schematic structure are introduced by marked Themes. There is little Thematic progression, but the pattern is from Rheme → Theme and it occurs between elements of schematic structure.

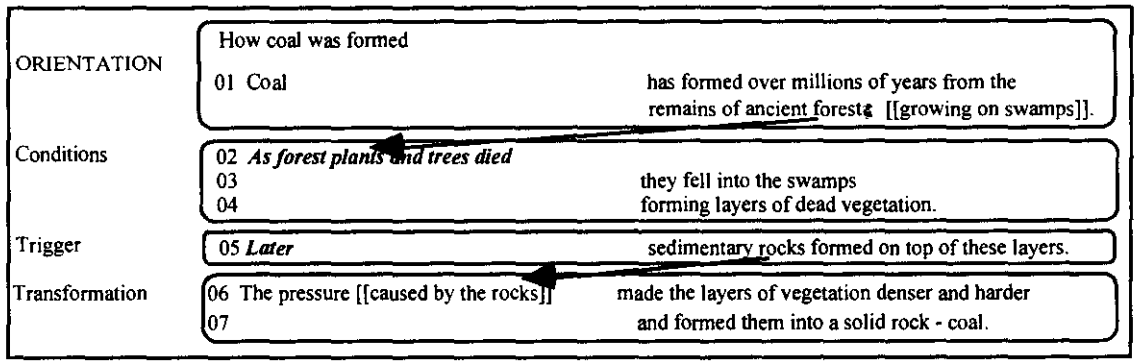


Figure 3.26 Method of development in PCOAL3

Clauses in the ORIENTATION element of both primary and secondary texts function textually as Hyper-Themes predicting subsequent Theme selection. There is a tendency for the elements of schematic structure in the IMPLICATION SEQUENCES stage of the primary texts to be introduced by marked topical Themes, as was the case in the secondary text SCOAL2. Only the secondary text SCOAL1 employed the summarise strategy in the CLOSURE element so it functioned textually as a Hyper-New accumulating, to some extent, information from previous News.

3.2.3 Conjunction and schematic structure in primary and secondary coal texts

The analyses of conjunction in the primary coal texts are shown in Figures 3.8a - 3.10a in Appendix 3. Table 3.17 summarises a comparison of conjunction in the primary and secondary coal texts. Most aspects of the use of conjunctive relations in the primary texts are very similar. However, PCOAL3 makes more use of external conjunctive relations than the other two texts, has more implicit conjunctive relations than the other texts, and is the only text to include a metaphorical realisation of conjunctive relations. The secondary texts

tend to have more external conjunction per conjunctively related unit than the primary, except for PCOAL3. SCOAL1 makes distinctively greater use of internal conjunction than any of the other texts.

Texts	Clauses	CRUs	Conjunctive relations				
			Internal	External	Metaphorical	Implicit	Explicit
PCOAL1	7	7	1	3	0	2	2
PCOAL2	5	4	1	2	0	1	2
PCOAL3	7	7	1	6	1	4	2
SCOAL1	12	10	4	5	1	4	4
SCOAL2	18	17	1	13	1	8	5
SCOAL3a	8	8	0	6	0	3	3
SCOAL3b	12	11	0	6	0	3	4

Table 3.17 Conjunction in the primary and secondary coal texts

Table 3.18 summarises a comparison of external conjunctive relations across the primary and secondary coal texts.

Texts	Clauses	CRUs	External Conjunctive relations																		total
			Temporal						Consequential												
									cause										concession		
			simultaneous			successive			consequence			contingency									
												condition			purpose						
			i	e	m	i	e	m	i	e	m	i	e	m		e	m	i	e	m	
PCOAL1	7	7		2		1															3
PCOAL2	5	4		1		1															2
PCOAL3	7	7		1		1	1		2		1										6
SCOAL1	12	10				2		1					2								5
SCOAL2	18	17	1	2		4	2		2		1								1		13
SCOAL3a	8	8	1	1		2				1									1		6
SCOAL3b	12	11		1		2	1									1			1		6

i = implicit; e = explicit; m = metaphorical

Table 3.18 External conjunctive relations in primary and secondary coal texts

Temporal conjunction dominates all texts. As noted above, more external conjunction occurs in PCOAL3 than the other primary texts and it is the only text to include consequential conjunctive relations. The other two primary texts are distinctive in that they include no consequential relations at all and this is the main difference in external conjunction between the primary and secondary texts.

The relationship between conjunction and schematic structure for the primary texts is summarised in Figure 3.27.

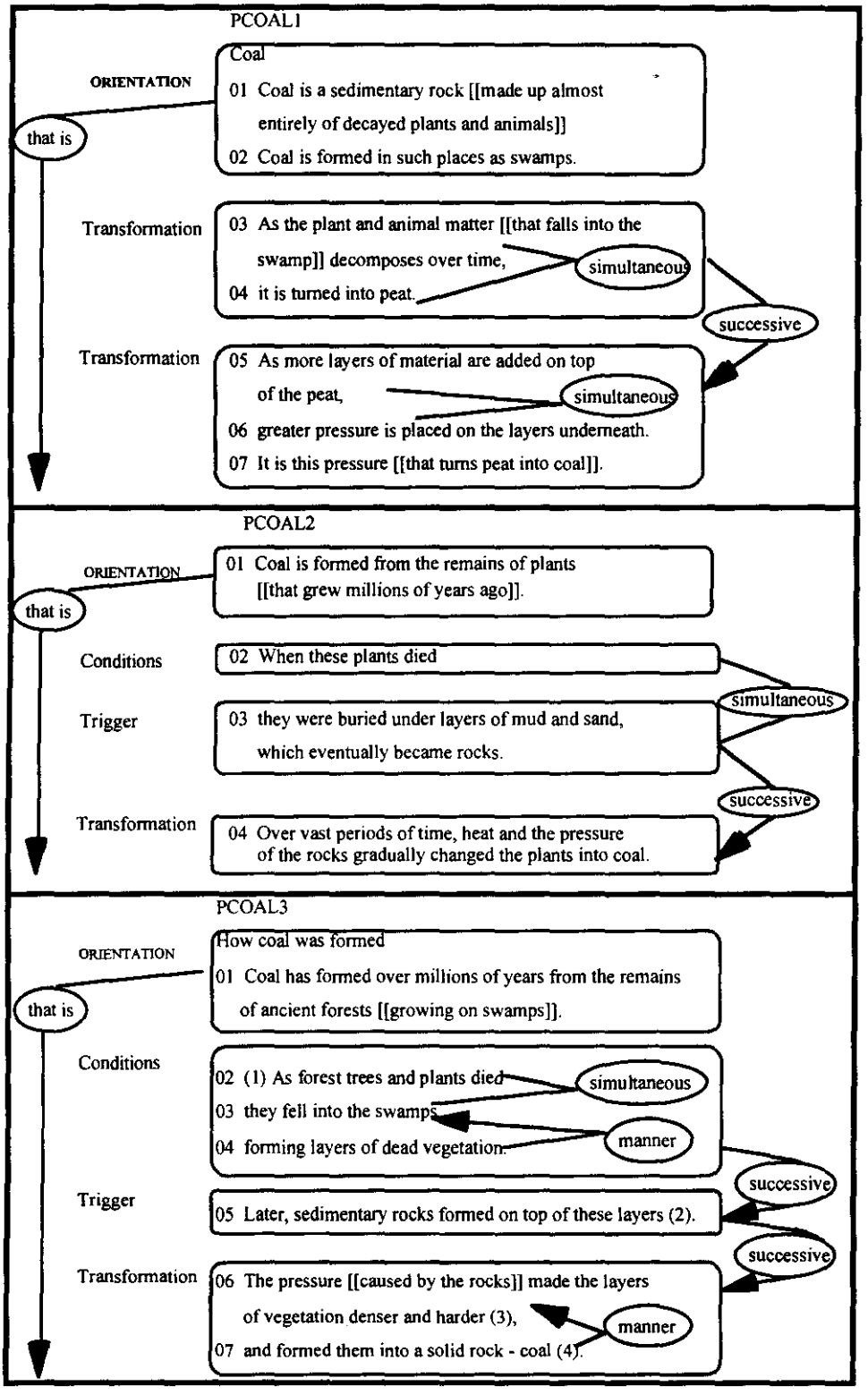


Figure 3.27 Conjunction and schematic structure in primary coal texts.

The pattern is very similar to that of the secondary texts. This can be seen in the comparison of SCOAL2 and PCOAL3 in Figure 3.28.

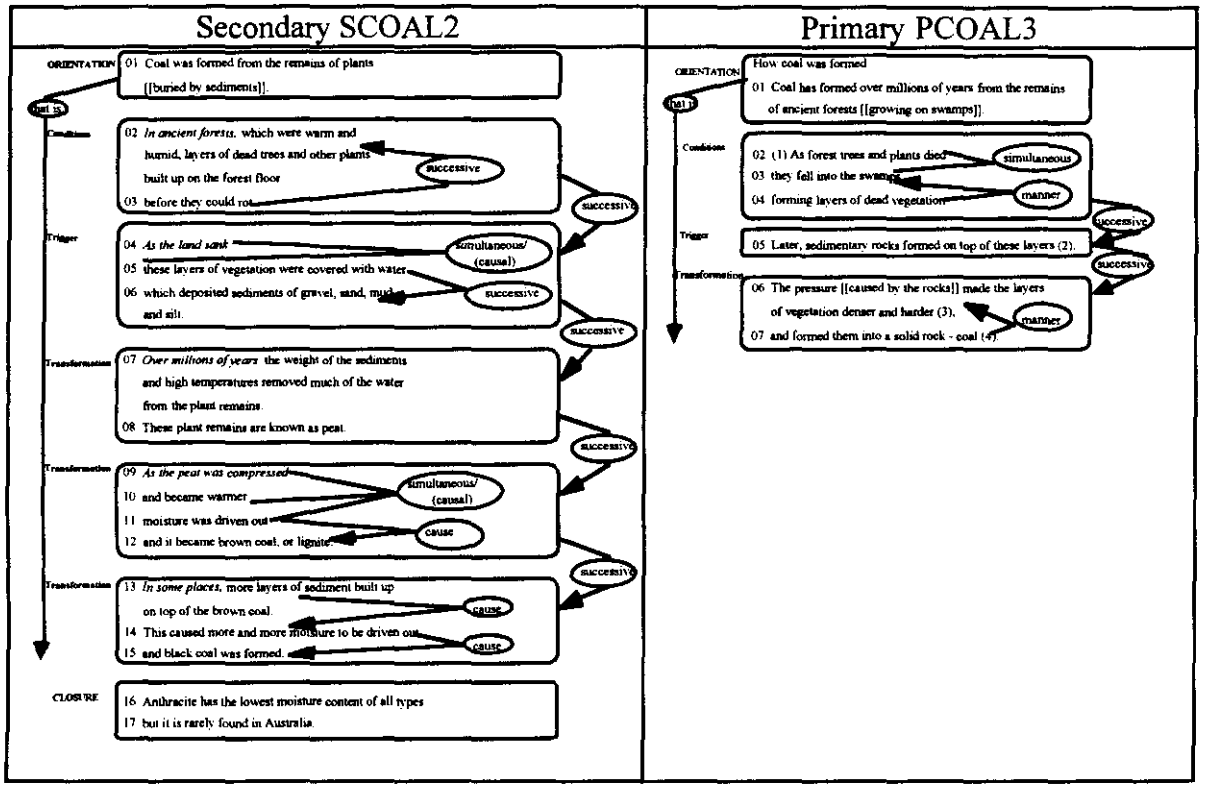


Figure 3.28 Comparison of conjunction and schematic structure for primary and secondary coal texts

The common pattern is that there is minimal scaffolding by internal conjunction; the elements of schematic structure are linked by external successive relations, and, where consequential relations are included, they occur within elements of schematic structure.

3.2.4 Relative "depth" of treatment: Variation in ideational meanings across texts within elements of schematic structure

The ideational meanings in the elements of schematic structure of the primary texts will be compared by relating the semantic maps for each element in turn to the semantic map showing the aggregated instantial meanings of the secondary texts for that element of structure. This comparison of primary texts will also show the extent to which the nuclear and elaborative meanings in the secondary texts occur in the primary texts as well as the occurrence of additional meanings in the primary texts. The means of access to the meanings in the primary texts will be categorised as literal or inferential and then sub-categorised in the same manner as those of the secondary texts, according to the system described in Chapter two (Figure 2.8 in section 2.2.4.2). A summary of the comparisons across primary texts and between the primary and secondary texts on these dimensions will then be presented.

ORIENTATION

The meanings within the ORIENTATION element of PCOAL2 and PCOAL3 will be considered first. These are shown in Figure 3.29 mapped onto the meanings in the ORIENTATION element of the secondary texts (SCOAL1 and SCOAL2) which also used the summarise strategy. The meanings common to the primary and secondary texts are shown in thick bold lines. The meanings which occur in the secondary texts only are shown in faint lines. The meanings occurring in the primary texts only are shown in normal lines. These are, in fact, common for both primary texts, except that the location *in swamps* does not occur in PCOAL2. The significant difference between the primary and secondary texts here is the absence of the meaning *sediments bury* from the primary texts.

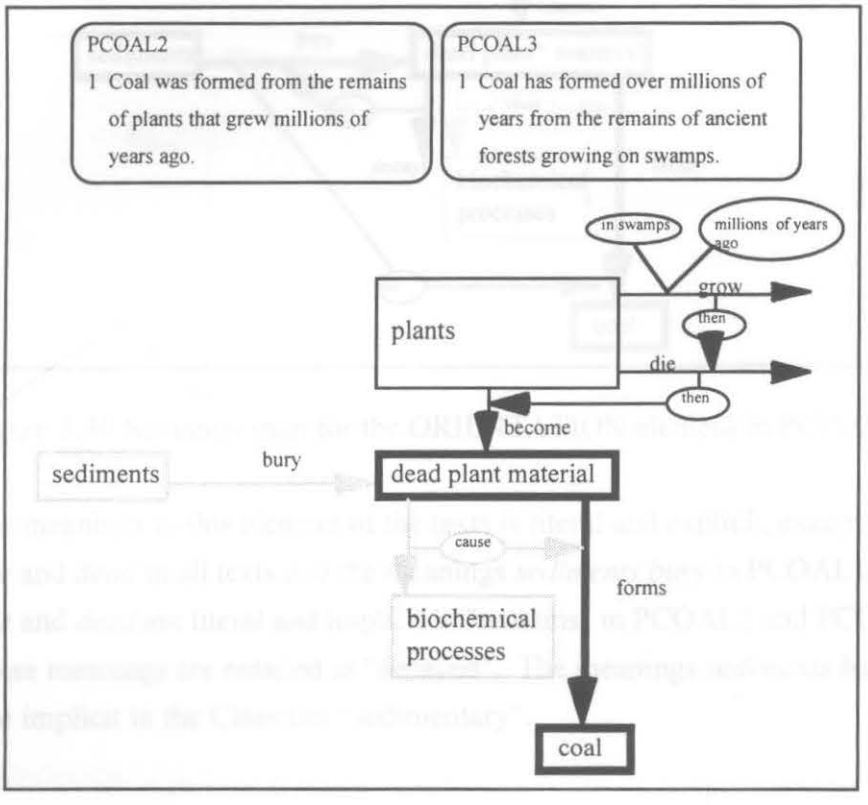


Figure 3.29 Semantic map of the ORIENTATION element of PCOAL2 and PCOAL3

Because of the inaccuracies noted previously, the meanings in the ORIENTATION element of PCOAL1 will now be considered separately. They are shown in Figure 3.30, again mapped onto the meanings in this element of the relevant secondary texts and using the same conventions as indicated above. PCOAL 1 does include the meaning *sediments bury* in common with the secondary texts and realised here as the Classifier "sedimentary". The distorting meaning is the process *decay* (and the inclusion of *animals*). PCOAL1 does not include the meaning *millions of years ago.* The other meanings are common with

PCOAL2 and PCOAL3, except that, as noted above, PCOAL2 does not include the location *in swamps*.

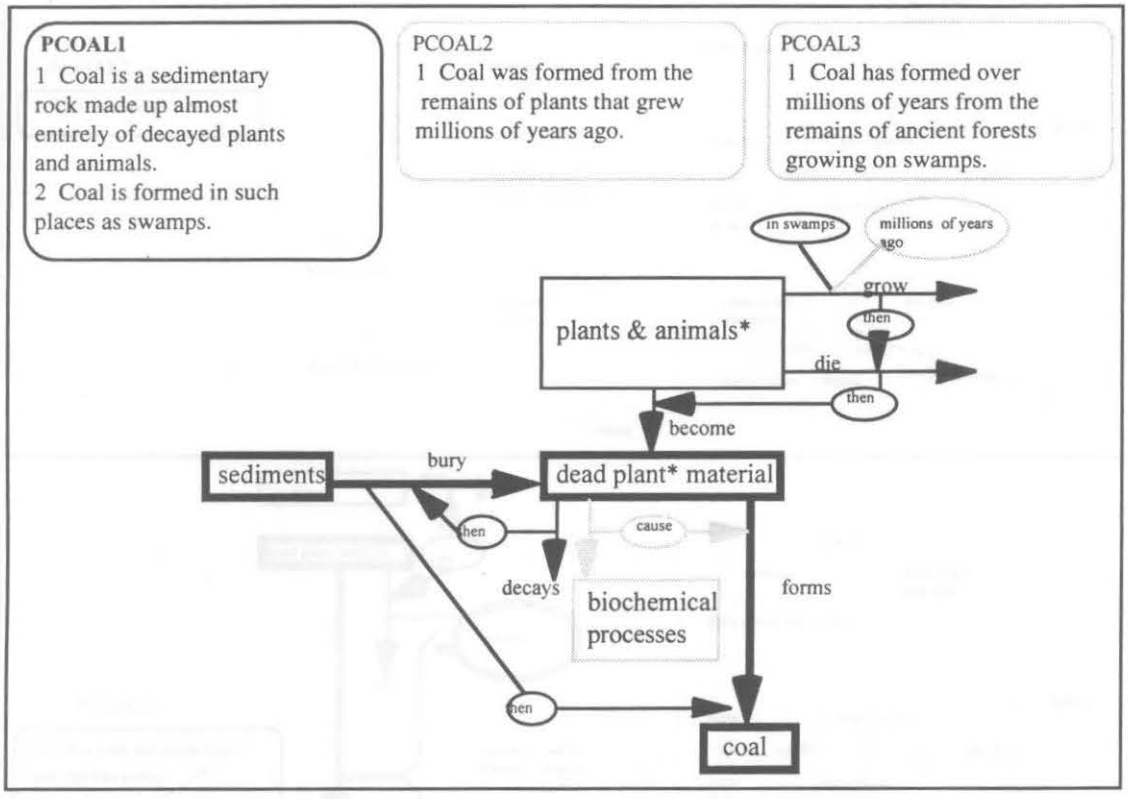


Figure 3.30 Semantic map for the ORIENTATION element in PCOAL3

Access to the meanings in this element of the texts is literal and explicit, except for the meanings *die* and *dead* in all texts and the meanings *sediments bury* in PCOAL1. The meanings *die* and *dead* are literal and implicit in "remains" in PCOAL2 and PCOAL3. In PCOAL1 these meanings are entailed in "decayed". The meanings *sediments bury* in PCOAL1 are implicit in the Classifier "sedimentary".

Conditions

The Conditions element occurs only in PCOAL2 and PCOAL3. The meanings for this element in both texts are shown in the semantic map in Figure 3.31. The meanings from the primary texts have been mapped onto the meanings from the secondary texts. Nuclear meanings are shown in thick lines. Those that occurred only in the secondary texts are shown in faint thick lines, while the nuclear meanings which also occurred in the particular primary texts represented are shown in bold thick lines. Elaborative meanings occurring only in the secondary texts are shown in faint thin lines, while those occurring in the primary texts only are shown in regular thin lines and the elaborative meanings in the primary texts which also occurred in the secondary texts are shown in double lines.

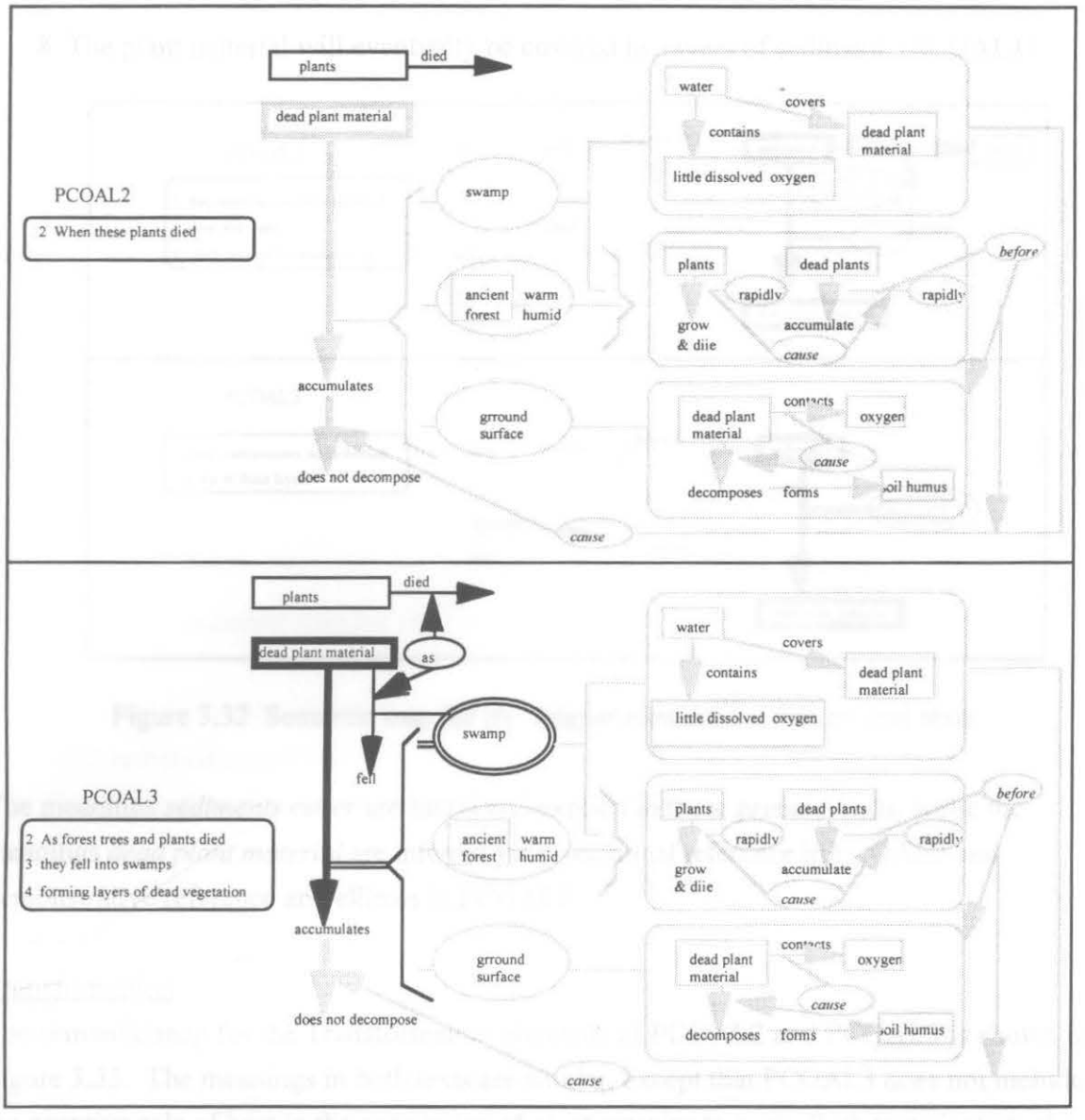


Figure 3.31 Semantic map for the Conditions element of PCOAL2 and PCOAL3

PCOAL3 includes the nuclear meanings from the secondary texts except for the meaning *does not decompose*. The only elaborative meaning shared across primary and secondary texts is the location *in swamps* in PCOAL3. Access to the meanings in this element of the above texts is literal and explicit.

Trigger

The Trigger element occurs in PCOAL2 and PCOAL3. The semantic map for this element of structure is shown in Figure 3.32. The meanings are similar in both texts and, while they do not include all of the nuclear meanings shown on the map, which were derived from the secondary texts SOCAL1 and SCOAL2, they do include the "core" nuclear meanings which occurred in SCOAL1:

8 The plant material will eventually be covered by layers of sediment. (SCOAL1)

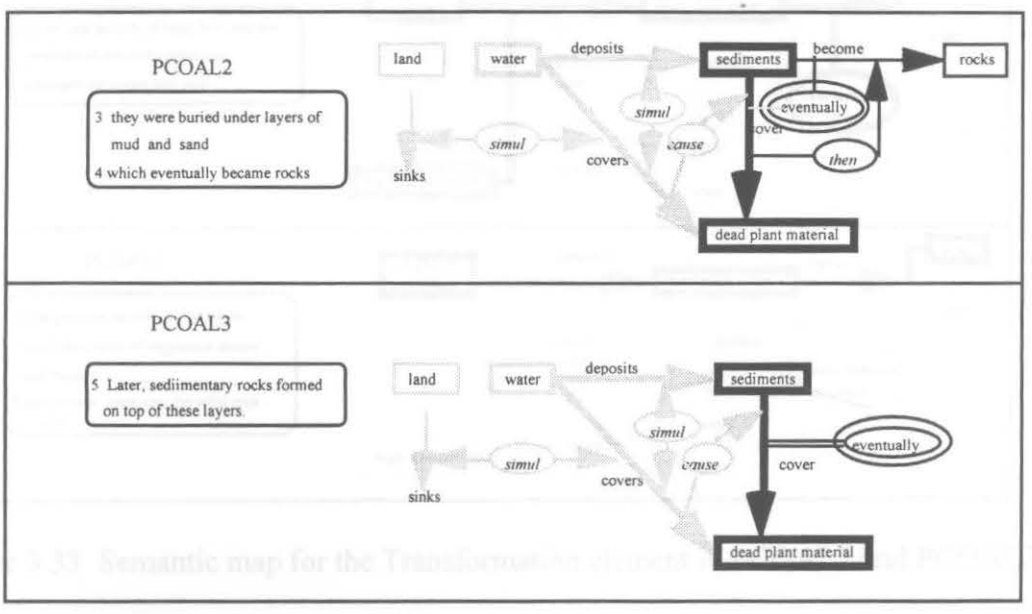


Figure 3.32 Semantic map for the Trigger element in primary coal texts

The meanings *sediments cover* are literal and explicit in these primary texts, while the meanings *dead plant material* are inferred via pronominal reference in PCOAL2 and demonstrative reference and ellipsis in PCOAL3.

Transformation

The semantic map for the Transformation elements of PCOAL2 and PCOAL3 is shown in Figure 3.33. The meanings in both texts are similar, except that PCOAL3 does not include the agentive role of heat in the conversion of plant remains to coal. Both texts include the essential nuclear meanings of the secondary texts but almost none of the elaborative meanings. However, it should be noted that, in both texts, the extent in time, *millions of years*, is explicit only in the ORIENTATION element. In PCOAL3 it would need to be inferred ideationally by the reader from the explicit mention earlier in the text. "Over vast periods of time" realises this meaning implicitly in PCOAL2.

The other meanings which are not literal and explicit correspond across both texts. The meaning *compress* is scriptally implicit. In PCOAL2 it can be inferred from the role of "pressure", made explicit in the text, if one already has knowledge of this aspect of the Field. In PCOAL3 *compress* can be similarly inferred if one has knowledge of pressure and how this can make things "denser and harder". In both texts the fact that the "plants/vegetation" referred to in this element are *dead* can be inferred from demonstrative reference to explicit realisations earlier in the text.

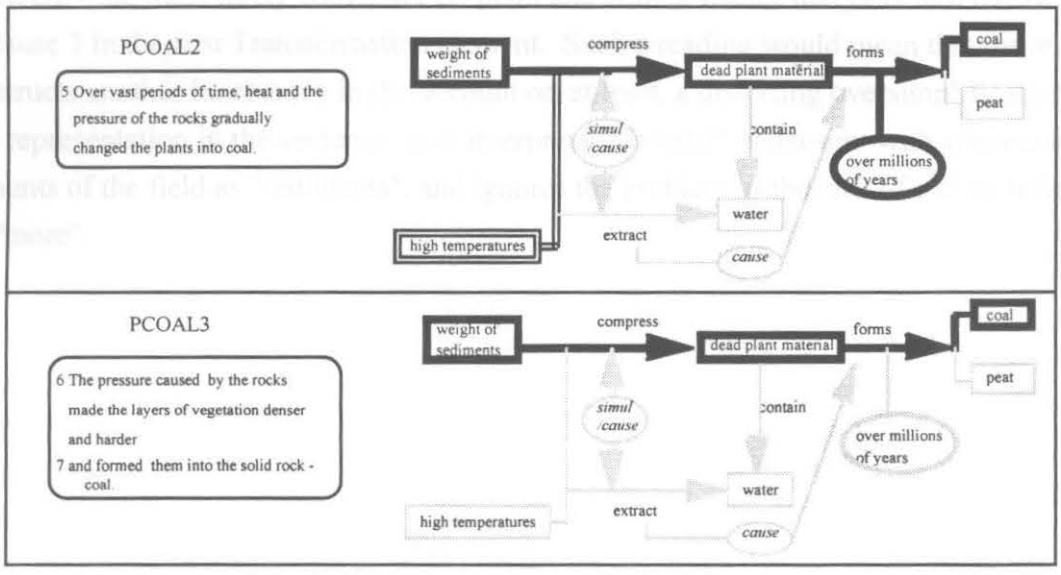


Figure 3.33 Semantic map for the Transformation element in PCOAL2 and PCOAL3

The two Transformation elements in PCOAL1 are problematic. Each will be discussed in turn. The semantic map for both is shown in Figure 3.34 below. The inaccuracies in the first Transformation element have already been discussed.

3 As the plant and animal matter that falls into the swamp decomposes over time
4 it is turned into peat. (PCOAL1)

The effect of this inaccuracy is to change the meaning of "non-decomposition" from the Conditions element into the meaning *decompose* and import this into the Transformation element. The meaning *fell into the swamp*, which is appropriate to the Conditions element as illustrated in PCOAL3 (see Figure 3.31 above), is also imported into this first Transformation element. The disruption of these semantic choices to the schematic structure can be seen in Figure 3.34.

The main problem with the second Transformation element is the interpretation of the comparative "more" and the general lexical item "material".

5 As more layers of material are added on top of the peat
6 greater pressure is placed on the layers underneath.
7 It is this pressure that turns peat into coal.

The consensual construction of the Field across the other primary and secondary texts indicates that "material" should realise the meanings *sediments of mud, sand* etc., however there are no referents like these for the comparative "more". In fact, it is difficult to locate

a referent - the most likely contender is "plant and animal matter that falls into the swamp" in clause 3 in the first Transformation element. Such a reading would mean that the text constructs another inaccuracy in the account or, at least, a distorting oversimplification. The representation in the semantic map interprets "material" consistent with consensual accounts of the field as "sediments", and ignores the problem of the lack of a clear referent for "more".

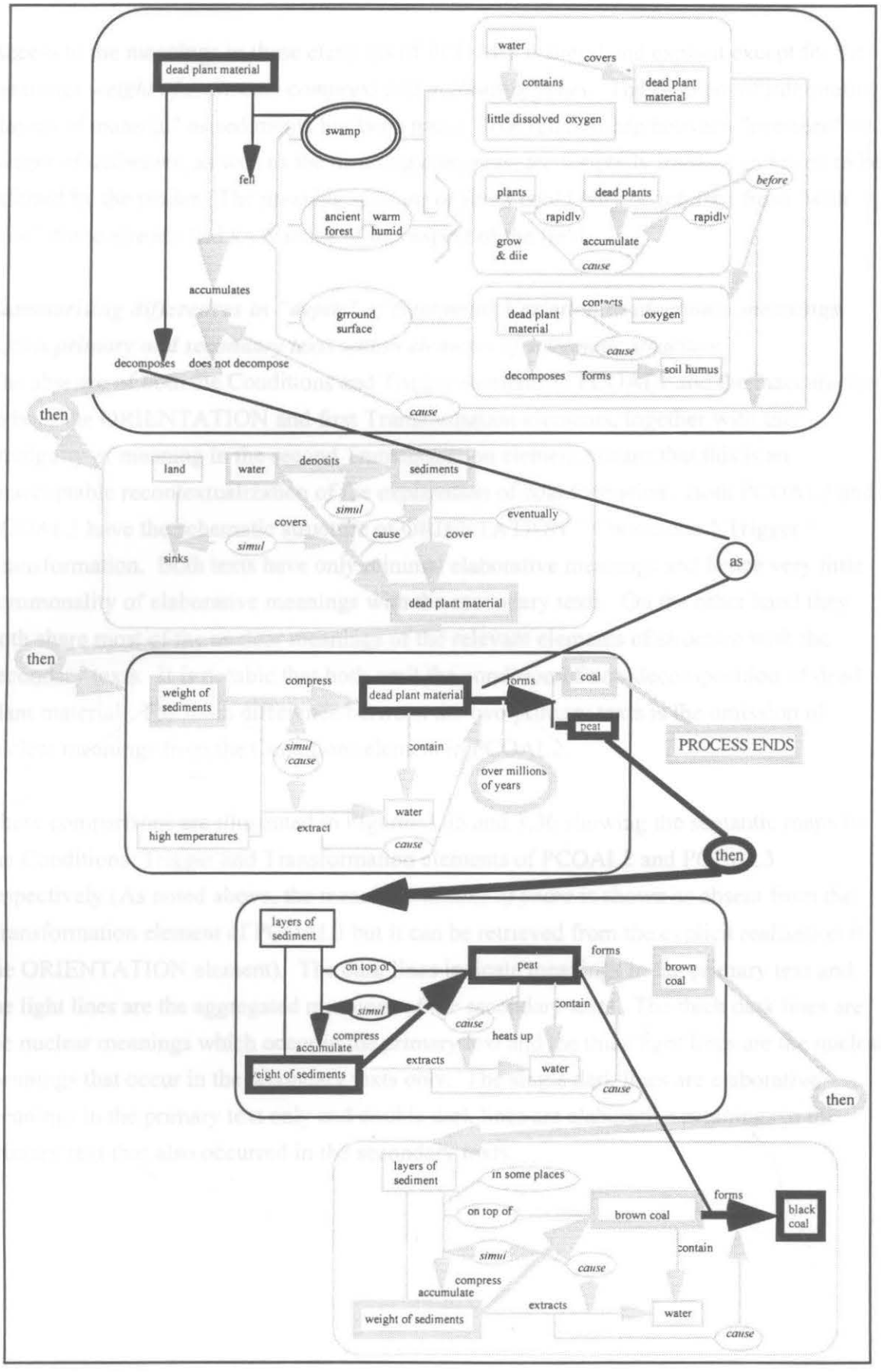


Figure 3.34 Semantic map for IMPLICATION SEQUENCES elements of PCOAL1

Access to the meanings in these elements of PCOAL1 is literal and explicit except for the meanings *weight of sediments compress* and *millions of years*. The problem of interpreting "layers of material" as sediments has been noted. The relationship between "pressure" and *weight of sediments*, as well as the meaning *compress*, are scriptally implicit and need to be inferred by the reader. The meaning *millions of years* could only be inferred from "with time" if one already had knowledge of this aspect of the field.

Summarising differences in "depth" of treatment: Variation in ideational meanings across primary and secondary texts within elements of schematic structure.

The absence of both the Conditions and Trigger elements in PCOAL1 and the inaccuracies in both the ORIENTATION and first Transformation elements, together with the ambiguity of meaning in the second Transformation element, means that this is an unacceptable recontextualization of the explanation of coal formation. Both PCOAL2 and PCOAL3 have the schematic structure of ORIENTATION ^ Conditions ^ Trigger ^ Transformation. Both texts have only minimal elaborative meanings and hence very little commonality of elaborative meanings with the secondary texts. On the other hand they both share most of the nuclear meanings of the relevant elements of structure with the secondary texts. It is notable that both omit the condition of non-decomposition of dead plant material. The main difference between the two primary texts is the omission of nuclear meanings from the Conditions element in PCOAL2.

These comparisons are illustrated in Figures 3.35 and 3.36 showing the semantic maps for the Conditions, Trigger and Transformation elements of PCOAL2 and PCOAL3 respectively (As noted above, the meaning *millions of years* is shown as absent from the Transformation element of PCOAL3 but it can be retrieved from the explicit realisation in the ORIENTATION element). The dark lines indicate meanings in the primary text and the light lines are the aggregated meanings of the secondary texts. The thick dark lines are the nuclear meanings which occur in the primary text and the thick light lines are the nuclear meanings that occur in the secondary texts only. The single dark lines are elaborative meanings in the primary text only and double dark lines are elaborative meanings in the primary text that also occurred in the secondary texts.

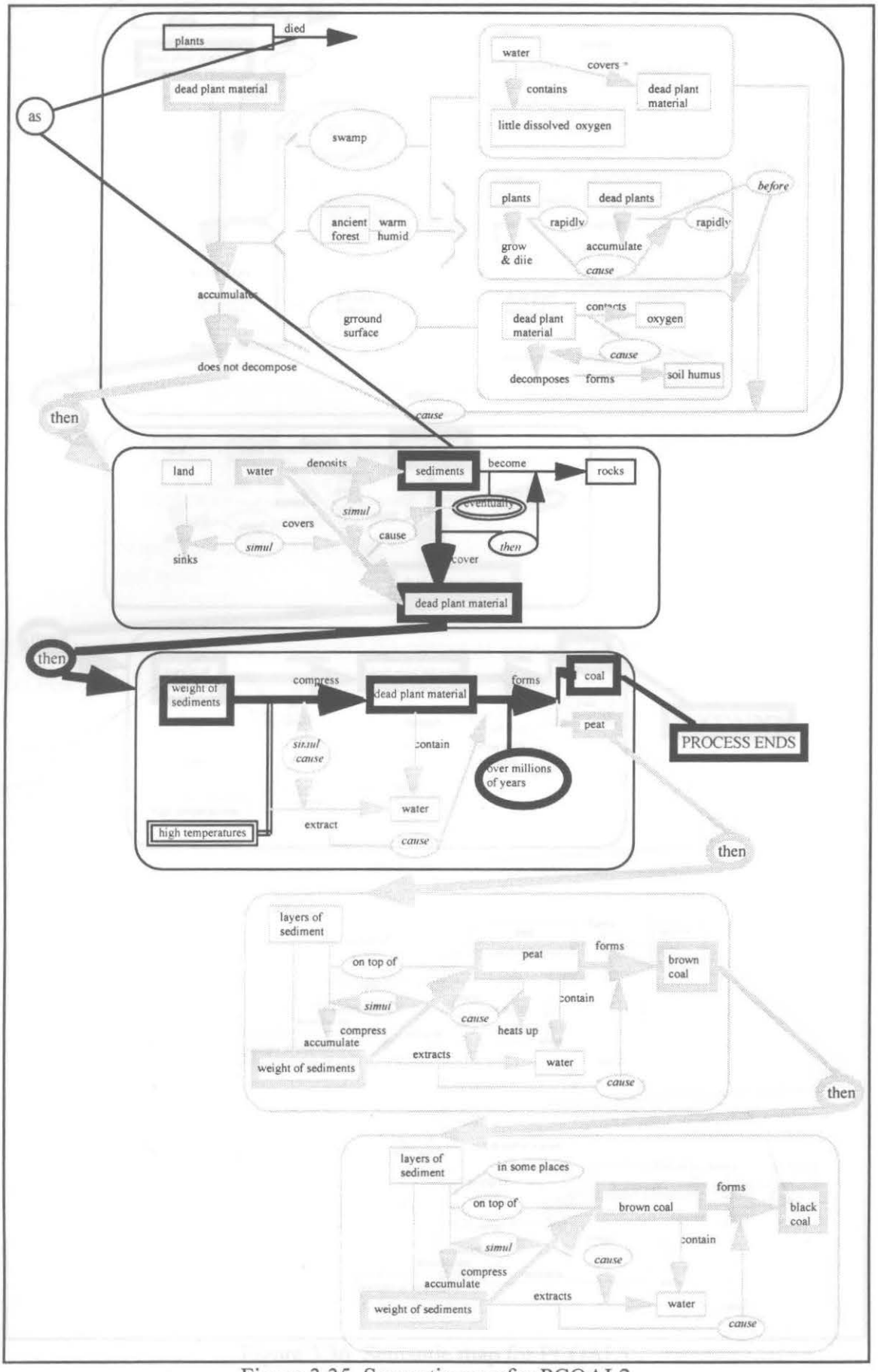


Figure 3.35 Semantic map for PCOAL2

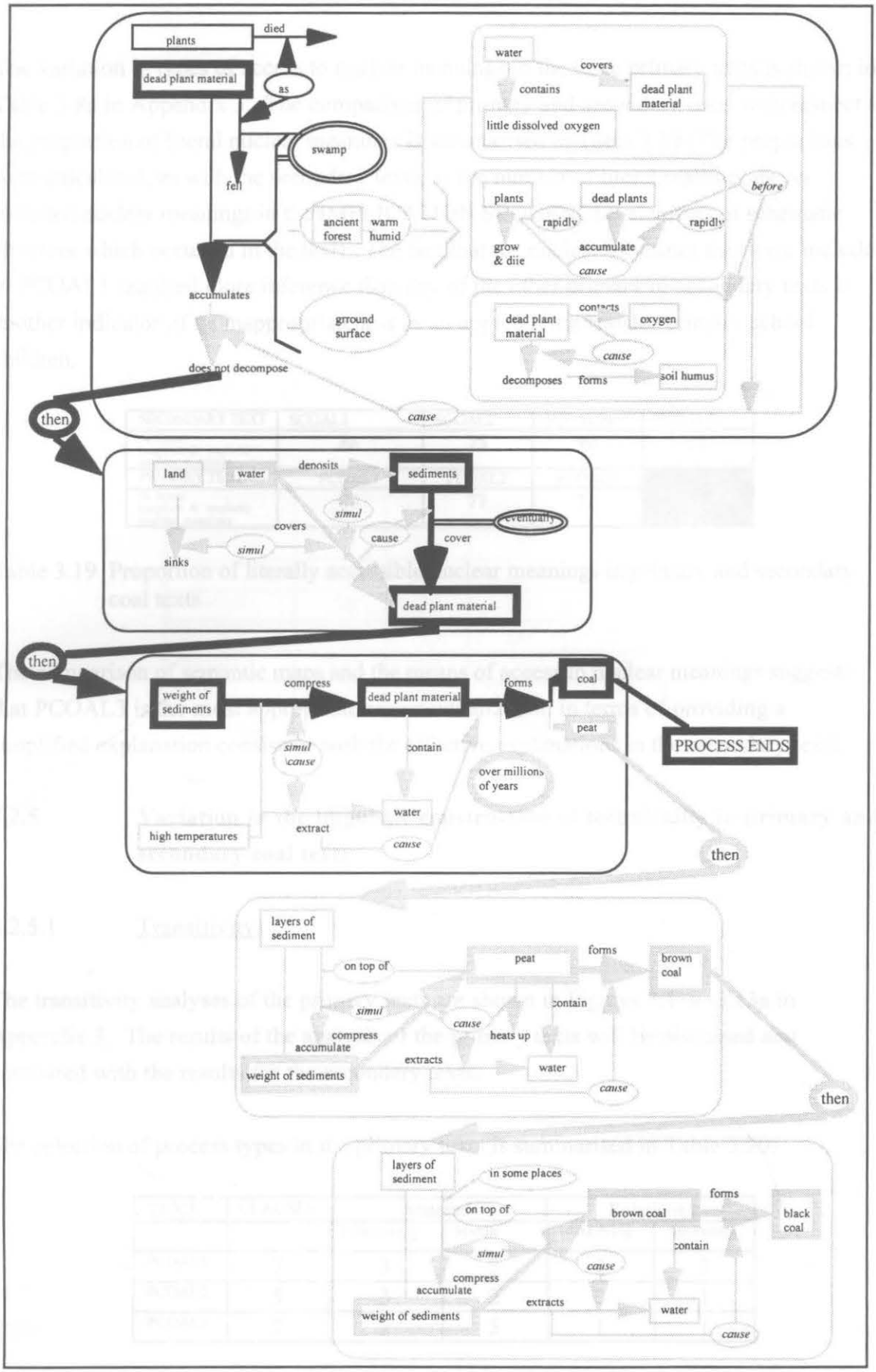


Figure 3.36 Semantic map for PCOAL3

The variation in types of access to nuclear meanings in the three primary texts is shown in Table 3.8a in Appendix 3. The comparison of primary and secondary texts with respect to the proportion of literal nuclear meanings is summarised in Table 3.19 (The proportions were calculated, as with the secondary texts, as the number of literal realisations per included nuclear meanings in the IMPLICATION SEQUENCES elements of schematic structure which occurred in the text). The fact that the nuclear meanings that were included in PCOAL1 required more inference than any of the other primary or secondary texts is another indicator of its inappropriateness as an apprenticing text for primary school children.

SECONDARY TEXT	SCOAL1	SCOAL2	SCOAL3a	SCOAL3b
% literal (explicit & implicit) nuclear meanings	86	75	90	68
PRIMARY TEXT	PCOAL1	PCOAL2	PCOAL3	
% literal (explicit & implicit) nuclear meanings	60	77	71	

Table 3.19 Proportion of literally accessible nuclear meanings in primary and secondary coal texts

The comparison of semantic maps and the means of access to nuclear meanings suggests that PCOAL3 is the most appropriate recontextualization in terms of providing a simplified explanation consistent with the effective explanations in the secondary texts.

3.2.5 Variation in the linguistic construction of technicality in primary and secondary coal texts

3.2.5.1 Transitivity

The transitivity analyses of the primary texts are shown in Figures 3.11a -3.13a in Appendix 3. The results of the analysis of the primary texts will be discussed and compared with the results for the secondary texts.

The selection of process types in the primary texts is summarised in Table 3.20.

TEXT	CLAUSES	Material		Relational	
		Effective	Middle	Identifying	Attributive
PCOAL1	7	3	2	2	3
PCOAL2	5	3	2	0	1
PCOAL3	7	2	5	1	1

Table 3.20 Comparison of process types in primary coal texts

Material processes dominate and marginally more of these are effective than middle, except for PCOAL3. Agency for effective Material processes is realised explicitly only once in each of the texts PCOAL2 and PCOAL3. The range of selections for Medium is similar across the primary texts, with realisations of *plant materials/remains* dominating. "Coal" is selected once in all texts and the realisation of *sediments* occurs once in each of PCOAL2 and PCOAL3. PCOAL1 also includes one instance of "peat" as Medium, reflecting its inclusion of more than one Transformation element.

The comparison of process types in the primary and secondary texts is summarised in Table 3.21. It shows the proportion of each process type in a text to the total number of processes in that text.

TEXT	Material		Relational	
	Effective	Middle	Identifying	Attributive
SCOAL1	.43	.21	.29	.07
SCOAL2	.53	.21	.05	.21
SCOAL3a	.36	.27	.09	.27
SCOAL3b	.46	.15	.08	.31
PCOAL1	.30	.20	.20	.30
PCOAL2	.50	.33	.00	.17
PCOAL3	.22	.56	.11	.11

Table 3.21 Comparison of selection of process types across primary and secondary coal texts

There are two key differences. One is the low proportion of effective Material processes in PCOAL3 compared with the secondary texts (and with PCOAL2). The highest proportion of effective Material processes, and the highest proportion with explicit agency (50%) occurred in SCOAL2. This text also had the widest range of meanings realised as Medium in material clauses. These factors were partly related to the inclusion of three Transformation elements. However the low proportion of effective Material processes in PCOAL3 remains significant when compared with the secondary text (SCOAL1) and the primary text (PCOAL2), which included only one Transformation element. In fact it is in the ORIENTATION and Trigger elements where PCOAL3 contrasts with the other texts' selection of effective Material processes.

In the ORIENTATION element the variation of concern is the realisation of the meaning *forms* as a middle Material process in PCOAL3 and hence "coal" as Actor rather than Goal:

Coal has formed over millions of years from the remains of ancient forests growing on swamps (PCOAL3).

The choice in PCOAL1 and PCOAL2 is an effective Material process:

2 Coal is formed in such places as swamps (PCOAL1)

1 Coal was formed from the remains of plants that grew millions of years ago (PCOAL2).

In these clauses the grammatical choice indicates that agency is involved and hence orients the reader to causality, whereas the middle Material process in PCOAL3 orients the reader more to the explanation as simply the unfolding of events over time.

In the Trigger element the same orientation can be seen in the realisation of the nuclear meaning *sediments cover dead plant material*. The semantic map and primary text segments for the Trigger element are shown in Figure 3.37.

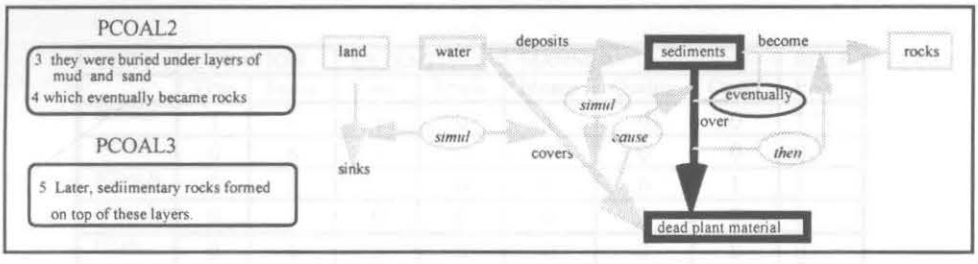


Figure 3.37 Semantic map for the Trigger element of PCOAL2 and PCOAL3

The first concern is with the realisation of the meaning *cover*. Although the effective, Material process in PCOAL2 is realised in an agentless passive clause, the implied agency indicates a causal relationship. This causal relationship is only available in PCOAL3 if the reader already knows the implication sequence which is distilled into the Classifier "sedimentary". The realisation of *cover* in PCOAL3 by the combination of middle Material process and Circumstance of spatial location ("formed on top of..") constructs a sequential rather than a causal interpretation. In the secondary texts, *cover* is realised as an effective Material process and *sediments* are realised as Agent/Actor or Medium/Goal but not as Medium/Actor as in PCOAL3.

The second key difference in the relative proportions of the process types across texts shown in Table 3.21 is the significantly larger proportion of Relational: identifying clauses in SCOAL1. This was shown (in 3.1.5.1) to be related to the greater technicality of this text.

Although PCOAL1 is a shorter text, it also has a somewhat higher proportion of Relational: identifying clauses, but unfortunately the first of these (01) defines coal inaccurately. The other defines "pressure" as "It [[that turns coal into peat]]" (clause 7). The only other Relational: identifying clause in the primary texts occurs in PCOAL3, where the Relational: identifying: circumstantial clause defines pressure by enhancement:

The pressure caused by the rocks (PCOAL3).

Again, as in the secondary texts, Relational: attributive clauses were infrequent but occurred more than Relational: identifying clauses. Four of the five occurrences in the primary texts were either intensive or circumstantial with resultative Attributes ("that turns coal into peat";"which became rocks"). The other instance was Relational: attributive possessive ("made up of decayed plants and animals").

The circumstantial transitivity for primary and secondary texts is summarised in Table 3.22.

TEXT	LOCATION		EXTENT		MANNER			ROLE
	Time	Space	Time	Space	Means	Quality	Comp	Role
SCOAL1	1	5	1	0	1	0	0	1
SCOAL2	0	6	1	0	1	0	0	0
SCOAL3a	0	3	1	0	0	0	1	1
SCOAL3b	0	3	0	0	0	0	1	3
PCOAL1	0	4	1	0	0	0	0	0
PCOAL2	2	1	1	0	1	1	0	1
PCOAL3	1	3	1	0	1	0	0	1

Table 3.22 Comparison of circumstantial transitivity in primary and secondary coal texts

The pattern is similar for primary and secondary texts. Circumstances of location in space predominate. Circumstances of time are relatively few and those that occur in SCOAL1 and PCOAL1 (e.g. "eventually"; "over time") do not indicate the time frame for the formation of coal as millions of years. This is clearly indicated in the other primary and secondary texts. The Circumstances of role are role:result in the primary texts, as are all but one in this category in the secondary texts. These and the Circumstances of manner:means indicate nodes in a causal chain and while they are not distributed in any clear pattern across texts, there are no occurrences of these categories in PCOAL1.

3.2.5.1.1 *Naming and defining technical terms in primary coal texts*

The analysis of the use of resources for naming and defining technical terms in primary texts was carried out as for the secondary texts. The results are shown in Table 3.23.

Category	PCOAL1	PCOAL2	PCOAL3
GROUP RANK			
1 Nominal group parataxis			
2 Verbal group parataxis			
3 Embedded clauses			
CLAUSE RANK			
4 Relational intensive identifying clause	Coal is a sedimentary rock [[made up almost entirely of decayed plants and animals]].		
5 Relational possessive attributive clause			
CLAUSE COMPLEX			
6 Projection			
7 Paratactic elaborating clause			
DISCOURSE SEMANTICS			
8 Reference			
DISCOURSE SEMANTICS AND LEXICOGRAMMAR			
9 Reference and relational identifying clause			
UNDEFINED TECHNICAL TERMS	sedimentary decayed decomposes peat pressure	pressure	sedimentary pressure denser

Table 3.23 Defining, naming or assuming technical terms in primary coal texts

The primary texts are clearly very poor at apprenticing young readers to the discourse of science through the naming and defining of technical terms - especially since the one definition that does occur is wrong! The relative use of resources for constructing technicality and undefined technical terms across primary and secondary texts is shown in Table 3.24.

TEXTS	CLAUSES	PROPORTION OF RESOURCES FOR DEFINING PER CLAUSE	PROPORTION OF UNDEFINED TECHNICAL TERMS
SCOAL1	10	.5	.2
SCOAL2	18	.22	0
SCOAL3a;b	20	.1	.05
PCOAL1	7	.14	.71
PCOAL2	5	0	.2
PCOAL3	7	0	.43

Table 3.24 Comparison of resources for constructing technicality and undefined technical terms in primary and secondary coal texts

SCOAL1 and SCOAL2 are the most effective texts in apprenticing readers to the discourse of science through the definition of technical terms. The primary texts had high proportions of undefined technical terms, including "pressure", which did not occur in any of the secondary texts. The secondary texts SCOAL3a and SCOAL3b used commonsense lexis (e.g. "squeezed") which did not occur in the primary texts. The primary texts did not evidence this kind of commonsense orientation to the Field, but they tended to assume rather than construct technicality.

3.2.5.2 Grammatical metaphor in primary coal texts

The analyses of grammatical metaphor in the primary coal texts are shown in Tables 3.9a - 3.11a in Appendix 3. The types and density of grammatical metaphor in the primary and secondary texts are summarised in Table 3.25.

Text	Clauses	Type of Metaphor								Density
		1a	1c	2a	5a	**6a**	12a	12b	12c	
SCOAL1	12	**5**	0	0	2	**3**	0	0	0	0.83
SCOAL2	18	**3**	1	0	0	**3**	0	1	0	0.44
SCOAL3a	8	**2**	0	0	0	**1**	0	0	0	0.38
SCOAL3b	12	**2**	1	1	0	**2**	1	0	1	0.67
PCOAL1	7				1					0.14
PCOAL2	5	**1**								0.20
PCOAL3	7	**1**						1		0.29

Table 3.25 Density of grammatical metaphor in the primary and secondary coal texts

Since there is little use of grammatical metaphor in the primary texts, and undefined technical terms contribute substantially to their technicality, grammatical metaphor plays little role in the construction of technicality in these texts.

Summarising realisational variation in the construction of technicality

Transitivity choices in the secondary texts distinguished SCOAL1 through the greater incidence of Relational: identifying Clauses and SCOAL2 through the greater incidence of effective Material clauses and a greater proportion of these with explicit agency, as well as the greatest range of meanings realised as Medium. These choices reflected the higher technicality of SCOAL1 and the more extended account of the full range of Transformation elements in coal formation in SCOAL2. The most significant variation in transitivity choices that occurred in the primary texts was the low proportion of effective Material processes in PCOAL3, partly due to its realisation of meanings in the ORIENTATION and TRIGGER elements as middle clauses in contrast to their realisation as effective clauses in the other texts.

SCOAL1 and SCOAL2 were more effective in deploying resources for naming and defining technical terms to apprentice readers to the discourse of science. The primary texts were very poor in this respect, with no effective deployment of such resources and a greater proportion of undefined technical terms.

The primary texts made very little use of grammatical metaphor. Much greater use of grammatical metaphor was made in the secondary texts, especially SCOAL1, where the higher density of grammatical metaphor was related to the greater technicality.

3.2.6 The relationship between causal conjunction, "depth" of explanation and relative technicality of the primary and secondary coal texts

As reported in section 3.1.6, no systematic relationship was found in the secondary texts between the relative deployment of temporal and consequential conjunction and the relative technicality of the texts. It was shown that consequential conjunction occurred only within elements of schematic structure in elaborative meanings or in making causal links between elaborative and nuclear meanings. The results of the analyses of the primary texts are consistent with these findings.

The only primary text to include consequential conjunctive relations was PCOAL3. As in the secondary texts, the consequential conjunction in PCOAL3 occurred within an element of schematic structure. Since, like the other primary texts, the elaborative meanings in PCOAL3 are minimal, the connection between their inclusion and the incidence of causal conjunction is not as clearly demonstrable as it is for the secondary texts. However, it can be illustrated by comparing the Transformation element of PCOAL3 with that of PCOAL2 in Figure 3.38.

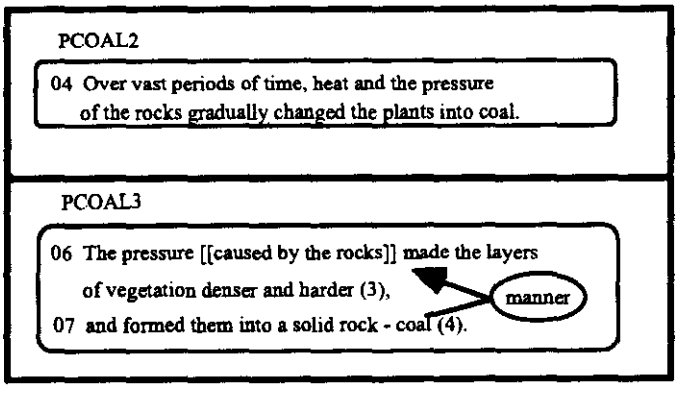


Figure 3.38 Transformation elements of PCOAL2 and PCOAL3

In both texts the nuclear meaning *compress* is scriptally implicit in the technical term pressure, but in PCOAL3 there is the additional elaboration "made denser and harder", and it is this which is linked by the consequential conjunctive relation of manner to the nuclear meaning in clause seven. The metaphorical realisation of causal conjunction ("caused") in clause six also elaborates an implication sequence which is simply realised as a participant in PCOAL2 ("the pressure of the rocks").

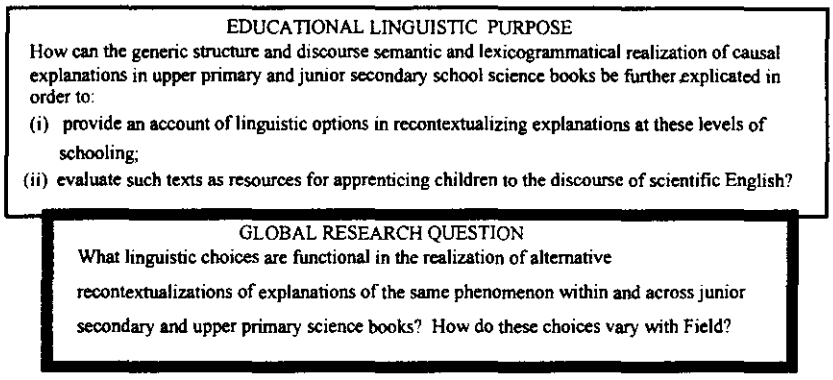
Some explanations of coal formation in primary texts like PCOAL2 could be characterised as "sequential" explanations because of the absence of causal conjunction, achieved largely by minimising elaborative meanings within elements of schematic structure. Others like PCOAL3, also with fairly minimal elaborative meanings, do include causal conjunctive relations in some elements.

However, such a distinction between a sequential and a causal orientation is not as clear cut as this might suggest. The causal orientation of PCOAL3 does seem to be undercut to some extent by inconsistent grammatical choices in other elements such as the selection of middle material processes in the ORIENTATION and Trigger elements discussed in the previous section.

The causal orientation of the primary texts is limited and inconsistent. As with the secondary texts, where causal relations were more prominent, causal conjunction in the primary texts is associated with the occurrence of (albeit minimal) elaborative meanings within elements of schematic structure and not with the relative technicality of the texts.

3.3 Educational implications

This section presents a progressive contrastive summary of the results of the analyses of the secondary and primary texts, as a means of addressing research question seven, which involves summarising the variation in the linguistic dimensions of recontextualization specified in research questions one through six. In so doing, progress toward addressing the global research question and the educational linguistic purpose of the study is also indicated.



Eliminating inadequate texts

An obvious outcome of these analyses is the convergence of results in identifying clearly inadequate explanatory texts at both primary and secondary levels. The secondary texts SCOAL3a and SCOAL3b compare very poorly with the other secondary texts on multiple dimensions of variation. They do not include the Trigger element of schematic structure, which is an essential stage in the explanation of coal formation because it deals with the events that initiate the process; the Theme selections do not scaffold the schematic structuring or the progression of experiential meanings in the text; both texts omit nuclear meanings from the Transformation element; they include fewer elaborative meanings, and they are the least technical texts, with the lowest proportion of definition of technical terms. The same kind of comparisons distinguish PCOAL1 from the other primary texts. As well as omitting both the Conditions and the Trigger elements of schematic structure, it is based on inaccurate information; and has the highest proportion of undefined technical terms of both primary and secondary texts. The elimination of inadequate texts then, is the first step in using the results of these kinds of analyses to develop an account of the linguistic options available in constructing effective recontextualizations of explanations of this Field.

Examining the functionality of variation as a basis for critical reading and text renovation.

The concept of a "prototypical" junior secondary school textbook explanation of this Field seems unrealistic, given the range of treatments of the Field across texts. A more productive basis for intervention, having eliminated inadequate texts, is to consider the functionality of any differences between the remaining texts along the various linguistic dimensions of variation being investigated. At the level of genre the differences between SCOAL1 and SCOAL2 are in the number of Transformation elements and in the use of the summarise strategy in the ORIENTATION and CLOSURE of SCOAL1. In this text the contextualize strategy in the ORIENTATION ("an important biochemical sedimentary rock") indicates that the text will be more concerned with the significance to coal formation of the technical information about oxygen deprivation in the Conditions element than with

differentiating the latter stages of coal formation according to the type of coal produced. This accounts for the collapsing of the Transformation stages into a single element of schematic structure and it also accounts for extensive elaborative meanings in the Conditions element and none in the other elements. SCOAL2 on the other hand includes the three Transformation stages as separate elements of schematic structure and it is in these elements where elaborative meanings are more extensive in this text. The differences due to the contextualize strategy however, do not explain why the elaborative meanings giving the reason for non-decomposition are different in these texts. This kind of variation requires critical attention in the context of teaching and learning from the text and authors should attend to the need to acknowledge within their texts, such competing or complementary information.

More resources for naming and defining technical terms and a greater proportion of undefined technical terms occurred in SCOAL1. The lower technicality of SCOAL2 was partially due to its use of commonsense terms like "rot", where SCOAL1 uses the more technical "decomposes" - and relates this to the readers' everyday, commonsense experience. The use of verbal group parataxis ("decomposes, or rots") in such cases would have enhanced the role of SCOAL2 in apprenticing readers to the technicality of the Field. On the other hand this text did use similar resources like Thing ^ Qualifier structures to define technical terms like "sediment", which remained undefined in SCOAL1. Clearly there is a need for more consistent and strategic deployment of grammatical and discourse semantic resources for introducing technicality.

The density of grammatical metaphor was greater in SCOAL1, but the metaphorical realisations were not essential to the construction of the technicality. For example, instead of clause seven, "However <<6-6.1)>> decomposition is prevented", it is quite possible to have "However<<6-6.1>> the dead plant material cannot decompose". Of course this would involve repercussions in terms of textual meaning, but the Theme analyses did not point to this as being highly significant. It also seems to make little difference whether one uses the metaphorical structure "plant remains" or the congruent forms "dead plant leaves and stems" or "layers of dead trees and other plants". The density of grammatical metaphor in all texts was quite low and the somewhat higher density in SCOAL1, although related to the higher technicality, does not seem essential to its construction.

The patterns of Theme selection in scaffolding schematic structure in SCOAL1 and SCOAL2 were shown to be different but both highly functional, and in both cases the ORIENTATION functioned as a Hyper-Theme, predictive of subsequent Topical Theme choices. The differences in patterns of Thematic choice can also be related to the contextualize strategy, which highlighted the Conditions element in SCOAL1, whereas the

points of departure for three differentiated Transformation stages were significant in SCOAL2. Only SCOAL1 used the summarise strategy in the CLOSURE element and hence only this text showed some accumulation of News as a Hyper-New. However, the comment strategy in the CLOSURE element of SCOAL2 was also functional, given the different contextualization of this explanation.

The somewhat higher incidence of internal conjunction in SCOAL1 was also related to the summarise strategy in the CLOSURE element, the internal relation of consequence:manner linking previous implication sequences as the rhetorical means for this conclusion. The deployment of external temporal and consequential conjunctive relations was shown to be similar across both texts, with a somewhat higher proportion of temporal relations in SCOAL2 due to the inclusion of the three separate Transformation elements.

The only dimension of variation to cause significant concern within the appropriate secondary texts then, is the unexplained difference in the selection of different elaborative meanings in the Conditions element. However, the role of the texts in apprenticing readers to the discourse forms of scientific English could also be improved through more effective deployment of resources for the naming and defining of technical terms.

Towards a semiosis of effective recontextualization in primary science books.
Having eliminated inadequate texts, a first step toward an account of the semiosis of effective recontextualization at the primary level is to examine the functionality of similarities and differences between the primary and secondary texts. At the level of genre in these texts there is a great deal of commonality. Both primary texts PCOAL2 and PCOAL3 include an ORIENTATION element and the Conditions, Trigger and Transformation elements of schematic structure, which are essential to the explanation of coal formation. Also the pattern of Theme selections in both of these texts approximated the effective pattern of Theme choices in SCOAL2, with marked Themes introducing new elements of structure.

There are two areas of significant difference between primary and secondary texts, which are similar across the primary texts. The first of these is the selection of nuclear meanings. Neither PCOAL2 nor PCOAL3 include the nuclear meanings *dead plant material does not decompose*. This seems to be an effective and consistent simplification strategy used in the primary texts. The second area of difference between primary and secondary texts is in the density of grammatical metaphor, with both primary texts deploying much less metaphor than the secondary texts. Again this seems to be a consistent and effective strategy, which amounts in part, to using realisations like "plants" and "vegetation" rather than "plant remains".

The remaining differences between primary and secondary texts are those for which there are also differences across the primary texts. The functionality of this variation needs to be examined to identify possible problematic aspects of the semiosis of recontextualization. One area of difference is conjunctive relations. The primary texts contain very few external consequential conjunctive relations in comparison with the secondary texts, and in fact, these are confined to PCOAL3. The analyses showed that consequential conjunction occurred in elaborative meanings within elements of schematic structure in the secondary texts, and the primary texts contain very little elaborative meaning. Hence it is not surprising that few consequential conjunctive relations occurred. It therefore seems that a simplification strategy of minimising elaborative meanings results in the primary texts becoming more sequentially rather than causally oriented. However, it is clearly not a necessary feature of the recontextualization of such explanations at this level as evidenced by the inclusion of at least some elaborative meanings involving consequential conjunction in one text. It is also the case that elaborative meanings in the Transformation elements of SCOAL2 were not technical and did not involve significant use of grammatical metaphor. Primary texts could certainly include these meanings, incorporating consequential relations, without decreasing the accessibility of the explanation to primary school readers.

There was a significantly lower proportion of effective Material processes and higher proportion of middle Material process in PCOAL3 compared with PCOAL2 and the secondary texts. This was discussed in section 3.2.5 above and does seem to be an aberration, which effaces causality and constructs an inappropriate orientation to events simply unfolding over time. The final area of concern is the construction of technicality. The primary texts included a number of undefined technical terms and made no effective use of resources for naming and defining technical terms. In this respect they compared poorly with the secondary texts, although, as noted above, this dimension was also not entirely satisfactorily dealt with at the secondary level.

Strategies for recontextualizing the Field in primary texts would include maintaining the schematic structure of secondary texts, using marked Topical Themes to scaffold the introduction of elements of structure in the IMPLICATION SEQUENCES stage and maintaining the nuclear meanings of the secondary texts. To simplify the explanation, elaborative meanings can be minimised, however, it is not necessary for these to be eliminated as elaborative meanings in the Transformation stage in some secondary texts involved little technicality or grammatical metaphor. Where the ideational semantics involves causality through the action of an agent, the grammatical realisations should deploy effective processes, and primary texts need to deploy resources for naming and defining the technical terms they introduce.

Chapter 4

Explanations of sound waves

This chapter reports on analyses of explanations of sound waves in three secondary and three primary school science books addressing the research questions listed in Figure 4.1.

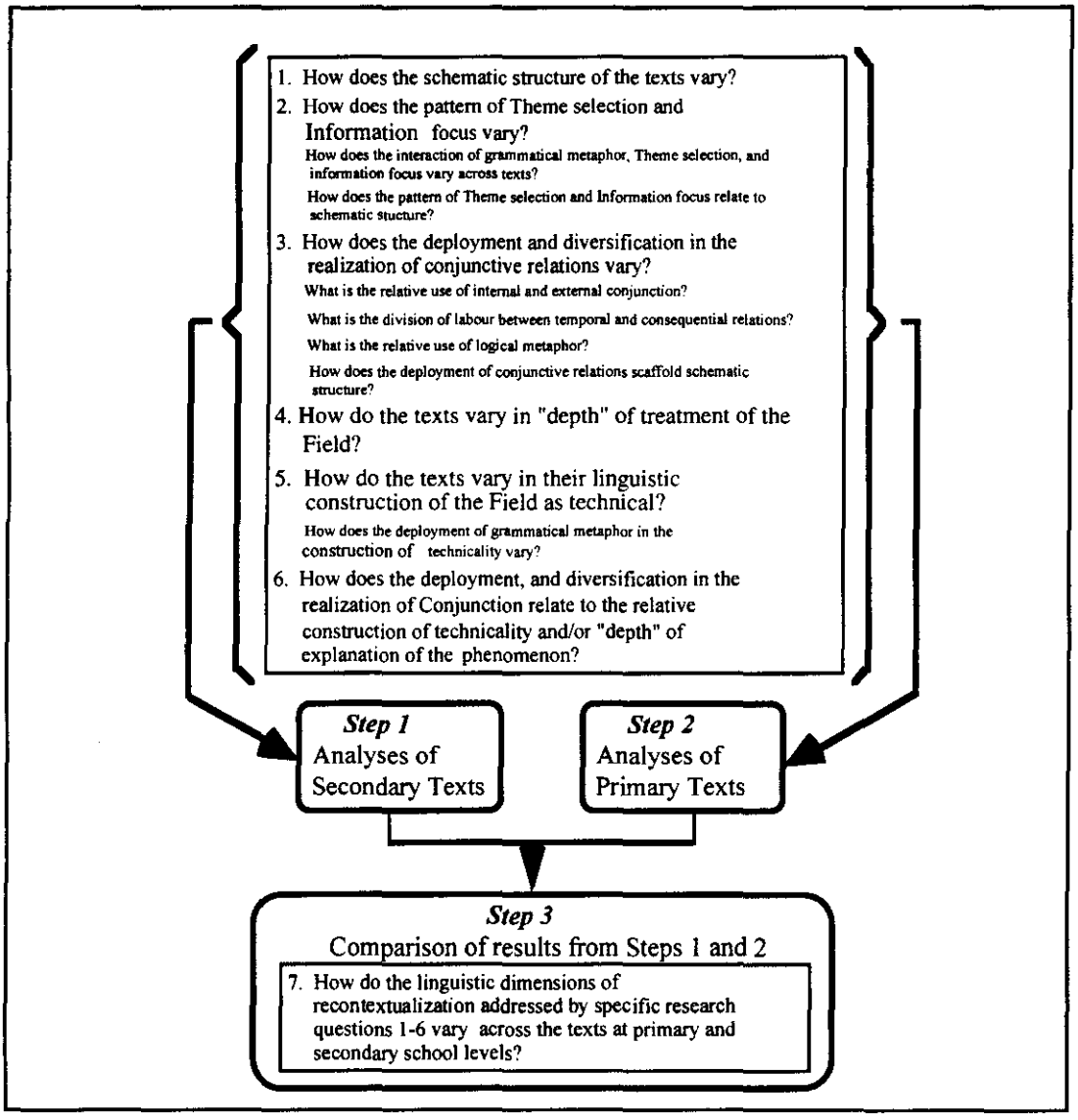


Figure 4.1 Research questions addressed in chapter four

The secondary texts are dealt with in the first section with separate sub-sections allocated to each of the research questions one through six. Then the results of the analyses of the primary texts are reported in the same manner, and including, for each research question, comparison with the corresponding results for secondary texts. Finally, these comparisons

are summarised to address research question seven, the global research question and the educational linguistic purpose of the study.

4.1 Secondary sound texts

4.1.1 Schematic structure in secondary sound texts

The schematic structure proposed for the secondary sound texts is:

ORIENTATION ^ PHENOMENON EXEMPLIFICATION ^ IMPLICATION SEQUENCES ^{n} ^ CLOSURE

The ORIENTATION has the function of preparing the reader for the text that follows. To account for the variation across texts in the strategies used to achieve this function, it is necessary to apply the concept of "rank" to describe "layers of staging" as discussed by Martin (1994; 1995:24). The layering within the ORIENTATION element is:

Phenomenon Identification ^ (Link) ^ (Analogic Account)

In all three texts the Phenomenon Identification occurs as the title/subheading for the section. In SSND1 it is a Wh question and in the other two texts it is a nominal group:

> What causes and transmits sounds? (SSND1)
> Sound as wave motion (SSND2)
> Sound waves (SSND3)

The Link relates the current text to previous text sections. This relationship is realised explicitly in SSND3:

> 01 You have just seen a number of sources of sound,
> 02 many being produced in a way similar to musical instruments.
> 03 In each case, a vibration was needed
> 04 to produce the sound.

In SSND1 the Link also recapitulates what was covered in the previous section but this relationship is not explicitly signalled:

> 01 [[To make sounds]] requires vibrations [[which disturb the air]]
> 02 Small vibrations cause soft sounds.
> 03 Large vibrations disturb the air more
> 04 to produce loud sounds.
> 04a Vibrating materials produce sound.

The fact that this element is a Link can be appreciated by referring to the questions at the end of the previous section of the text:

> QUESTIONS
> 1. Sound is produced by vibrations. How can you tell
>   (a) that the ruler vibrates to produce sound
>   (b) that the ticket and straw are vibrating to produce sound?
> 2. What is the effect on sound when you
>   (a) blow harder on the ticket and the straw
>   (b) strum harder on the ruler?
> 3. As the size of the vibrations gets larger, what happens to the sound?
> 4. As the speed of the vibrations gets greater what happens to the sound?
>
> (Chapman et al, 1989:280)

There is no Link element in SSND2.

Analogic Accounts occur in two of the texts. Their function is to provide a preliminary explanation by drawing an analogy between sound waves and some other aspect of everyday experience. The following analogic account occurs in SSND1:

> 05 Vibrating materials send sound waves through the air
> 06 As the materials vibrate
> 07 they disturb the air particles near them.
> 08 These air particles disturb other air particles and so on.
> 09 Just like a long chain of dominoes, the disturbance or sound wave is passed on from air particle to air particle.
> 10 Unlike the dominoes, the air particles spring back to their original position.
> 11 Sound waves travel through gases, liquids and solids
> 12 because they all contain particles [[which will carry or transmit disturbances]].
> 13 However, sound waves will not travel through a vacuum
> 13.1 which is an empty space:
> 14 without particles [[to transmit the disturbance from a vibrating object]], sound waves cannot be formed.

In SSND2 the Analogic Account is much briefer:

> 01 If you throw a stone into a pond
> 02 the disturbance produces waves [[which travel across the pond in all directions]].
> 03 The waves [[associated with sound]] are similar in some ways different in others.

The PHENOMENON EXEMPLIFICATION is a particular instance of the production of sound waves which the subsequent text will explain. This element of schematic structure occurs in all three texts:

15 Figure 15.1 shows a vibrating object [[producing sound waves]]. (SSND1)

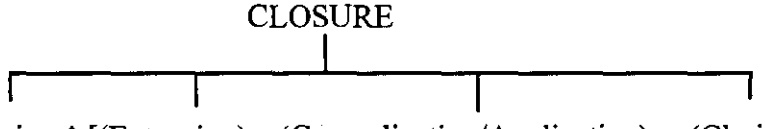
04 Fig 8.31 shows how pressure differences are produced in the air around a vibrating hacksaw blade. (SSND2)

05 If we look at how a tuning fork produces sound
06 we can learn just what sound is. (SSND3)

The IMPLICATION SEQUENCES detail the chain of events which produce sound waves in the particular instance selected in the previous element of structure. The IMPLICATION SEQUENCES in SSND1 are shown below:

16 As the object moves to the right
17 it pushes or compresses the air particles next to it.
18 The compressed air particles then push on the particles to their right
19 and compress them.
20 As each air particle pushes on the next one to its right
21 the compression travels through the air.
22 When the vibrating object moves back to its left
23 the air particles next to it are no longer being pushed.
24 They spread out
25 or are stretched apart.
26 As a compression travels through the air
27 it is followed by the stretching apart of air particles.
28 Because the vibrating object continually moves back and forth
29 a series of compressions and stretchings of air particles is sent out from the object. (SSND1)

The CLOSURE element functions to draw some conclusion to the text such that it steps outside of the detail of the processes of formation of the phenomenon. Considerable variation in this element across the texts again necessitated the application of the notion of layers of staging. The layering of the CLOSURE element is as follows:



Conclusion ^ [(Extension) . (Generalization/Application) . (Clarification)]

The Conclusion is similar to Shea's (1988) notion of State and to the summarise strategy described by Cross (1992). It is called a Conclusion here because in both texts in which it occurs it is linked to the IMPLICATION SEQUENCES by the internal conjunctive relation - consequence:manner. The Conclusion element occurs in SSND1 and SSND3:

30 These compressions and stretchings make up a sound wave. (SSND1)

23 Thus sound is a compression wave [[that can be heard]]. (SSND3)

Although the Conclusion component occurs in the CLOSURE element of two of the texts, it is considered an obligatory element of schematic structure. The omission of this element in SSND2 is very problematic. There is no explicit definition of a sound wave in this text.

The optional Extension component provides an explanation of an additional aspect of sound waves, i.e. that they travel in all directions, and occurs only in SSND1. The Generalisation component also occurs only in SSND1:

34 The same process can occur with the particles in a liquid or a solid
35 so that they will also transmit sound. (SSND1)

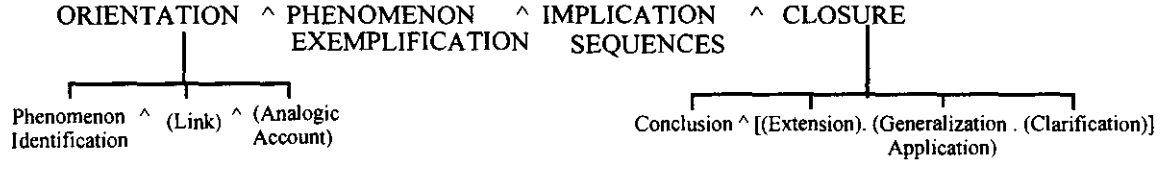
The Application element occurs in SSND2. It is a further instance of the production of sound waves included to show how the IMPLICATION SEQUENCES relevant to the previous PHENOMENON EXEMPLIFICATION applies in other instances.

10 A loudspeaker works in much the same way
11 vibrating forwards and backwards
12 producing compressions and rarefactions
12.1 which move out through the air in the room. (SSND2)

The Clarification component also occurs only in SSND2. It functions to obviate misconceptions that may have arisen from the earlier account of the IMPLICATION SEQUENCES.

13 It is important to note that the air molecules move backwards and forwards as the compressions and rarefactions are transmitted outwards but the air as a whole does not move - winds are not set up. (SSND2)

The possible schematic structures in the secondary textbook explanations of sound waves can be summarised as follows:



The organisation of the secondary sound texts in terms of the proposed schematic structure is shown in Table 4.1.

	SSND1	SSND2	SSND3
ORIENTATION			
Phenomenon Identification	What causes and transmits sounds?	Sound as wave motion	Sound waves
Link	01 [[To make sounds]] requires vibrations [[which disturb the air]]. 02 Small vibrations cause soft sounds. 03 Large vibrations disturb the air more 04 to produce loud sounds. 04a Vibrating materials produce sound		01 You have just seen a number of sources of sound, 02 many being produced in a way similar to musical instruments. 03 in each case a vibration was needed 04 to produce the sound
Analogic Account	05 Vibrating materials send sound waves through the air 06 As the materials vibrate 07 they disturb the air particles near them. 08 These air particles disturb other air particles and so on. 09 Just like a long chain of dominoes, the disturbance or sound wave is passed on from air particle to air particle. 10 Unlike the dominoes, the air particles spring back to their original position.	01 if you throw a stone into a pond 02 the disturbance produces waves [[which travel across the pond in all directions]] 03 The waves [[associated with sound]] are similar in some ways different in others.	
	11 Sound waves travel through gases, liquids and solids 12 because they all contain particles [[which will carry or transmit disturbances]]. 13 However, sound waves will not travel through a vacuum 13.1 which is an empty space: 14 without particles [[to transmit the disturbance from a vibrating object]], sound waves cannot be formed.		
PHENOMENON EXEMPLIFICATION	15 Figure 15.1 shows a vibrating object [[producing sound waves]].	04 Fig 8.31 shows how pressure differences are produced in the air around a vibrating hacksaw blade.	05 If we look at how a tuning fork produces sound 06 we can learn just what sound is.
IMPLICATION SEQUENCES	16 As the object moves to the right 17 it pushes or compresses the air particles next to it. 18 The compressed air particles then push on the particles to their right 19 and compress them. 20 As each air particle pushes on the next one to its right 21 the compression travels through the air. 22 When the vibrating object moves back to its left 23 the air particles next to it are no longer being pushed. 24 They spread out 25 or are stretched apart. 26 As a compression travels through the air 27 it is followed by the stretching apart of air particles. 28 Because the vibrating object continually moves back and forth 29 a series of compressions and stretchings of air particles is sent out from the object.	*Fig 8.31* *04a A hacksaw blade is clamped in a vice* *04b and plucked* *04c As the blade moves to the right (middle diagram)* *04d it compresses the air molecules* *04e producing a high pressure area in the direction of motion and a low pressure area on the other side* *04f As the blade flicks back (right diagram)* *04g a new high pressure area is produced on the left , a new low pressure one on the right.* 05 As the high pressure area is produced 06 the air molecules move out to the low pressure area in front of them 07 increasing the pressure there 08 and reducing the pressure behind them. 09 The high pressure areas (=**compressions**) and low pressure area (=**rarefactions**) both move outwards from the blade.	07 By looking closely at one of the prongs 08 you can see that it is moving to and fro (vibrating). 09 As the prong moves outwards 10 it squashes, or compresses the surrounding air. 11 The particles of air are pushed outwards 12 crowding against and bashing into their neighbours 13 before they bounce back. 14 The neighbouring air particles are then pushed out 15 to hit the next air particles and so on. 16 This region of slightly squashed together air moving out from the prong is called a compression. 17 When the prong of the tuning fork moves back again 18 the rebounding air particles move back into the space that is left. 19 This region where the air goes thinner is called a rarefaction 20 and also moves outwards. 21 The particles of air move to and fro in the same direction in which the wave moves 22 and do not move along with the compression.
CLOSURE			
Conclusion	30 These compressions and stretchings make up a sound wave		23 Thus sound is a compression wave that can be heard.
Extension	31 The vibrating object focuses most of the sound waves in the general direction of its vibrations. 32 However, bending of the edges of the sound waves has the effect of sending them out in all directions around the vibrating object. 33 This is shown by the top view of the vibrating object in figure 15.1.		
Generalisation/ Application	34 The same process can occur with the particles in a liquid or a solid 35 so that they will also transmit sound.	10 A loudspeaker works in much the same way 11 vibrating forwards and backwards 12 producing compressions and rarefactions 12.1 which move out through the air in the room.	
Clarification		13 It is important to note that the air molecules move backwards and forwards as the compressions and rarefactions are transmitted outwards but the air as a whole does not move winds are not set up.	

Table 4.1 Schematic structure of secondary sound texts

A problematic aspect of SSND2 is the role of the extended text accompanying the illustration (shown in italics in Table 4.1 above). The thematizing of "Fig 8.31" in clause

04 and the presuming reference to "the high pressure area" in clause 05, suggest that the sub-text accompanying the diagram is to be read as interpolated between clauses 04 and 05 as shown above.

The variation in schematic structure is mainly in the selection of optional components within the ORIENTATION and CLOSURE. The exception to this is the absence of the Conclusion component in the CLOSURE of SSND2.

4.1.2 Theme and schematic structure in secondary sound texts

In all texts the sub-heading functioning as Phenomenon Identification in the ORIENTATION stage of schematic structure, also functioned as a Macro-Theme, predicting the PHENOMENON EXEMPLIFICATION as a Hyper-Theme, which, in turn predicted the Thematic patterning in the IMPLICATION SEQUENCES. This hierarchy of periodicity was pointed out by Martin (1993b:244) and illustrated using text SSND3 in Chapter two (2.2.2.1). It is further illustrated for SSND2 in Figure 4.2.

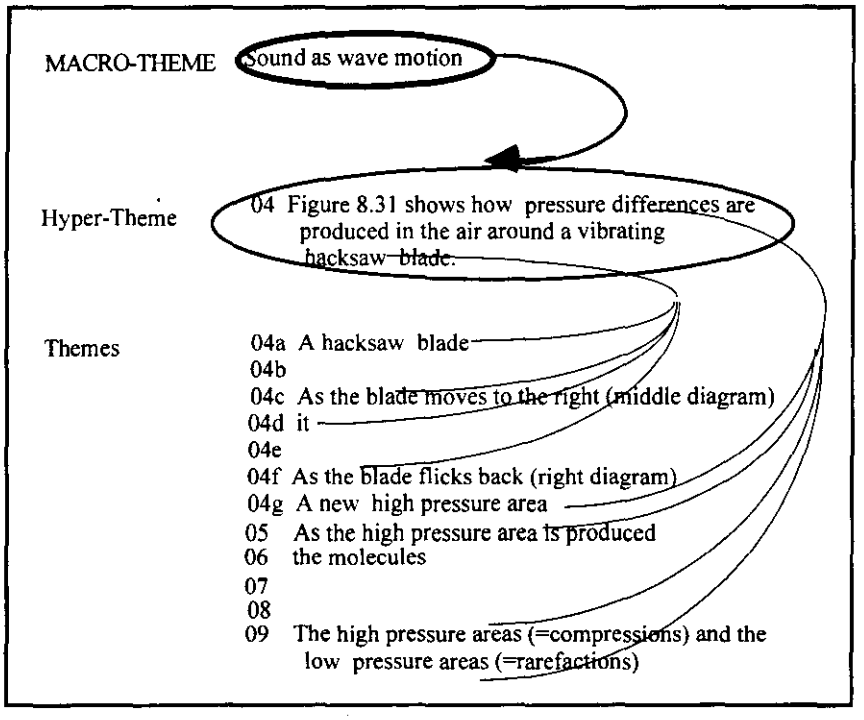


Figure 4.2 Macro-Theme, Hyper-Theme and Theme in SSND2

The Theme analysis again followed Martin (1992:435 & 440) to show "method of development". The relationship between patterns of Theme selection and schematic structure for all texts is shown in Figures 4.1a - 4.3a in Appendix 4.

The predominance of marked Themes in the IMPLICATION SEQUENCES in SSND1 is a central resource in the method of development of this element of the text. The role of the thematic β clauses is to update what is Given information as the text progresses. Part of this is to track the component events in the commonsense, observable implication sequence i.e. the movement back and forward of the vibrating object. These component events as marked Themes in clauses 16 and 22 are accumulated as a marked Theme in clause 28. But, in addition, the marked Themes in clauses 20 and 26 pick up the new information from previous clauses, realising uncommonsense implication sequences, and thematize this information to update the Given as the relevant point of departure for the further introduction of new information in the subsequent α clauses. While the marked Themes in 16 and 22 are constituent events in the sequence realised in 28, 20 in a sense, is in a constituency relation to 26. So the method of development is progressively moving the point of departure from constituent events to macro events in terms of both commonsense and uncommonsense implication sequences, as illustrated in Figure 4.3.

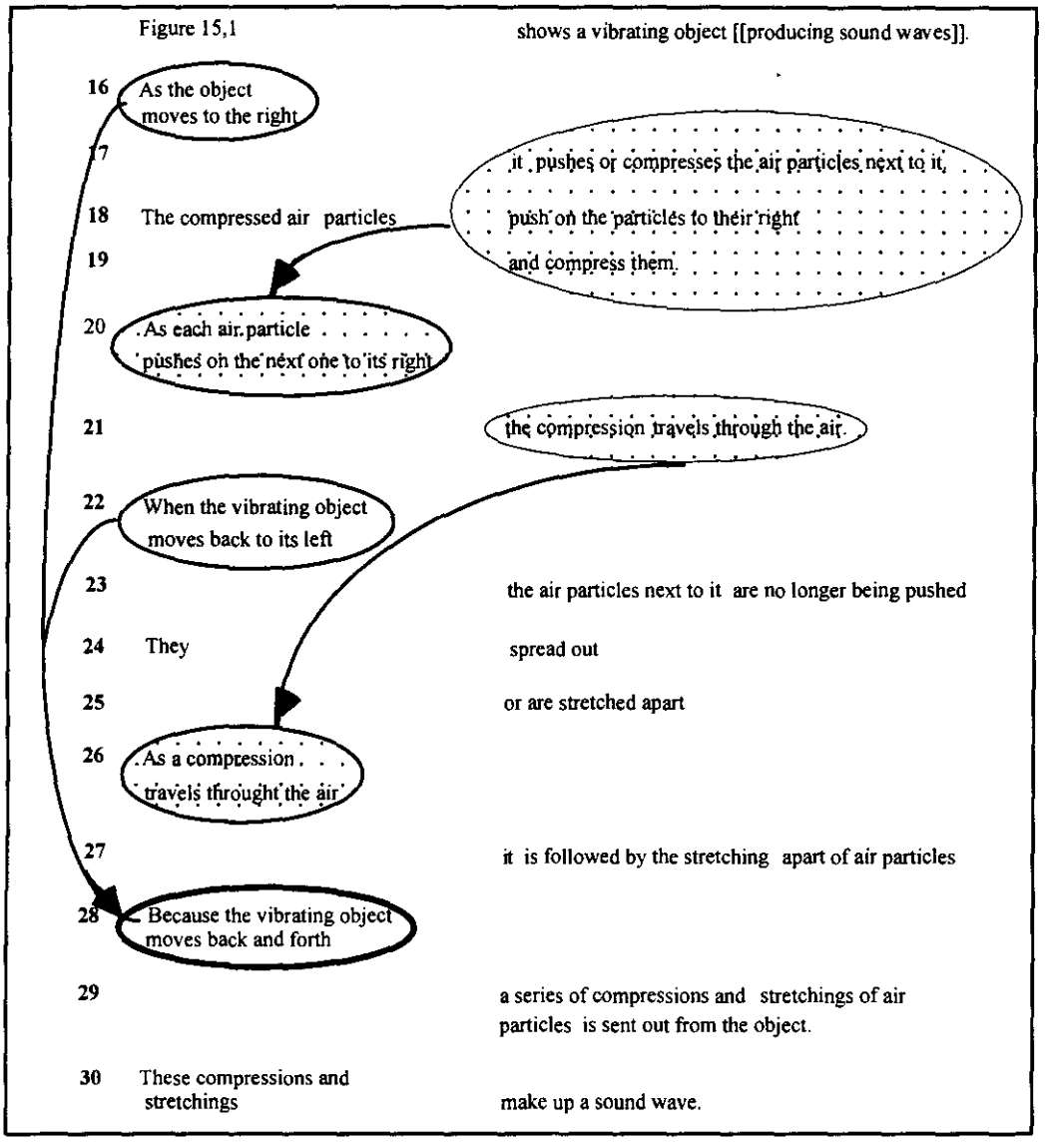


Figure 4.3 "Method of development" in the IMPLICATION SEQUENCES of SSND1

But it is in the progression of new information in the rhematic α clauses where the events in the technical implication sequences are condensed and reconstrued at higher levels of abstraction. This reconstrual necessitates nominalisation and hence deployment of this form of grammatical metaphor must be introduced through the Rheme. So the new information, progressively introduced and distilled rhematically through nominalisation, is finally accumulated as Hyper-New in clause 30, which functions as the Conclusion in the CLOSURE element of schematic structure. This progressive accumulation is illustrated in Figure 4.4.

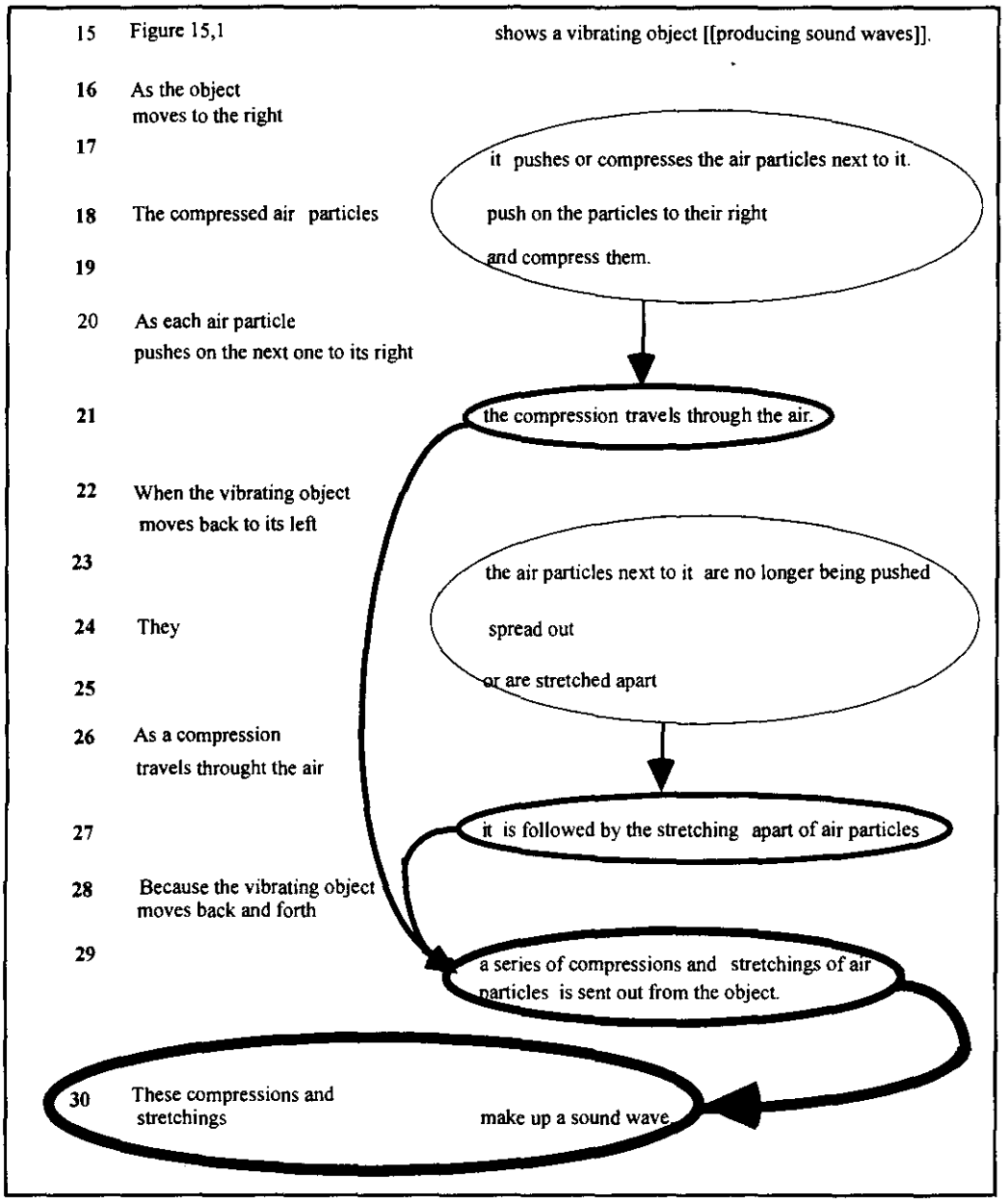


Figure 4.4 The accumulation of information as Hyper-New in SSND1

There are fewer marked Themes in the IMPLICATION SEQUENCES of SSND2, and while these do update the Given information as the text progresses, they do not achieve the same cumulative effect as SSND1. This can be seen in Figure 4.5. The constituent commonsense events thematized in 04c and 04f are not accumulated in a subsequent Theme and similarly the single technical event as marked Theme in 05 precludes the same accumulation as in SSND1.

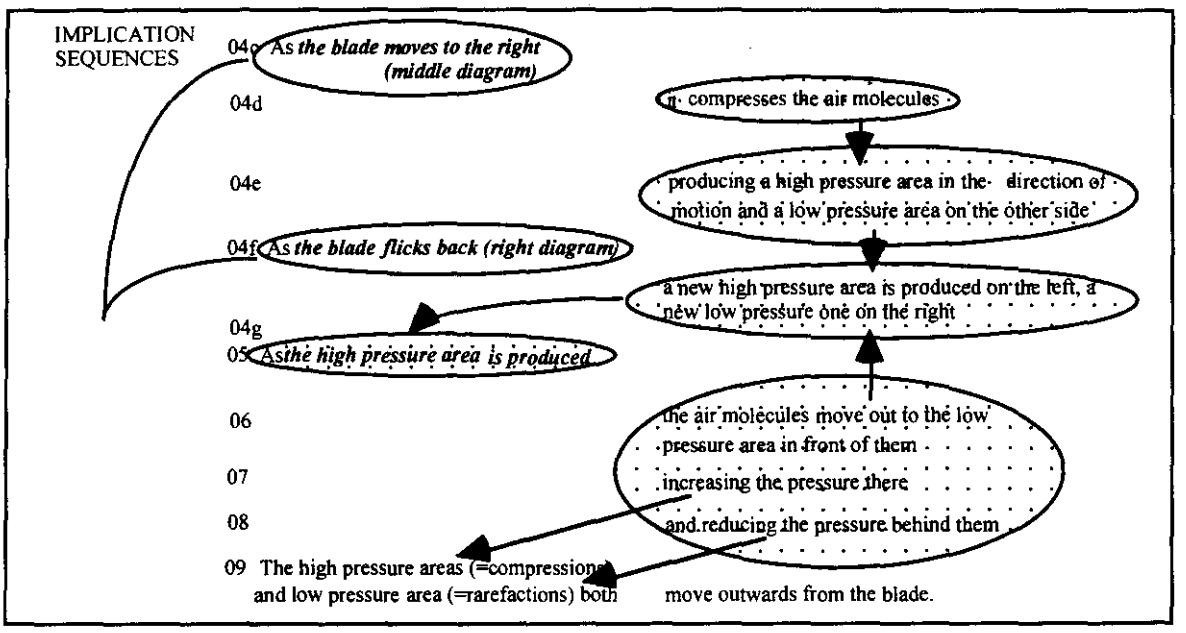


Figure 4.5 Patterns of Theme in the IMPLICATION SEQUENCES in SSND2

Like SSND1, it is in the Rhematic α clauses that the technical implication sequences are introduced. However, there is not the same progressive reconstrual of these as macro-events and their ultimate accumulation in a Hyper-New. The new information in clauses 06-08 in fact deconstructs the nominalised macro-events previously introduced in clauses 04e - 04f in the sub-text accompanying the diagram. While the Theme in clause 09 does pick up new information from the previous Rhematic clauses, this provides the updated Given for the new information to be introduced in clause 09, which is that the compressions and rarefactions move out from the blade. So in this text we do not have an effective Hyper-New which also functions as the Conclusion element of schematic structure, as was the case with SSND1.

SSND3 also has fewer marked Themes than SSND1. What is similar in the method of development for all three texts is the progression through the Theme of the component events of the commonsense activity sequence i.e. the vibration of the object, with each movement of the object realised in a thematic β clause. But in SSND3 these are also not accumulated in a subsequent marked theme realising the whole of the observable event sequence (In fact the whole event is introduced Rhematically in clause 08, prior to the component events). In addition, although the Theme selections do update Given information about the technical implication sequences as the text progresses, by picking up new information developed and distilled through the Rhemes, again there is no cumulative effect as in SSND1. This can be seen in Figure 4.6.

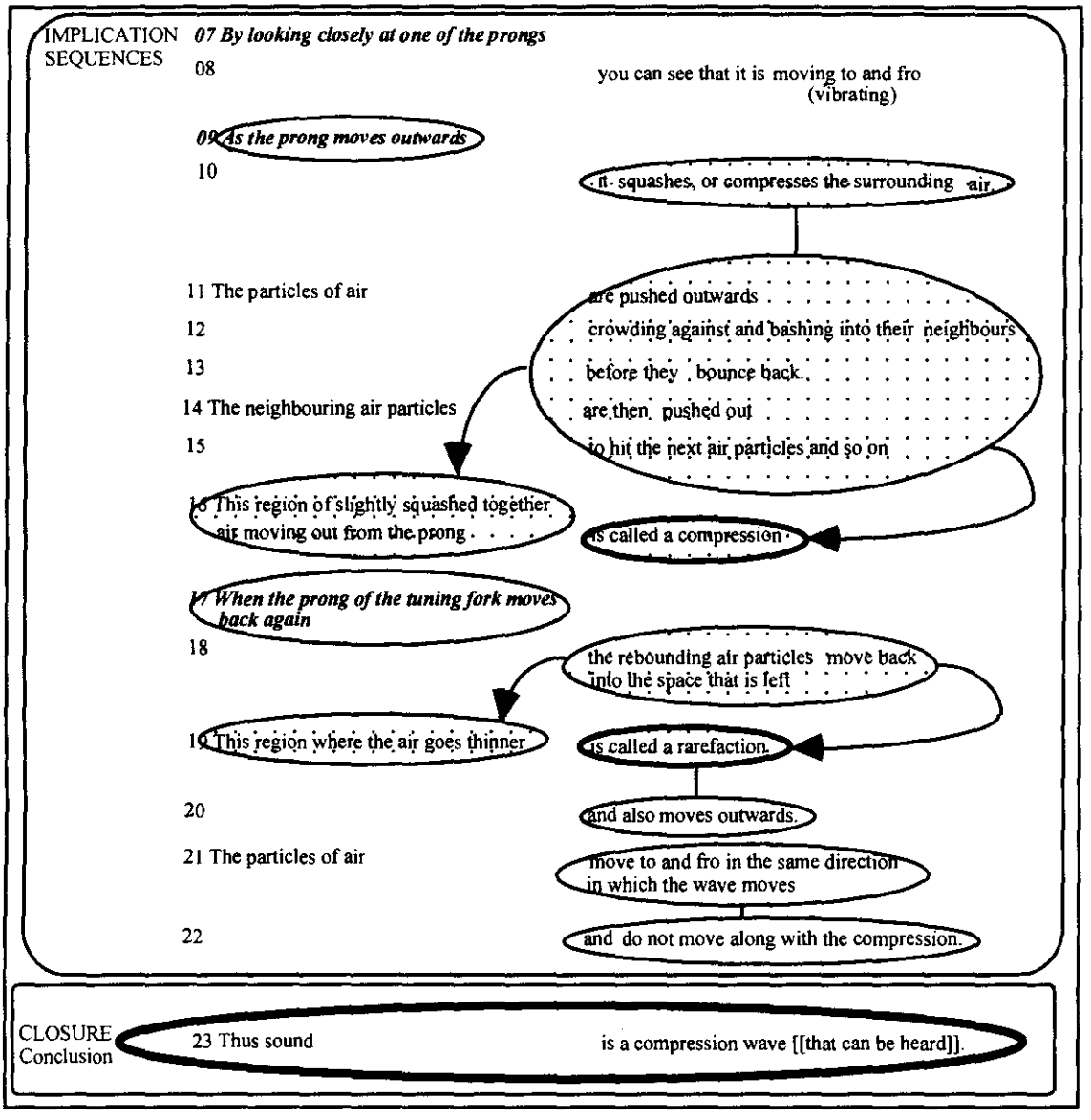


Figure 4.6 Patterns of Theme and New in SSND3

As in the other texts the technical events are introduced and distilled as macro-events in Rhemes as new information. As shown in Figure 4.6, there is more systematic accumulation of technical information through the Rhemes in this text than in SSND2. However, a comparison with Figure 4.4 shows that the accumulation of this new information as Hyper-New in clause 23 of SSND3 is not as clear as the accumulation in SSND1 in clause 30 as Hyper-New.

4.1.3 Conjunction in secondary sound texts

The analyses of conjunctive relations in the secondary sound texts are shown in Figures 4.4a - 4.6a in Appendix 4 and the results are summarised in Table 4.2.

Text	Clauses	CRUs	Conjunctive relations				
			Internal	External	Metaphorical	Implicit	Explicit
SSND1	37	36	10	25	07	14	14
SSND2	21	20	04	15	06	09	04
SSND3	23	23	02	13	02	04	09

CRUs = Conjunctively Related Units

Table 4.2 Conjunction in secondary sound texts

What is most significant about these results is the proportionately greater use of internal conjunction in SSND1 than in the other texts. This reflects differences in schematic structure, in that SSND1 includes an extended ANALOGIC ACCOUNT, in which several instances of internal conjunction occur, as well as a PHENOMENON EXEMPLIFICATION and IMPLICATION SEQUENCES, in which further instances occur. However, a comparison of the incidence of internal conjunction in the PHENOMENON EXEMPLIFICATION, IMPLICATION SEQUENCES and the Conclusion within the CLOSURE element, across all texts (Table 4.3), shows that the higher proportion of internal conjunction in SSND1 still holds, reflecting a difference in the reasoning in the text and not just the inclusion of a lengthy optional element of schematic structure.

Text	CRUs	Conjunctive relations		
		Internal	External	External Metaphorical
SSND1	15	04	09	03
SSND2	13	01	09	02
SSND3	19	02	12	01

Table 4.3 Conjunction in PHENOMENON EXEMPLIFICATION, IMPLICATION SEQUENCES and Conclusion elements of secondary sound texts.

What is common about the deployment of internal conjunction is that it scaffolds the staging of the texts into the elements of schematic structure as identified in the previous section. What is different across texts is the orchestration of internal and external conjunctive relations in realising the reasoning within the IMPLICATION SEQUENCES.

4.1.3.1 Conjunction and schematic structure

The internal conjunction marks off the elements of schematic structure largely by the combination of internal reformulation and internal consequence producing in the Analogic Account and the PHENOMENON EXEMPLIFICATION - IMPLICATION SEQUENCES, the kind of "sandwich structures" referred to by Martin (1993b:235) as typical of scientific explanation. The relationship between conjunction and schematic structure for the three texts is shown in Figures 4.4a - 4.6a in Appendix 4.

4.1.3.2 Conjunction and reasoning

The reasoning required in the reconstrual of the PHENOMENON EXEMPLIFICATION as technical implication sequences and then as a nominalised technical "meta" event, is much more elaborated through internal conjunction in SSND1 than in the other texts. These differences will be discussed by first explicating the role of conjunctive relations in the PHENOMENON EXEMPLIFICATION, IMPLICATION SEQUENCES and Conclusion elements of SSND1 and then comparing this with the deployment of conjunctive relations in these elements of the other two texts.

In SSND1 the pattern is a "sandwich" structure in which units 16-27 are simultaneously the specification of unit 15 and the rhetorical means for units 28-29. However, this double function of units 16-27 is staged by further internal consequential relations so that 16-19 is the means for 20-21 and 22-25 is the means for 26-27, then, taken together, 16-27 is the means for 28-29. This pattern of reasoning is indicated in Figure 4.7.

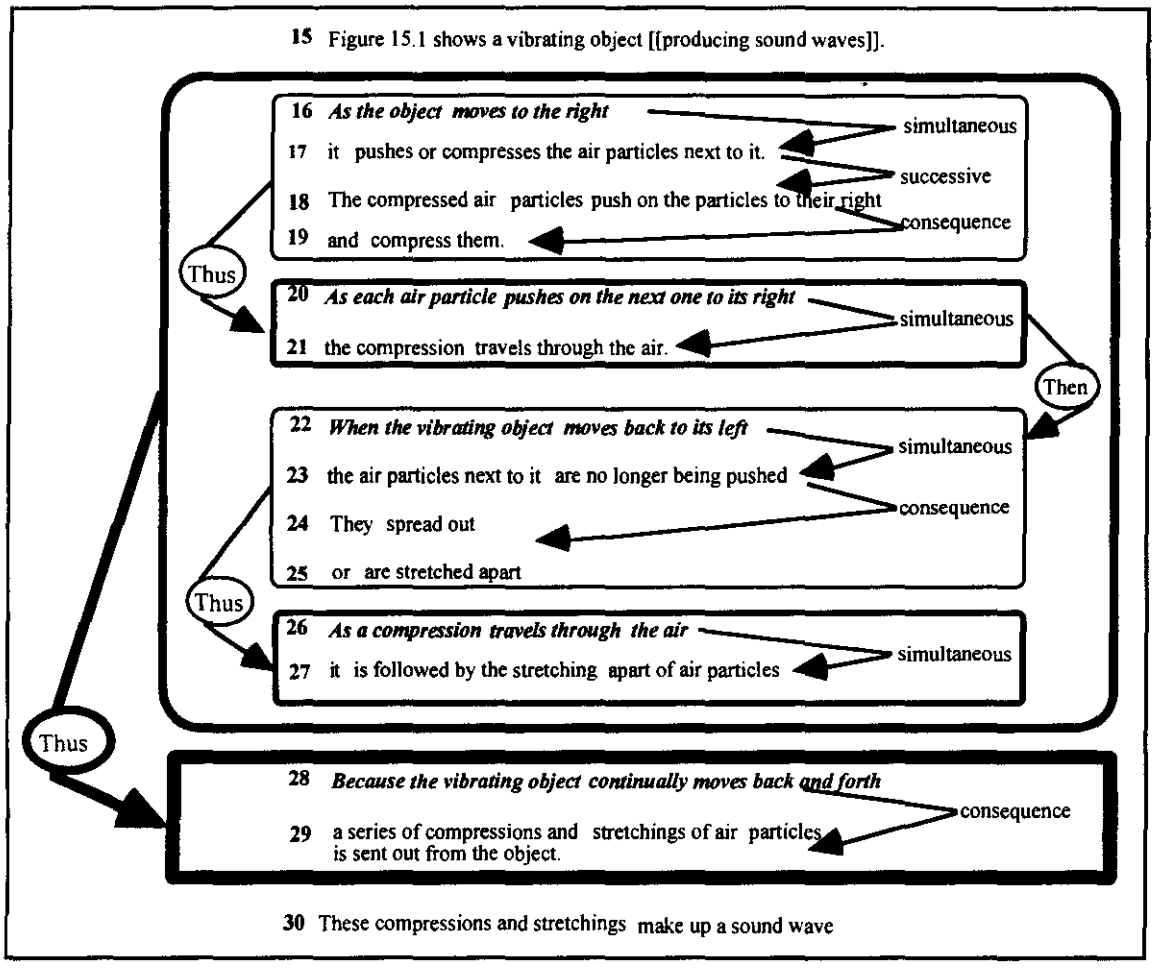


Figure 4.7 Internal conjunction and reasoning in SSND1

Within the first staging (16-21) we have the shift from the event of an object moving in a commonsense (potentially) observable implication sequence to the unobservable technical implication sequence of its compressing air particles and these compressing other air particles. This shift is achieved by the explicit, external, simultaneous relation between 16 and 17. (This external link of simultaneity could also be interpreted as conflating with an implicit logical relation of consequence.) External relations of succession and consequence then relate the commonsense event to the uncommonsense, unobservable implication sequence of air particles progressively compressing adjacent air particles - a technical event sequence. Now this recursion of technical events, realised again in clause 20, is related by external simultaneity (and implicitly consequentiality) to the single macro technical event in 21. It is the internal consequential relation that links 16-19 with 20-21 that provides the reasoning underlying the reconstrual of congruently realised recursive technical events in 16-19 (repeated in 20) as a metaphorically realised macro-technical event.

It is this orchestration of internal consequence and external simultaneity which is crucial in constructing the constituency relationship between the technical events and the macro

technical event at the rank above (This "constituency" can be thought of as a kind of Value/Token relationship.) This orchestration of internal and external conjunctive relations can also be seen in the combination of explicit simultaneity linking units 26 and 27 and the internal consequence relating these to previous units. In this case we have not only the construction of the macro event of the "stretching apart of air particles" moving out from the vibrating object but also the logical relation of this macro event occurring simultaneously with the previously constructed macro event of the compression moving out from the vibrating object. So we now have a macro-event complex in 26-27. The internal reasoning required to construct the macro-event of "the stretching apart of air particles" moving out, assumes an extension of the event sequence in 23-25 including the kind of logical relations developed in units 18-21. i.e. following unit 25 one would assume:

25a *so they are not pushing on the air particles to their right*
25b *and these also spread out.*
25c *As each of the air particles stops pushing on the next one to its right*
25d *a stretching apart of air particles moves through the air.*

The internal consequential relation involved in the logical shift from 24-25 to 26-27 then includes that in the inferred implication sequence between *25a-25b* and *25c-25d* as well as the internal consequential relation which reasons that the new macro-event is linked by simultaneity to the macro-event previously constructed to establish the macro-event complex.

The final internal consequential relation providing the rhetorical means for 28-29 extends in scope back to unit 16. It is the cumulation of previous reasoning that makes it possible to establish the consequential relation between the recursion of the observable implication sequence (the vibration of the object - unit 28) and the recursion of the macro-event complex (established by the logical metaphor "series" in unit 29). This recursive macro-event complex is then reconstrued nominally as the meta event in the Conclusion in clause 30:

30 These compressions and stretchings make up a sound wave.

In SSND2 the only internal conjunction is the single conjunctive relation which reformulates the PHENOMENON EXEMPLIFICATION as the IMPLICATION SEQUENCES. There is no internal consequential conjunction and no "sandwich" structure.

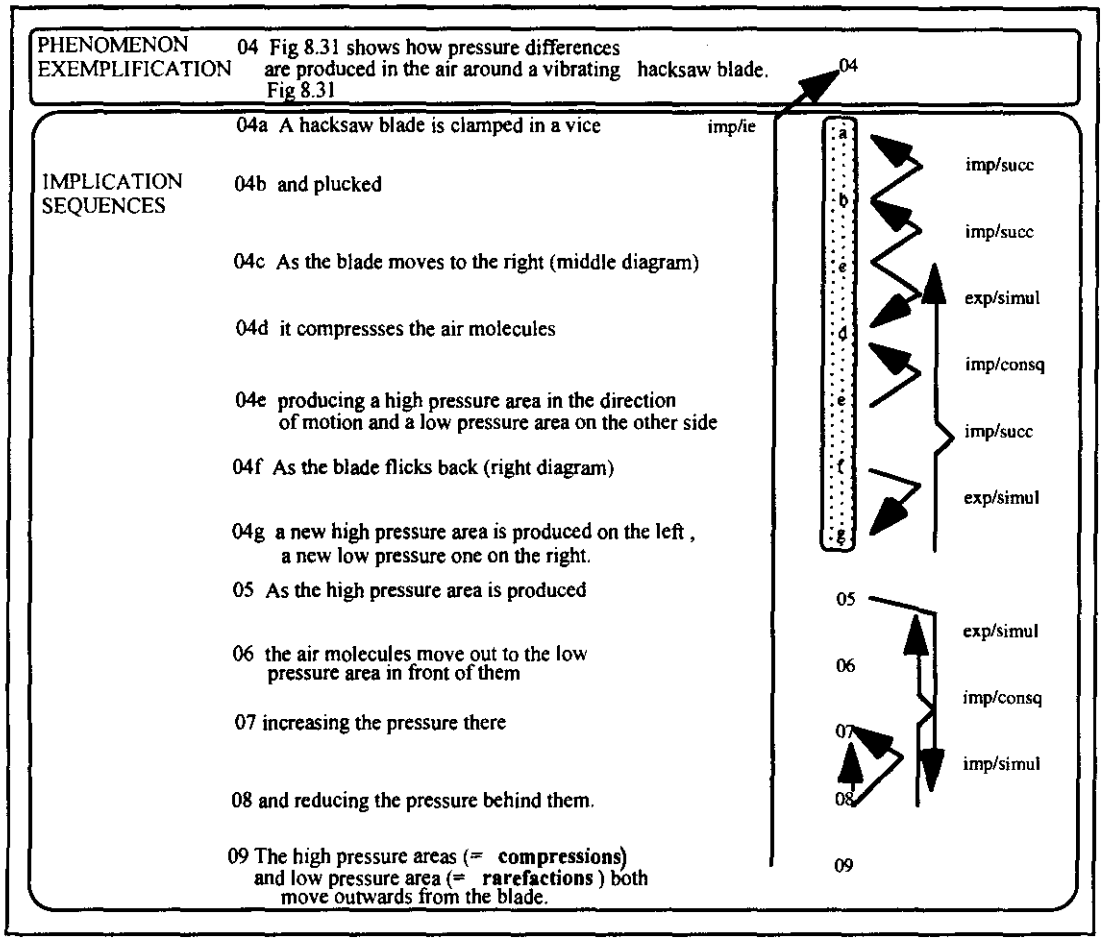


Figure 4.8 Conjunction in the PHENOMENON EXEMPLIFICATION and IMPLICATION SEQUENCES of SSND2

As in SSND1 the notion of explaining the cause of sound waves by reconstruing observable events in terms of unobservable technical events is supported by the external conjunctive relations of simultaneity, which can also be read as conflating external consequence (04c-04d; 04f-04g). However, in this text, this logical relation of simultaneity does not link recursive technical events of air molecules moving, with macro technical events of compressions or high pressure areas moving, as occurred in SSND1. It is only as a "repair strategy" in the Conclusion element, that the congruent technical implication sequences are linked (within an embedded clause) by external simultaneity to metaphorically realised macro technical events:

13 It is important to note that the air molecules move backwards and forwards as the compressions and rarefactions are transmitted outwards but the air as a whole does not move - winds are not set up.

Part of the reason that this text segment is necessary is because the clause in which the macro-events are introduced is logically isolated from the remainder of the text. This can be

seen by noting clause 09 in the Figure 4.8. As noted in the analysis of SSND1, it is the recursion of the technical events (air particles moving and compressing adjacent air particles) related by external simultaneity to the macro-event which constructs the "dynamic constituency" or Value/Token relation between the events realised at two different levels of abstraction. And this is necessary to avoid the misconception about actual literal movement of air away from the vibrating object. Furthermore, it is the congruent account of the unobservable technical implication sequence that is the rhetorical means for constructing it as a recursive event which can be then be linked by simultaneity to the macro-event. Hence internal consequential relations are crucial to effective reconstrual of technical events in terms of a macro technical event. Not only is there no realisation of the recursion of technical events in this text (apart from the "repair strategy") but the crucial internal consequential relations are entirely absent. Obviously there is also no realisation of the recursion of macro-event complexes (a series of compressions and rarefactions moving out from the object) reconstrued as a meta event - the sound wave travelling through the air. Hence there is no Conclusion element in this text. The text lacks the clear reasoning of SSND1.

In SSND3 there are only two internal conjunctive relations forming the "sandwich" structure in which units 07 - 22 are simultaneously the specification of 05-06 and the rhetorical means for 23, as shown in Figure 4.9.

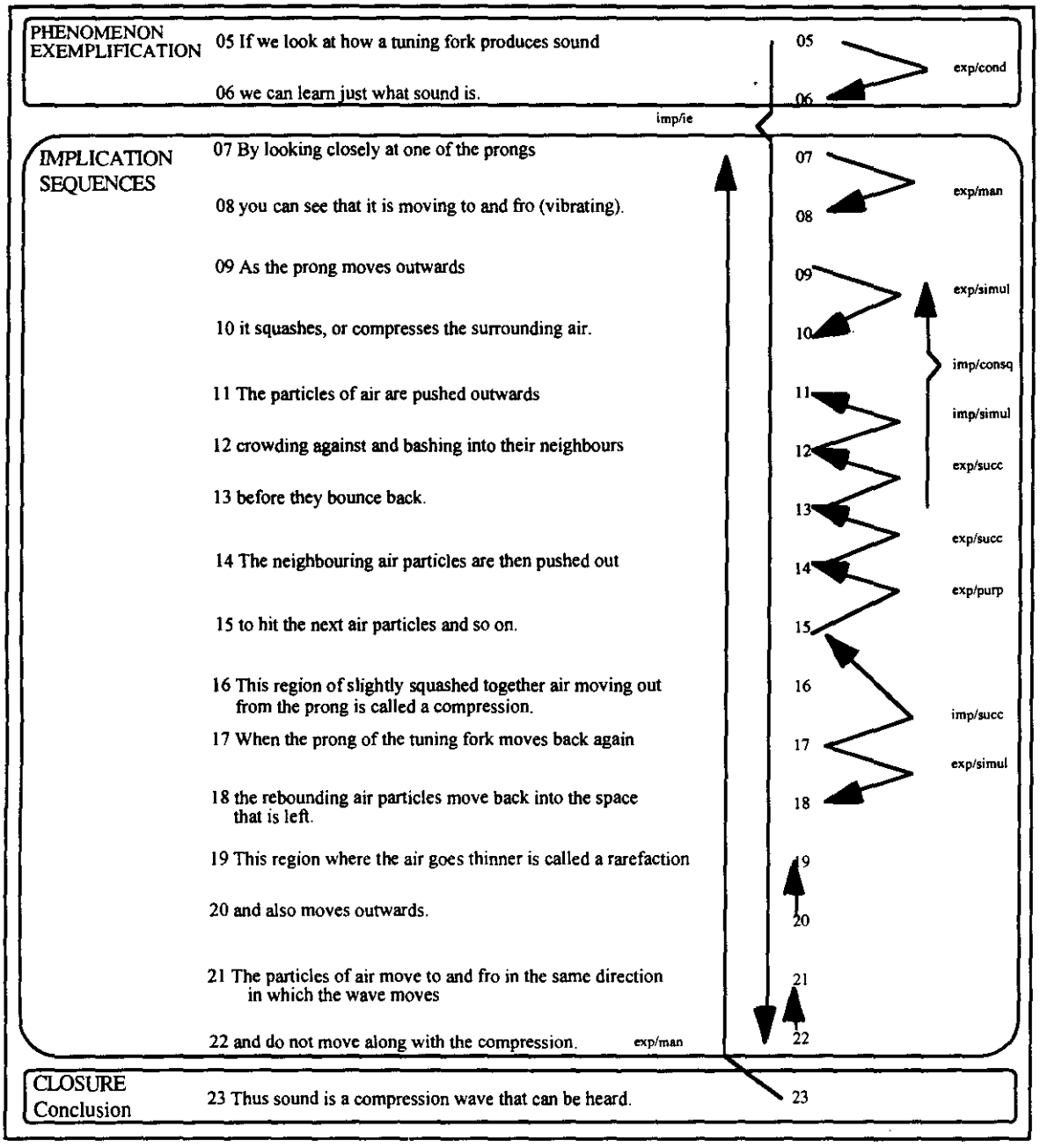


Figure 4.9 Conjunction in the PHENOMENON EXEMPLIFICATION, IMPLICATION SEQUENCES and Conclusion of SSND3

It is significant to note that unit 16 is not conjunctively related to the prior or following text. It is this unit that confronts the reconstrual of technical events as a macro technical event:

16 This region of slightly squashed together air moving out from the prong is called a compression.

This is agnate to the following units from SSND1:

20 As each particle pushes on the next one to its right
21 the compression travels through the air.

The simultaneous/(consequential) logical relation which constructs the "Value/Token" relationship between the technical event sequence in 20 and the macro technical event in 21 in SSND1, is not included in SSND3. Furthermore in SSND1, it is the recursion of the technical event sequence in 20 which is reconstrued as a macro event in 21 and the internal consequential relation linking 20-21 with 16-19 is the rhetorical means for this. Now this recursion is realised in SSND3:

14 The neighbouring air particles are then pushed out
15 to hit the next air particles and so on.

But the recursion is not linked logically to the event in 16 which is only realised metaphorically in the extended nominal group as Value in the Relational: identifying clause ("This region of slightly squashed together air moving out from the prong"). The inadequate realisation of this "dynamic constituency" in SSND3 is explicitly taken into account in the text with the "repair strategy" in units 21 and 22:

21 The particles of air move to and fro in the same direction in which the wave moves
22 and do not move along with the compression.

The part of the explanation beginning with unit 17 deals with what happens when the prong of the tuning fork moves back in the opposite direction. In this segment of SSND3 there are very few logical relations linking the events compared with the agnate segment of SSND1. This can be seen in Figure 4.10:

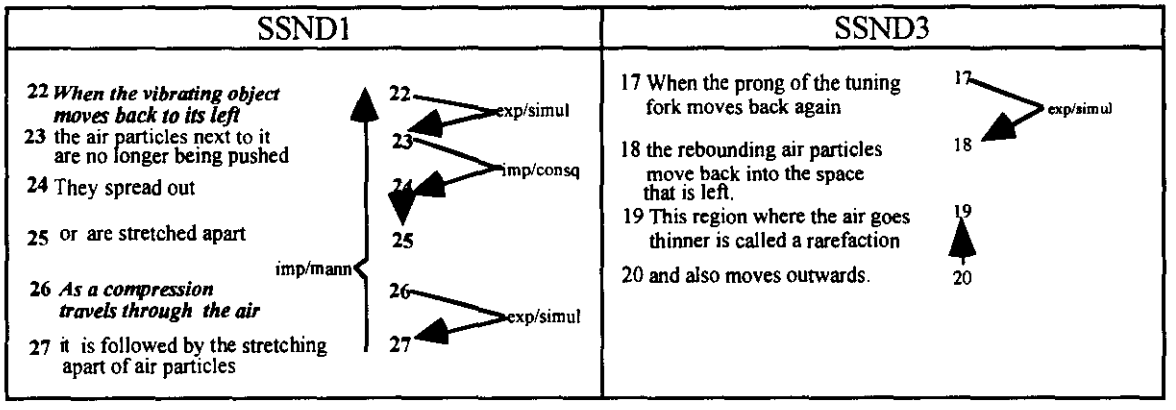


Figure 4.10 Comparison of conjunction in agnate segments of SSND1 and SSND3

In SSND3 the commonsense metaphor of "bouncing" (introduced in unit 13) is used as a Classifier for air particles, obviating the external consequential relation which links 23 and 24 in SSND1. In SSND3 there is no reasoning - even implicit - to support unit 20. By contrast in SSND1, the implicit, internal consequential relation linking 22-24 with 25-26 indicates that the newly established technical event sequence in 22-24 can be reconstrued as a macro event occurring subsequently to the previously established macro event and that it also occurs as a result of the recursion of the constituent technical event sequences.

It is difficult to see how the Conclusion to SSND3 constructed by the text's only internal consequential relation linking 23 to 07-22 (Figure 4.9 above), is derived from the latter sequence of clauses. As the premises for 23, there are obvious logical gaps in the rhetorical development from 07-22, as noted above in relation to clauses 16 and 20. By contrast, in SSND1 the internal consequence linking 28-29 with 16-27 reasons that, on the basis of the previous two segments establishing the macro events, the recursion of the commonsense, observable events results in recursion of the macro events. The recursive macro events are then Value to the Token for the meta event - the sound wave:

28 Because the vibrating object continually moves back and forth
29 a series of compressions and stretchings of air particles is sent out from the object.
30 These compressions and stretchings make up a sound wave. (SSND1)

The role of more extensive internal conjunction in constructing the elaborated reasoning in SSND1 contributes to a more effective explanation than the other two texts.

4.1.4 "Depth" of treatment and variation across texts in the selection of, and reader access to, ideational meanings.

Two aspects of variation in meaning availability were explored. The first involved the construction of semantic maps, as detailed in Chapter two (2.3.3.4), to chart the relative distribution across texts of meanings categorised as nuclear, elaborative and peripheral. The construction of the semantic map for the IMPLICATION SEQUENCES element of the secondary sound texts is briefly discussed. The results of the analysis are reported for designated phases of the IMPLICATION SEQUENCES in turn, and then a consolidated semantic map for each text is provided to show overall variation across texts in depth of treatment from this perspective.

The second aspect of variation in meaning availability explored was the means of reader access to ideational meanings. This involved categorisation of nuclear and elaborative meanings in the IMPLICATION SEQUENCES in each text according to the network of meaning access discussed in Chapter two and summarised in Figure 2.8.

4.1.4.1 A semantic map for IMPLICATION SEQUENCES in the secondary sound texts

The semantic mapping focuses on the IMPLICATION SEQUENCES because this obligatory element of schematic structure is the core of the explanation of sound waves and is the most extensive common element of schematic structure across the texts. The semantic map indicating the instantial semantics of the explanation of sound waves as evidenced in the three secondary texts is shown in Figure 4.11. Again the "main path" was determined by an algorithm similar to that applied by Paris and McKeown (1987). This involves backtracking from the "goal state" to the "start state", tracking the process line directed to the goal state to the participant from which it emanates and then picking up all process lines directed to this participant, tracking these to the participant(s) from which they emanate, and so on. Relation lines connecting map segments are part of the main path. The main path then, determines the nuclear meanings, which are those connected by thick black lines in the figure. Elaborative meanings are those other than the ones indicated by thick lines. Elaborative meanings which occur in only one text are *marginalised* elaborative meanings and are indicated by faint dotted lines. Elaborative meanings which occurred in at least two of the texts are *endorsed* elaborative meanings and are indicated by normal black lines. Peripheral meanings are not directly relevant to the technical events comprising sound waves and are not mapped, e.g.

04a A hacksaw blade is clamped in a vice (SSND2)

07 By looking closely at one of the prongs (SSND3).

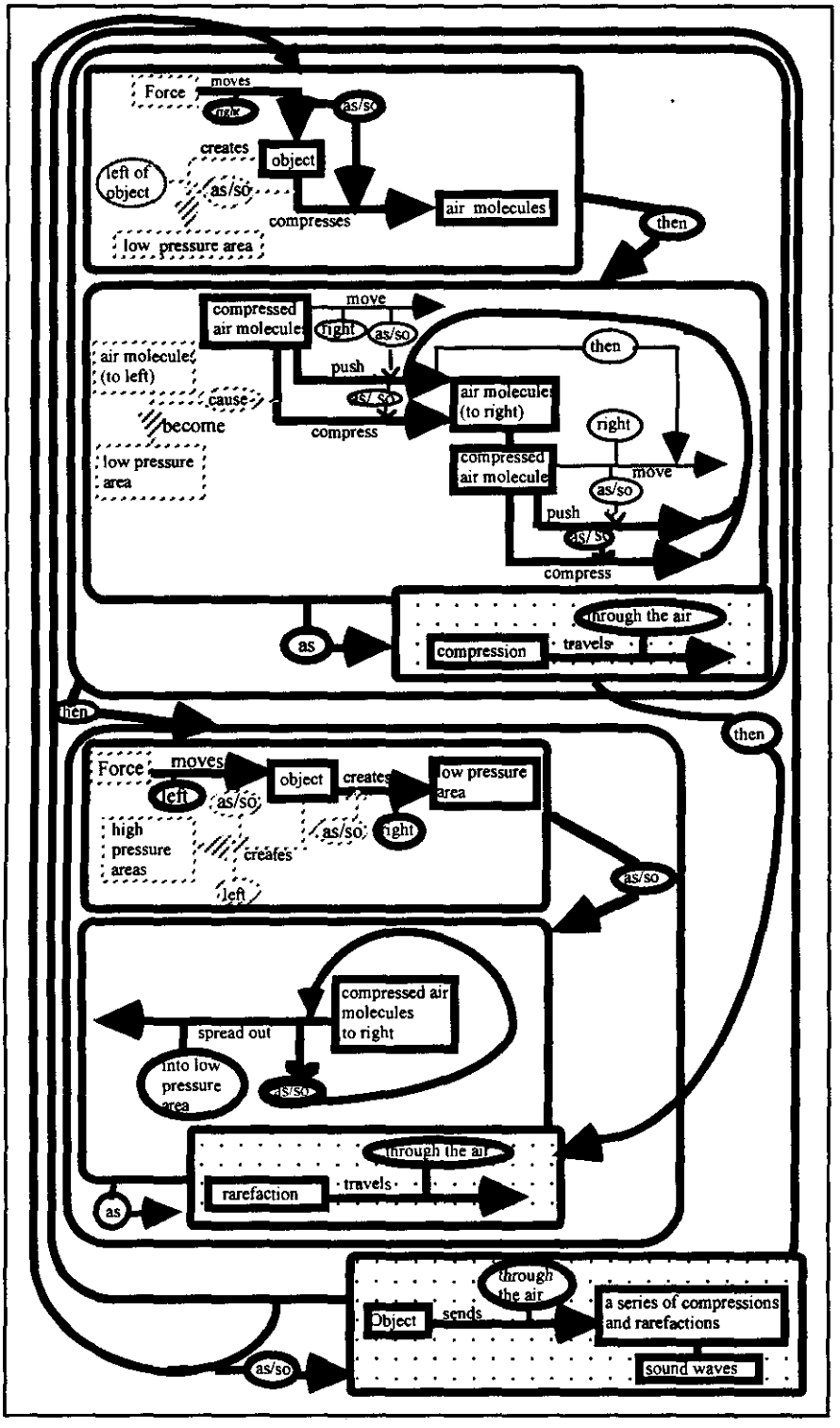


Figure 4.11 Instantial semantics of formation of sound waves in secondary texts

Figure 4.11 maps not only the temporal and consequential progression of events but also their progression through levels of abstraction. This is indicated by the map segments on "dotted" background. The final map segment (Figure 4.12) is an abstraction from the recursion of events represented by the combination of the rest of the map segments.

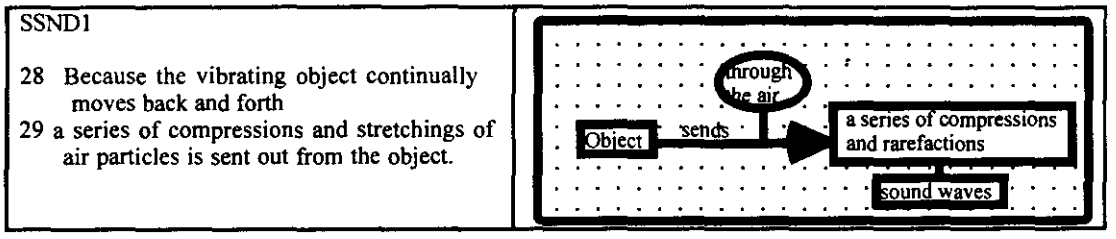


Figure 4.12 Final segment in semantic map for sound texts

The map segment in Figure 4.13 is an abstraction from the meanings represented in Figure 4.14 and so on.

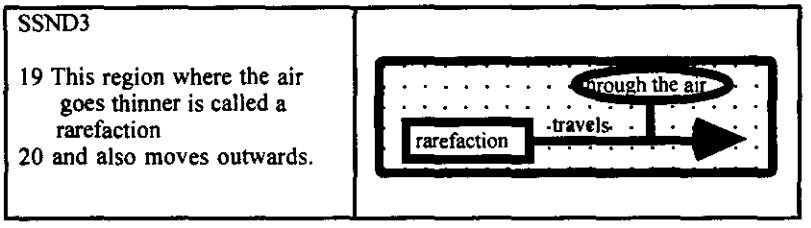


Figure 4.13 Map segment as abstraction from previous segment in semantic map for sound texts

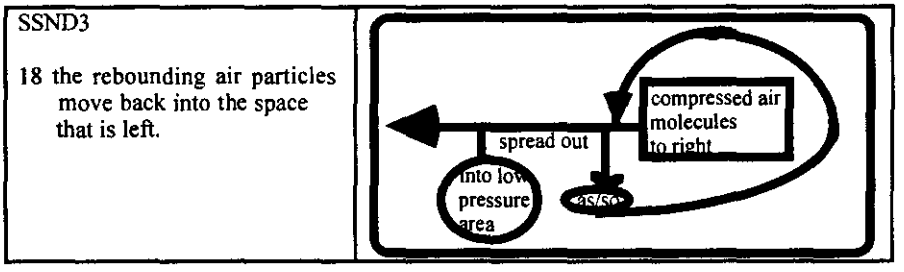


Figure 4.14 Segment from semantic map for sound texts

Since the main path is tracked through the map segment in Figure 4.12 to the remaining text segments as a whole, Figure 4.13 is the next point from which to track back the main path. Its meanings are therefore considered nuclear and are linked by the relation line to the meanings in the map segment shown in Figure 4.14 above. There is only one participant-process representation in this segment so this is considered nuclear (i.e. essential to the progression of the text) and is linked by the relation line to the meanings in the next map segment shown in Figure 4.15.

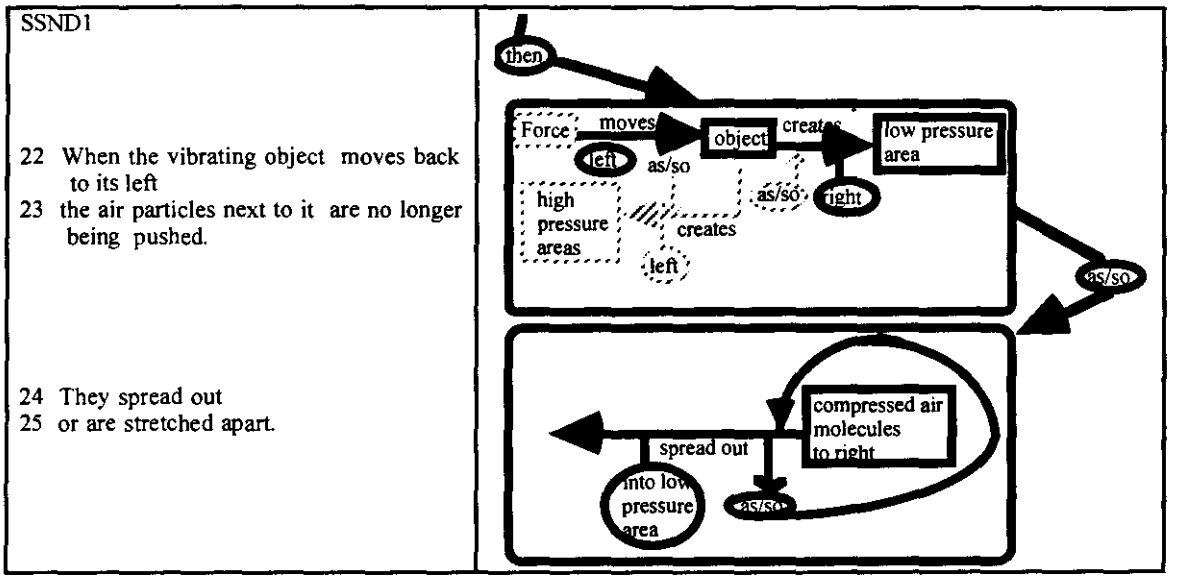


Figure 4.15 Tracking the main path within and across map segments

The final participant in this segment is *low pressure area*, so the algorithm then proceeds by tracking the process lines directed to this, the participants from which they emanate, the process directed to those participants and so on, with relation lines linking across map segments.

The map represents the meanings underlying the vibrating object as *Force moves object to the right/left*. In fact the meaning *Force* is not instantiated in the secondary texts, apart from the hacksaw blade being "plucked" in SSND2. However, it is necessary to represent this aspect of the underlying semantics so that the application of the algorithm for determining the main path would include the meanings *object moves left/right*, which are clearly nuclear in that they are essential to the progression of the text.

4.1.4.2 Variation in ideational meanings in IMPLICATION SEQUENCES

The text segments and semantic maps for the first phase of the IMPLICATION SEQUENCES are shown in Figure 4.16.

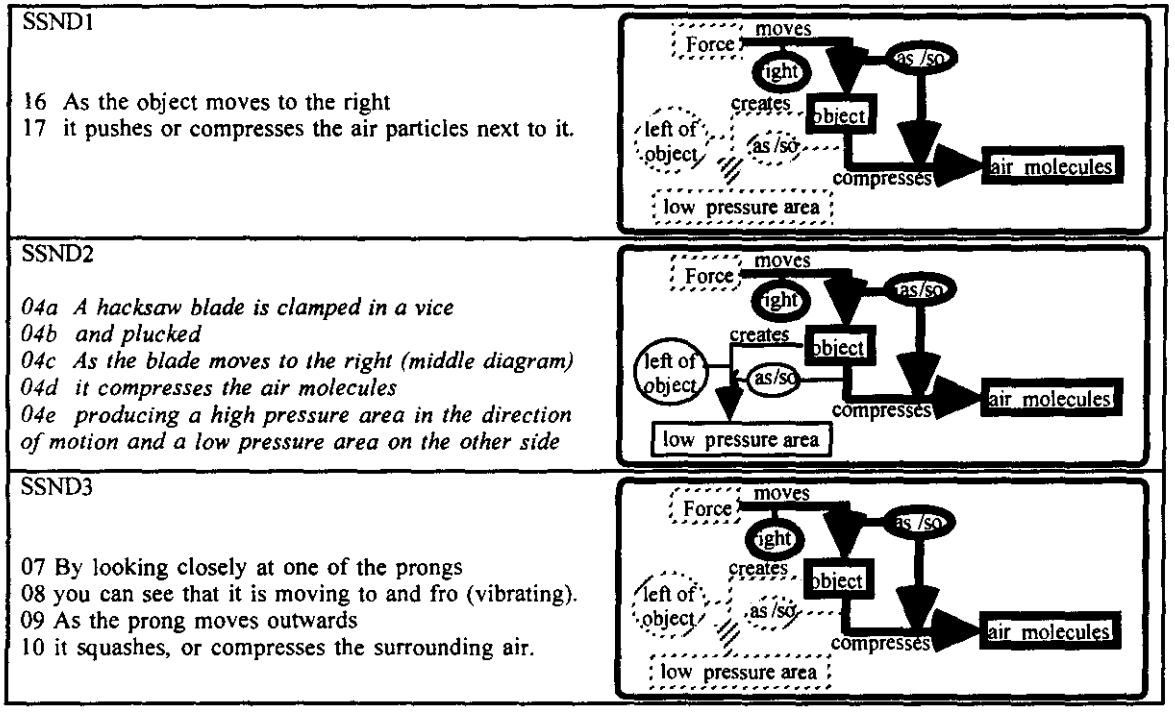


Figure 4.16 Semantic maps for first phase of IMPLICATION SEQUENCES in secondary sound texts

The nuclear meanings in this phase are common across the texts and the only elaborative meanings occur in SSND2. This is the only text to mention the effect of the vibrating object on air molecules to its left as well as those to its right. The other two texts focus only on the air to the right of the object.

The text segments and semantic maps for the second phase of the IMPLICATION SEQUENCES are shown in Figure 4.17.

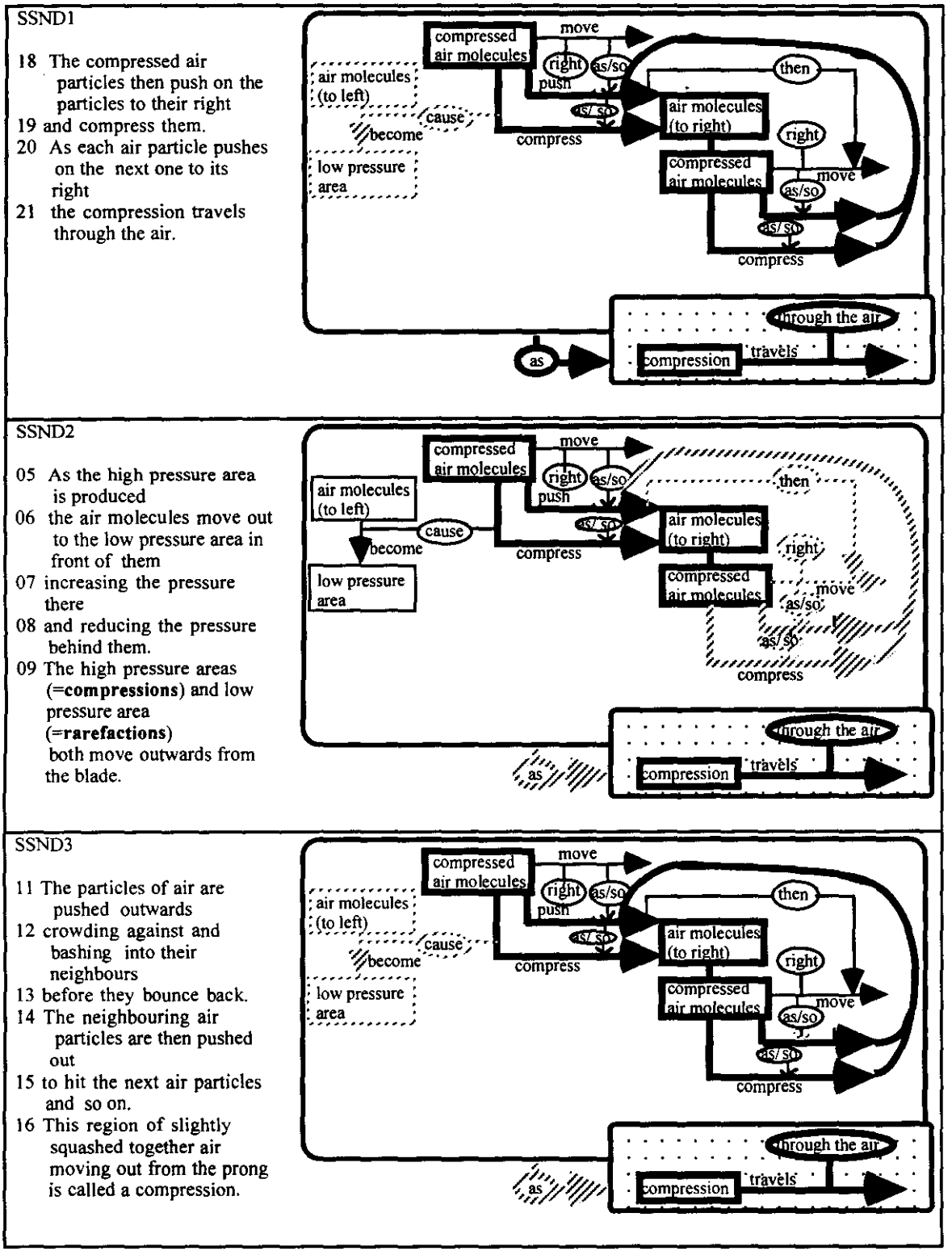


Figure 4.17 Semantic maps for second phase of IMPLICATION SEQUENCES in secondary sound texts

The meanings in this phase of SSND1 and SSND3 are quite similar except for the absence in SSND3 of the logical relation of simultaneity linking the recursive technical events to their more abstract formulation as *compression travels through the air.* This logical

relation is also absent in SSND2. In addition, SSND2 does not include the nuclear meaning of the recursion of the compressed air molecules moving out to compress adjacent air molecules. However, this text is the only one to include the elaborative meaning of the creation of a low pressure area behind the compressed air molecules as they move out to the low pressure area in front of them. (The meaning in clause 09 of SSND2 of the rarefaction moving out through the air is shown in a subsequent segment of the semantic map.)

The text segments and semantic maps for the third phase of the IMPLICATION SEQUENCES are shown in Figure 4.18.

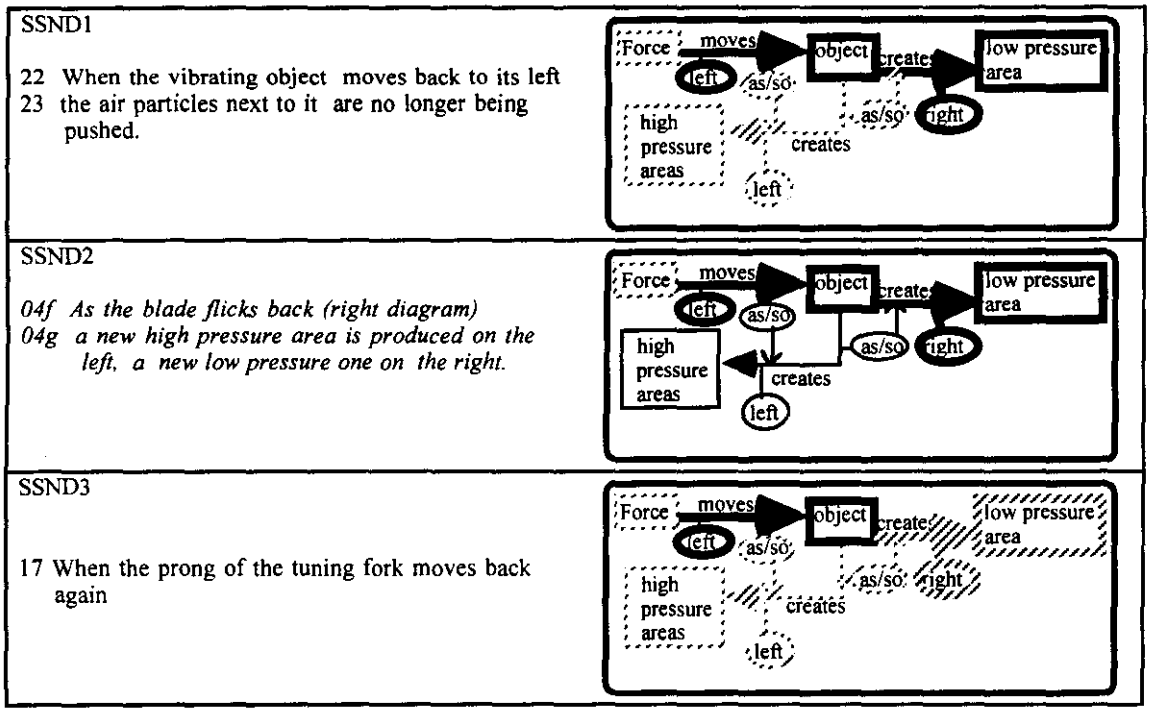


Figure 4.18 Semantic maps for third phase of IMPLICATION SEQUENCES in secondary sound texts

The difference in nuclear meanings here is that SSND3 does not indicate that the object's move to the left changes the pressure of the air to its right.

The text segments and semantic maps for the fourth phase of the IMPLICATION SEQUENCES are shown in Figure 4.19.

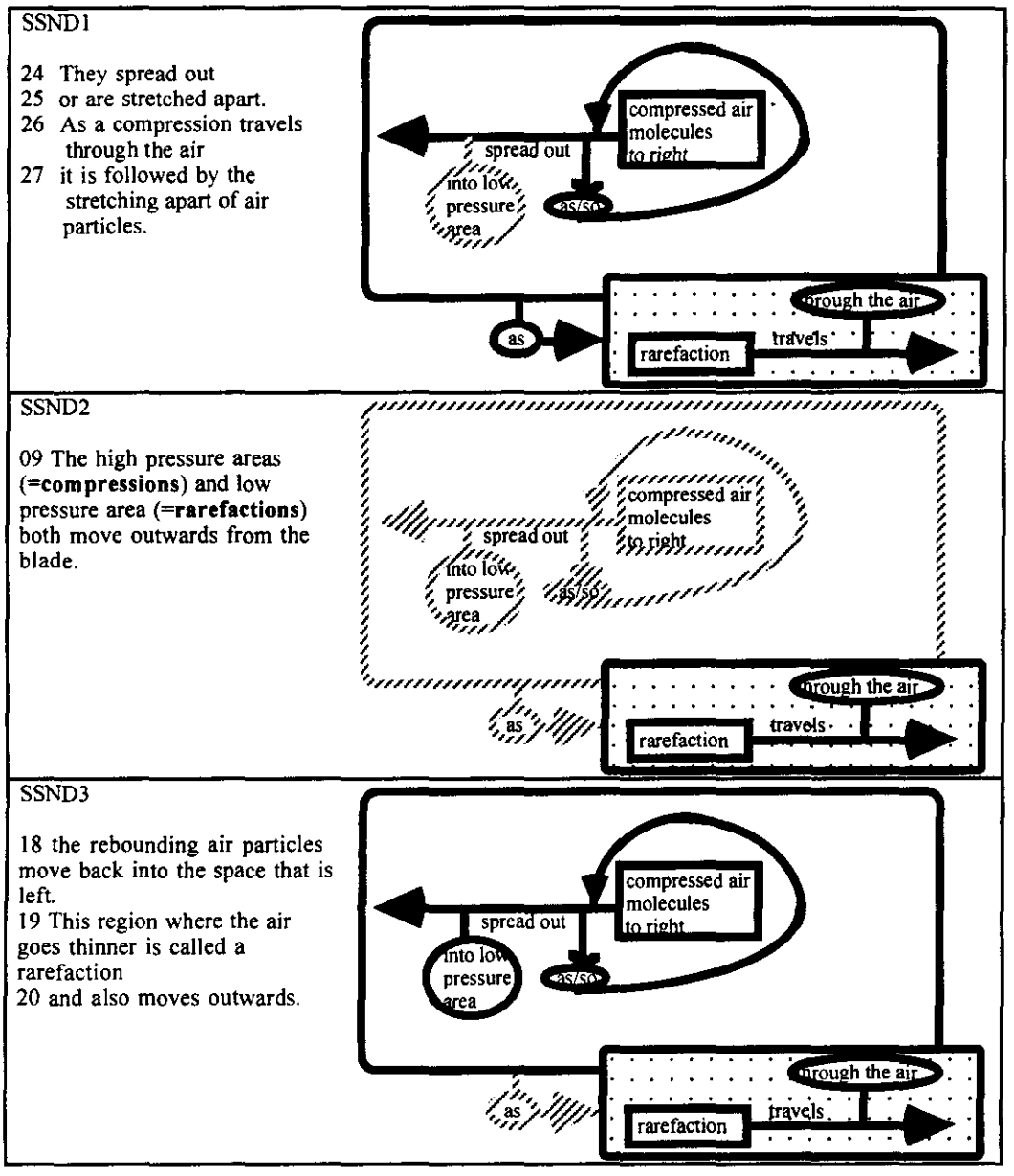


Figure 4.19 Semantic maps for fourth phase of IMPLICATION SEQUENCES in secondary sound texts

The obvious difference in the nuclear meanings in this phase is that SSND2 makes no mention of the compressed air molecules moving back to the left when the vibrating object moves to the left, although it indicates (Clauses 06-08, Figure 4.17 above) that a low pressure area is created behind the molecules as they move out. SSND1 indicates that the air molecules spread out but does not mention the low pressure area they move into. In SSND3 the meaning *low pressure area* is scriptally implicit in "the space that is left". The other difference is that only SSND1 includes the logical relation of simultaneity between the technical events and their more abstract formulation as a macro technical event.

The logical relation of temporal succession indicating that the rarefaction follows the compression, which is realised in clauses 26 and 27 in SSND1, is shown as a relation line on the complete semantic map for this text (Figure 4.21). The meaning that the compression travels through the air in SSND2 is shown on the previous map segment for this text (Figure 4.17 above).

The final phase in the IMPLICATION SEQUENCES element occurs only in SSND1. The semantic map and text segment are shown in Figure 4.20.

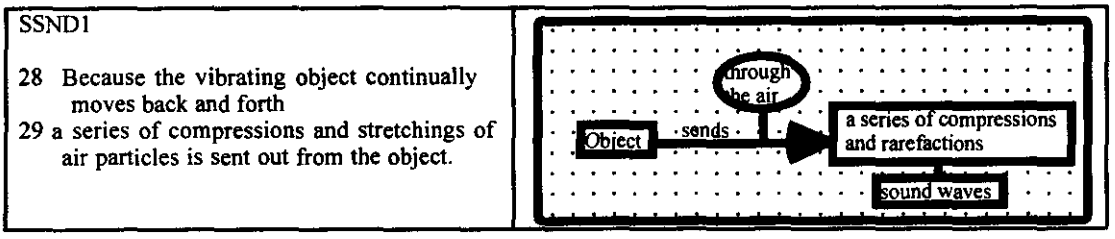


Figure 4.20 Semantic map for final phase of IMPLICATION SEQUENCES in SSND1

Summarising how secondary texts vary in their "depth" of treatment of the Field

There is significant variation across the three texts in the selection of nuclear meanings and elaborative meanings as shown in Figure 4.21. The major variation is between SSND1 and SSND3 on the one hand, and SSND2 on the other. The semantic maps for SSND1 and SSND3 are fairly similar. There are three differences. The final phase of abstraction, the meta technical event, *Object sends a series of compressions and rarefactions through the air*, does not occur in SSND3. The relations of simultaneity linking recursive technical events with the abstract macro technical event in a kind of Value/Token relationship (and similarly the meta technical event to previous observable and technical event sequences), are also absent from SSND3. Finally SSND3 does not indicate that the object's move to the left changes the pressure of the air to its right. Both SSND1 and SSND3 exclude the elaborative meanings concerned with the effect of the vibrating object on air molecules to its left.

On the other hand SSND2, as well as excluding the final phase of abstraction and the logical relations of simultaneity linking technical events with more abstract formulations, also excludes the nuclear meanings of the recursion of the compressed air molecules moving out to compress adjacent air molecules, and the recursion of compressed air molecules moving back to the left when the vibrating object moves to the left.

There were few elaborative meanings. Most of these were marginalised, occurring in SSND2 only. Nuclear meanings were dealt with most comprehensively in SSND1.

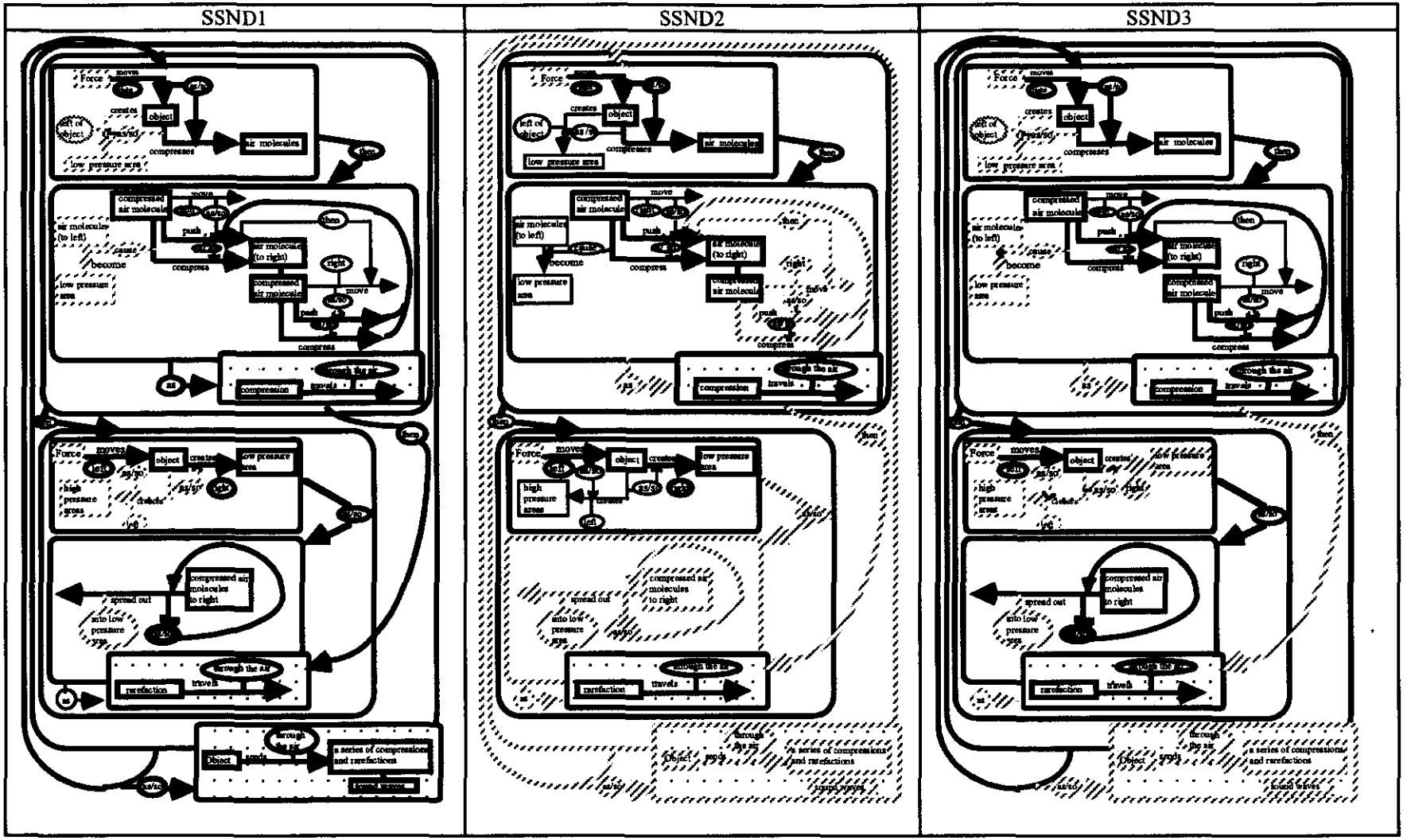


Figure 4.21 Nuclear and elaborative meanings in secondary sound texts

4.1.4.3 Variation in types of reader access to ideational meanings in IMPLICATION SEQUENCES

The results of the categorisation of nuclear and elaborative meanings in the IMPLICATION SEQUENCES are summarised in Tables 4.1a and 4.2a in Appendix 4.

The main finding was the higher proportion of literal meanings in SSND1, as shown in Table 4.4. The proportions were calculated as the number of literal realisations per nuclear meanings included in the text. Although SSND2 had the least comprehensive account of nuclear meanings, they were mainly literally accessible, whereas of the somewhat higher number of nuclear meanings in SSND3, a greater proportion relied on inference.

Text	SSND1	SSND2	SSND3
% Nuclear Meanings Literal (Explicit + Implicit)	85	83	76

Table 4.4 Proportion of nuclear meanings realised literally in secondary sound texts

Access to elaborative meanings is predominantly literal and explicit.

In summary, SSND1 deals most comprehensively with nuclear meanings and provides the greatest proportion of literal access to them. Elaborative meanings are minimal in this text. SSND3 deals less comprehensively with nuclear meanings and they are developed least in SSND2, however this text includes the greatest proportion of elaborative meanings.

4.1.5 Variation in the linguistic construction of technicality in secondary sound texts

The linguistic construction of technicality in these texts initially involves the reformulation of commonsense descriptions of sound production which are realised by grammatical metaphors fairly familiar in everyday talk. In this reformulation the explanation of how sound travels can be thought of as the reconstrual of commonsense, observable implication sequences in terms of uncommonsense, unobservable, technical implication sequences. The latter involving the progressive reconstrual of technical event sequences as macro technical events and then these as a "meta" technical event, so the implication sequences form a kind of rank scale of technicality. Firstly, we have the "commonsense", observable activity sequence of the object moving back and forth. The first rank of the invisible, uncommonsense, technical activity sequence is the object compressing air particles and those air particles compressing other air particles and so on. The second rank is the macro-events of the compression and rarefaction travelling outwards from the object. And the

third rank is the "meta-event' of the sound wave (i.e. a series of compressions and rarefactions) moving out from the object.

The previous section discussed the variation in the extent to which these texts dealt with the nuclear meanings involved in this reconstrual, with SSND1 providing the most comprehensive account. The discussion of conjunction (4.1.3.2) showed that the orchestration of internal consequence and external simultaneity was crucial to the construction of a kind of constituency or "Value/Token" relationship between technical event sequences and their reconstrual at a higher level of abstraction - with this occurring effectively in SSND1 only. The discussion of the Theme analyses (4.1.2) indicated that SSND1 provided the most effective texturing of this reconstrual, with marked Themes structuring a method of development progressively moving the point of departure from constituent events to macro-events in terms of both commonsense and technical implication sequences and with new technical information, introduced rhematically, eventually being accumulated as a Hyper-New. This section will examine variation across texts in the patterning of choices from within the transitivity system and the deployment of grammatical metaphor in realising the experiential meanings involved in the progressive reconstrual along the rank scale of technicality noted above.

4.1.5.1 Transitivity

The transitivity analyses are shown in Figures 4.7a - 4.9a in Appendix 4. The selection of process types is summarised in Table 4.5.

TEXT	CLAUSES	Material		Mental	Relational						Behavioural	Verbal
		Effective	Middle		Identifying			Attributive				
					int	circ	poss	int	circ	poss		
SSND1	37	22	11	0	4	3	1			1		
SSND2	21	14	10	0				2				1
SSND3	23	8	10	4	4			1	1		2	

Table 4.5 Summary of process types in secondary sound texts

Material processes are predominant in all texts and the proportion of effective material processes to total processes is similar in SSND1 (52%) and SSND2 (52%) and lower in SSND3 (27%). The significance of this variation will be discussed by first outlining the deployment of effective and middle Material processes in SSND1 and then comparing this with the other two texts.

The deployment of effective Material clauses contributes to the construction of an agentive link between the middle clauses realising the observable event on the one hand and the

abstract technical events on the other. This begins with highly metaphorical realisations of the agentive link in effective Material clauses. For example:

05 Vibrating materials send sound waves through the air.

16 ... a vibrating object producing sound waves.

The metaphorical participants are subsequently "unpacked" and realised congruently as middle and effective Material clauses. Then there is a progressive re-metaphorization so that constituent events are realised as Things which can then function as participants in events realised grammatically at higher levels of abstraction. The explanation of how sound travels then, involves the semiotic reconstrual of familiar grammatical metaphors as congruently realised constituent commonsense and technical implication sequences, then as abstract events involving the use of more technical metaphors, which can be related to the original familiar metaphorical realisations.

The text SSND1 includes three discrete "passes" at this semiotic reconstrual, with greater delicacy of focus in each segment. The first "pass" is the Link element in clauses 01-04.

01 To make sounds requires vibrations which disturb the air.
02 Small vibrations cause soft sounds.
03 Large vibrations disturb the air more
04 to produce loud sounds.

The focus here is quite gross. All of the clauses are effective but the Agents are all nominalised event sequences and the Mediums are "sounds" and "air". The effective clauses grammaticalize causal relations but the level of abstraction remains high.

The second "pass" is the Analogic Account extending from clauses 05-14. The metaphorical realisations of the Agent and Medium in clause 05 are to be reformulated in the subsequent text.

05 Vibrating materials send sound waves through the air.
06 As the materials vibrate
07 they disturb the air particles near them.
08 These air particles disturb other air particles and so on.
09 Just like a long chain of dominoes, the disturbance or sound wave is passed on from air particle to air particle.
10 Unlike the dominoes, the air particles spring back to their original position.

11 Sound waves travel through gases, liquids and solids
12 because they all contain particles [[which will carry or transmit disturbances]].
13 However, sound waves will not travel through a vacuum
13.1 which is an empty space:
14 without particles [[to transmit the disturbance from a vibrating object]], sound waves cannot be formed.

The first step in this reconstrual is the unpacking of the nominalisation as Agent in clause 05 as a middle Material clause -

05 Vibrating materials ⟶ 06 As the materials vibrate

Then we have a technical invisible event in which the Medium from clause 06 becomes the Agent:

07 they disturb the air particles near them.

and the Medium from clause 07 becomes the Agent in the next clause:

08 These air particles disturb other air particles and so on.

These clauses typify the first rank on the rank scale of technicality. The events are invisible but are realised congruently. The technical events at this rank however, are then nominalised to become metaphorical participants in a technical event at a higher level of abstraction - a second rank on a rank scale of technicality:

09 ..... the disturbance or sound wave is passed on .....
12 .....which (particles) will carry or transmit disturbances.

These clauses at this second rank are effective. Clause 12 is linked by a consequential conjunctive relation to the middle Material clause (11) that reconstrues these events at a third level of abstraction:

11 Sound waves travel through gases, liquids and solids
12 because they all contain particles which will carry or transmit disturbances.

The third "pass" develops this reconstrual in much more detail. It consists of the PHENOMENON EXEMPLIFICATION ^ IMPLICATION SEQUENCES ^ Conclusion. The starting point is the PHENOMENON EXEMPLIFICATION in clause 15 - again a highly metaphorical realisation, which is to be reformulated.

15 Figure 15.1 shows a vibrating object [[producing sound waves]].
16 As the object moves to the right
17 it pushes or compresses the air particles next to it.
18 The compressed air particles then push on the particles to their right
19 and compress them.
20 As each air particle pushes on the next one to its right
21 the compression travels through the air.
22 When the vibrating object moves back to its left
23 the air particles next to it are no longer being pushed.
24 They spread out
25 or are stretched apart.
26 As a compression travels through the air
27 it is followed by the stretching apart of air particles.
28 Because the vibrating object continually moves back and forth
29 a series of compressions and stretchings of air particles is sent out from the object.
30 These compressions and stretchings make up a sound wave.

The commonsense events are realised in clauses 16, 22 and 28. These are all middle clauses in which the Medium is the same 'concrete' participant. The first rank of technical implication sequences is realised as clauses 17-20. These are all effective clauses. In clause 17 the Agent is "the object" i.e. the Medium from the commonsense event in the previous clause. This pattern where the Medium from one clause becomes the Agent in the next is sustained across clauses 18 through 20, with the Mediums/Agents all unobservable, technical participants. Then the effective clause 20 (summarising 18-19) is linked logically by explicit simultaneity and implicit consequence to 21 in a kind of Value/Token relationship. Therefore the middle Material clause of the macro-event (21) is linked to the middle material clause of the commonsense event (16) by a kind of "agentive chain" across the intervening effective clauses as indicated in Figure 4.22.

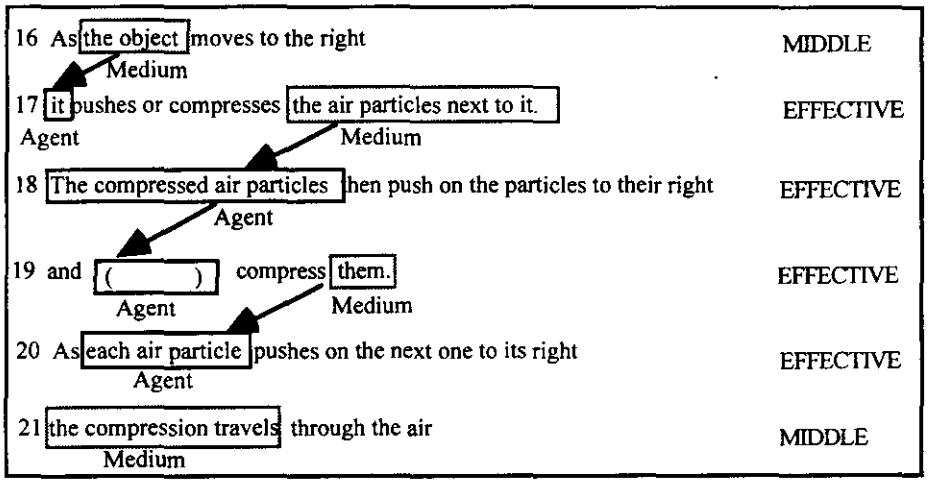


Figure 4.22 An "agentive chain" linking an observable event to a macro technical event

A similar argument could be made for the linking of the second macro-event (the stretching of air particles moving through the air) to the middle Material clause ...

"When the vibrating object moves back to its left..",

however this is not as clear because the effective clauses 24 and 26 are agentless passives and, in fact, the selection of "are stretched apart" in 26 and "spread out" in 25 sets up a tension between effective and middle realisations. There is no indication in the text as to the identity of the implied Agent in 26, nor is there any indication that "stretched apart" may refer to an analogy. Nevertheless, the agentive links between the commonsense events and the two macro events are picked up by the explicit external consequential relation between 28 and the recursive macro-event complex in 29, which is realised as an effective, Material, agentless passive clause. The complex nominalisation which is the participant in the "meta" technical event in clause 29 is then, in clause 30, identified with the original metaphorical participant, "sound wave" from clause 15. So the reconstrual comes full circle and the metaphorical, consequential relation realised by "producing" in clause 15 is explicable partly via the establishment of this kind of agentive chain between commonsense and technical events.

In the second text (SSND2) the PHENOMENON EXEMPLIFICATION is again realised by a highly metaphorical effective Material clause:

04 Fig 8.31 shows how pressure differences are produced in the air around a vibrating hacksaw blade.

The observable implication sequence is realised metaphorically as a nominal group in clause 04 (a vibrating hacksaw blade) and then the component events are realised as middle, Material clauses in 04c and 04f.

04c As the blade moves to the right (middle diagram)
04f As the blade flicks back (right diagram).

However, in this text the use of effective Material clauses in the realisation of invisible, technical implication sequences at the first rank on the rank scale of technicality discussed above in relation to SSND1, is very much attenuated. Following the observable event in 04c, the only realisation of a rank one technical event by an effective Material clause with explicit agency is 04d.

04c As the blade moves to the right (middle diagram)
04d it compresses the air molecules
04e producing a high pressure area in the direction of motion and a low pressure area on the other side.

Subsequent clauses are either non-finite, agentless passives or middle. The "air molecules" occur only as Medium (04d; 06) and have no agentive role in this text. The agency is effaced by the realisation of these events at a higher level of abstraction:

05 As the high pressure area is produced
06 the air molecules move out to the low pressure area in front of them
07 increasing the pressure there
08 and reducing the pressure behind them.

"producing a high pressure area", "increasing pressure" and "reducing pressure" are macro-events abstracted from constituent technical events at level one on the rank scale of technicality. But in this text there is minimal literal realisation of these constituent events. Clause 04d realises the initial unobservable, technical event of the blade compressing air molecules and then the middle Material clause 06 indicates the first stage only of the subsequent movement of air molecules. But there is no literal realisation of these molecules compressing adjacent molecules and the recursion of this technical event sequence. Unlike SSND1 then, in this text there is no agentive chain of unobservable technical events linking the observable commonsense events realised by middle Material processes (04c and 04f), and the unobservable abstract technical events (09), also realised by middle Material processes:

09 The high pressure areas (=compressions) and low pressure areas (=rarefactions) both move outwards from the blade.

The attenuation of this congruent realisation of rank one technical events means not only that there is no realisation of the recursion of the events in 05-08 but also that, although

clause 06 indicates that "the air molecules move out to the low pressure area in front of them", there is no indication that the molecules move back! There are then, no conjunctive relations between these (recursive) events and the macro-event complex realised in 09. So there is no construction of the kind of Value/Token relationship as occurred in SSND1. This means that 09 is quite likely to be read as a literal movement of "areas" of high and low pressure moving away from the blade, which was obviously recognised by the authors who included a "repair strategy" as the Clarification stage of the CLOSURE element:

13 It is important to note that the molecules move backwards and forwards
as the compressions and rarefactions are transmitted outwards
but the air as a whole does not move - winds are not set up.

The recursion of the macro-events in clause 09 is indicated implicitly by the non-finite processes and the plural forms in clauses 11 and 12 of the Application stage in the CLOSURE element :

10 A loudspeaker works in much the same way
11 vibrating forwards and backwards
12 producing compressions and rarefactions...

However there is no reconstrual of these recursive macro-events in this text as a meta-event - a sound wave moving through the air. In fact "sound wave" does not occur in this text.

In the third text (SSND3) the realisation of the PHENOMENON EXEMPLIFICATION does not include the same density of grammatical metaphor, which occurred in the other texts:

05 If we look at how a tuning fork produces sound
06 we can learn just what sound is.

However, three of the eight effective processes are realised by the lexical item "produce" and occur within the first five clauses in the LINK and PHENOMENON EXEMPLIFICATION elements.

01 You have just seen a number of sources of sound
02 Many <u>being produced</u> in a way similar to musical instruments.
03 in each case a vibration was needed
04 <u>to produce</u> the sound
05 If we look at how a tuning fork <u>produces</u> sound
06 we can learn just what sound is.
07 By looking closely at one of the prongs
08 you can see that it is moving to and fro (vibrating).

Part of the semiotic work to be done in the subsequent text is the unpacking of the metaphorical consequential relation realised in these process selections.

07 By looking closely at one of the prongs
08 you can see that it is moving to and fro (vibrating).
09 As the prong moves outwards
10 it squashes, or compresses the surrounding air.
11 The particles of air are pushed outwards
12 crowding against and bashing into their neighbours
13 before they bounce back.
14 The neighbouring air particles are then pushed out
15 to hit the next air particles and so on.
16 This region of slightly squashed together air moving out from the prong is called a compression.
17 When the prong of the tuning fork moves back again
18 the rebounding air particles move back into the space that is left.
19 This region where the air goes thinner is called a rarefaction
20 and also moves outwards.
21 The particles of air move to and fro in the same direction in which the wave moves
22 and do not move along with the compression.
23 Thus sound is a compression wave that can be heard.

The commonsense events are again realised as middle Material clauses (08, 09 and 17). In 08 the event is realised as an embedded clause which is the Phenomenon in a mental clause. The uncommonsense events at the first rank of technicality are realised by clauses 10-15. The first of these clauses is effective with the Agent being the same 'concrete' participant which was the Medium in the previous clause realising the observable event. However, the pattern of Medium becoming Agent in the next clause is not sustained. The lexical item "air particles" and its instantial synonym ("neighbours") are never Agent. They are the Mediums with middle processes like "bounce" and "move". In fact the remaining clauses in this implication sequence (11-15) are either middle, non-finite or finite, agentless passives. The ellipsed Agent in 11 is the same Agent as in 10. Clause 12 is non-finite. Clause 13 is middle. Clause 14 is another agentless passive and clause 15 is non-finite. So the agency has been obfuscated and, even if it had been sustained, there is no logical relation linking the technical events at rank one to the second rank of technicality - the macro-event realised as the Value in clause 16. There are no other effective, Material clauses in the remainder of the text so there is no construction of an "agentive chain" linking the commonsense events realised as middle Material clauses to the uncommonsense events as they are reconstrued at more abstract levels on the rank scale of technicality and realised as middle Material clauses:

16 This region of slightly squashed together air moving outwards from the prong.....

19 This region where the air goes thinner is called a rarefaction.
20 and also moves outward

21..... in the same direction in which the wave moves.

As in SSND2, the absence of this agentive chain and the conjunctive links between technical event sequences and their more abstract reconstrual as macro technical events, necessitates a rhetorical "repair strategy" subsequently in the text:

21 The particles of air move to and fro in the same direction in which the wave moves
22 and do not move along with the compression.

4.1.5.1.1 *Naming and defining technical terms in secondary sound texts*

The texts were analysed for the occurrence of resources for naming and defining technical terms as detailed in chapter two (2.2.4.3). The results are shown in Table 4.6 (The shaded sections indicate the use of Relational: identifying clauses to equate technical events with visual representations rather than to construct linguistic definitions).

Category	SSND1	SSND2	SSND3
GROUP RANK			
1 Nominal group parataxis	the disturbance or sound wave	high pressure areas (= compressions) low pressure areas (= rarefactions)	
1.1 Thing ^ Qualifier			
2 Verbal group parataxis	pushes or compresses		moving to and fro (vibrating) squashes or compresses
3 Embedded clauses			
CLAUSE RANK			
4 Relational intensive identifying clause	which (a vacuum) is an empty space Figure 15.1 shows a vibrating object [[producing sound waves]] These compressions and stretchings make up a sound wave. This is shown be the top view of the vibrating object in Figure 15.1.		This region of slightly squashed together air [[moving out from the prong]] is called a compression. This region [[where the air goes thinner]] is called a rarefaction. Thus sound is a compression wave [[that can be heard]].
5 Relational possessive attributive clause			
CLAUSE COMPLEX			
6 Projection			
7 Paratactic elaborating clause			
DISCOURSE SEMANTICS			
8 Reference	17 it pushes or compresses the air particles next to it 21 the compression		
DISCOURSE SEMANTICS AND LEXICOGRAMMAR			
9 Reference and relational identifying clause			
UNDEFINED TECHNICAL TERMS		pressure molecules	

Table 4.6 Defining, naming or assuming technical terms in secondary sound texts

SSND2 makes much less use of resources for naming and defining technical terms than the other texts. In addition, the technical terms that are named through nominal group apposition, sustain a high level of technicality rather than bridging from more commonsense naming to the technical, as occurs in examples of nominal and verbal group parataxis in the other texts. Furthermore, the technical terms "compression" and "rarefaction" in the other texts are constructed as distillations of technical event sequences through the resources of relational identifying clauses (SSND3) and reference (SSND1). The deployment of grammatical metaphor in defining technical events in this way is essential to the explanation of sound waves via the progressive reconstrual of technical events at greater levels of abstraction. In fact the effectiveness of the reconstrual depends more broadly on the

selection and strategic deployment of different types of grammatical metaphor, as *discussed in the following section.*

4.1.5.2 Grammatical metaphor in secondary sound texts

The analyses of grammatical metaphor are shown in Tables 4.3a - 4.5a in Appendix 4. (The analyses are based on the categories of grammatical metaphor summarised in Tables 2.12 and 2.13 in Chapter two). Table 4.7 compares the occurrence of categories of grammatical metaphor across the secondary sound texts. The number of instances of each category is shown in normal type. The frequency of each category per clause is shown in italics. The final column indicates the overall density of metaphor per clause in each text.

Text	Clauses	Type of Metaphor											
		1a	1e	2b	**5a**	5d	6a	6b	12a	**12b**	12d	Total	
SSND1	37	**15**	1		**10**			5	2	**6**		39	
		.44	*.03*		***.28***			*.14*	*.06*	*.17*			*1.08*
SSND2	22	**9**		1	**1**		2	1		**6**	1	21	
		.41		*.05*	***.05***		*.06*	*.05*		*.27*	*.05*		*.96*
SSND3	23	**5**			**2**	1	1	3		**2**		14	
		.28			***.09***	*.04*	*.04*	*.13*		***.09***			*.61*

Table 4.7 Frequency of occurrence of types of grammatical and logical metaphor in secondary sound texts

Differences across the texts are significant for categories 1a (Material process ➔Thing) and 5a (Material process ➔Classifier). The differences in the deployment of these categories of metaphor reflects the ways in which the texts effect the progressive reconstrual of technical events at greater levels of abstraction. Different types of grammatical metaphor are involved at each of the three levels on the rank scale of technicality. The deployment of grammatical metaphor at rank one involves the shift to quality. In SSND1 the ten instances of category 5a, involving a Material process functioning as a Classifier, are made up of seven occurrences of the structure "vibrating object", two of "vibrating materials" and one of "compressed air particles". Reconstrual at rank two necessitates the shift to Thing. So, in the Analogic Account in SSND1, "disturb"➔"disturbance" and in the IMPLICATION SEQUENCES the Process^Medium structures "compresses air particles" (clause 17) and "compress them" (clause 19) become the metaphorical Thing, "compression" (clause 21). This Thing is then a participant in the rank two reconstrual of the implication sequence as a macro-event: "the compression travels through the air" (clause 26). The concomitant movement back of the air particles when the object moves back to the left is also metaphorized as a Thing ("the stretching apart of air particles"), but avoids the technical nominalisation, "rarefaction". Further reconstrual at rank three also necessitates the resources of grammatical metaphor because it is the recursive macro-event complex which

needs to be reconstrued as a metaphorical Thing so that it can be a participant in the technical meta-event. It is therefore the logical relation involved in recursion i.e. temporal succession which is metaphorized to construct the metaphorical Thing "a series of compressions and stretchings of air particles" (clause 29). Through presuming demonstrative reference in clause 30, this metaphorical Thing is equated with the more familiar "sound wave" in the relational identifying clause. The development of the grammatical metaphor in SSND1 and the rank scale of technicality are shown in Figure 4.23.

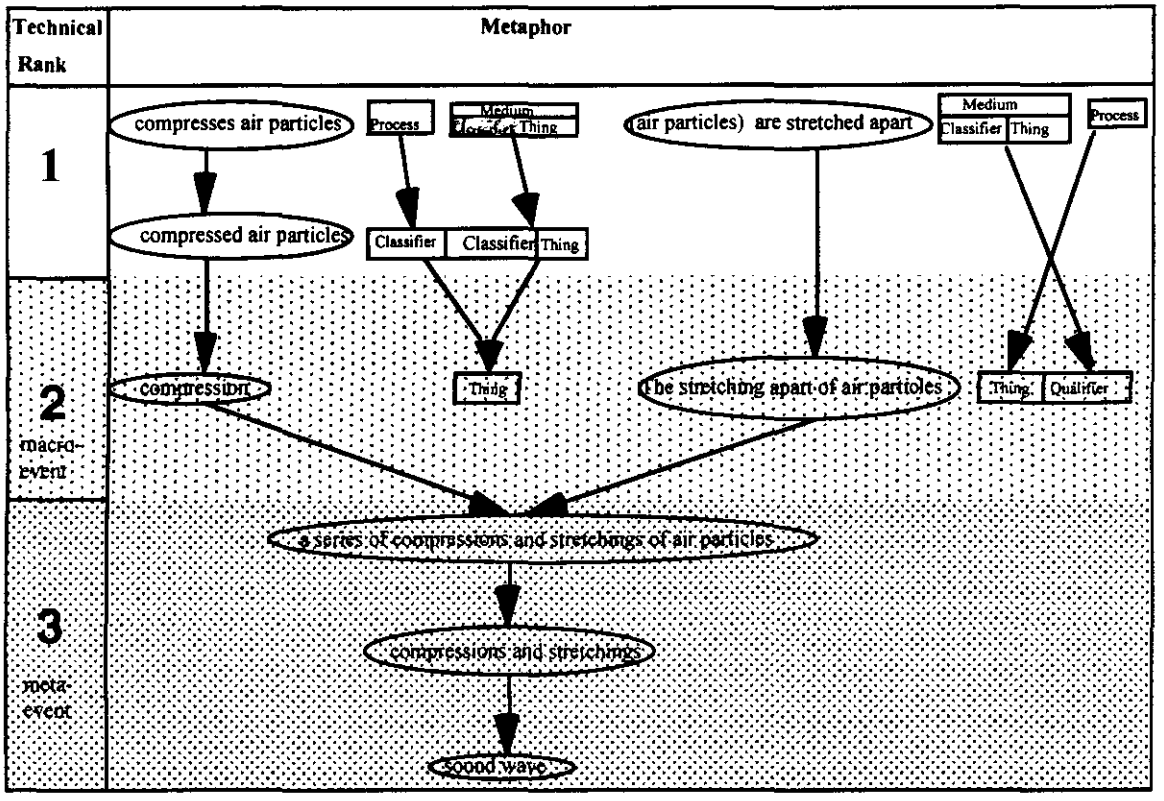


Figure 4.23 Grammatical metaphor and the construction of a rank scale of technicality

In SSND2 there is not the same focus on grammatical metaphor involving shift to quality to construct events at level one on the rank scale of technicality. There is only one instance of category 5a (Material process ➔ Classifier) - "a vibrating hacksaw blade", whereas there are ten in SSND1.

The reconstrual at level two on the rank scale of technicality of the technical event realised congruently in 04d does involve a shift to Thing in 04e and the consequential conjunctive relation between 04d and 04e means that there is a kind of Value/Token relationship as the Process^Medium of 04d is reconstrued as the nominal group complex in 04e:

04d it compresses the air molecules
04e producing a high pressure area in the direction of motion and a low pressure area on the other side.

But while in SSND1 "compression" is constructed logogenetically from "compresses the air particles" and "compressed air particles", this is not the case in SSND2 for the technical terms "high pressure area" and "low pressure area" for which there is no corresponding earlier congruent realisation.

In the main text the reconstrual of rank one technical events involving shift to Thing is also brought about by the technical term "pressure". This nominally realised technical abstraction can only be related inferentially to the underlying constituent technical events from which it derives.

05 As the high pressure area is produced
06 the air molecules move out to the low pressure area in front of them
07 increasing the pressure there
08 and reducing the pressure behind them.

The macro events at rank two on the scale of technicality in this text are eventually realised by the same form of grammatical metaphor involving shift to Thing as occurred in SSND1:

09 The high pressure areas (=compressions) and low pressure areas (=rarefactions) both move outwards from the blade.

However in SSND2 technicality is not constructed through the progressive generation of grammatical metaphor as occurred in SSND1, nor is there the deployment of conjunctive relations of internal consequence and external simultaneity to construct the "Value/Token" relationship between the construal of the events at different levels of abstraction.

In the third text (SSND3) there are again significant differences from SSND1 in the deployment of metaphor involving shift to quality at level one on the rank scale of technicality. There are problems in the deployment of metaphors involving shift to Thing to effect reconstrual of technical events at rank two, and there is no use of logical metaphor in further reconstrual at rank three.

In SSND3 there are only two instances of category 5a, involving Material processes realised as Classifiers, and only one of these occurs in realising a level one technical event:

18 the rebounding air particles move back into the space that is left

The other occurs within a rank two, macro technical event:

16 This region of slightly squashed together air moving out from the prong is called a compression.

The deployment of grammatical metaphor involving shift to Thing, which is necessary to the reconstrual of technical events at technical rank one as macro-events at rank two, is not well managed in SSND3. The first clause relevant to this shift to the macro event is 16:

16 This region of slightly squashed together air moving out from the prong is called a compression.

The metaphorical form of the Value causes a good deal of confusion, especially the Qualifier "moving out from the prong", because, in fact, there is no actual movement of air. There is no concrete participant which is actually transferred away from the prong. This is an abstraction from a series of event sequences which occur contiguously at fixed locations radiating from the vibrating object. It is the technical event of air particles compressing adjacent air particles which is appropriately condensed metaphorically as the Thing "compression". At the next level of abstraction then, this metaphorical Thing can be a participant in a macro technical event i.e. moving out from the prong. Part of the problem with this text is that "compression" does not function as a participant in a macro-event. "Rarefaction " does function as an ellipsed participant in clause 20:

19 This region where the air goes thinner is called a rarefaction
20 and also moves outwards.

But again the problem is that the nominalised Value, for which "rarefaction " is the Token in clause 19, constructs a technical term which names a concrete participant i.e. "This region where the air goes thinner". It is difficult to understand "rarefaction" as a reconstrual of an implication sequence because in the metaphorical form of the Value, the invisible event is downranked as a Qualifier ("where the air goes thinner") of the nominal group "This region". Hence 20 seems to realise the actual transference of a concrete participant rather than the occurrence of an abstract event and the notion of the reconstrual of technical events at one rank as macro-events at a higher level of abstraction is lost. In this text there is no realisation of a macro-event complex and no use of the logical metaphor which reconstrues the recursive macro-event complex as a Thing as in the following clause from SSND1:

29 a series of compressions and stretchings is sent out from the object

So, in SSND3, this recursive macro-event complex is not reconstrued as a participant in an event at a higher level of abstraction i.e. sound wave. Instead sound is defined as "a compression wave that can be heard" (23). Now, if the abstract participant "wave" is actually constituted by a series of alternating compressions and rarefactions, it is difficult to understand the use of the metaphorical Thing "compression" as a Classifier of "wave". This Classifier^Thing structure seems to be an inappropriate conflation of two different levels of abstraction. The deployment of grammatical metaphor does not support the reconstrual of unobservable events at progressively greater levels of abstraction on a rank scale of technicality as was achieved in SSND1.

The texts also vary in their relative deployment of logical metaphor (Categories 12a - 12c), with SSND1 and SSND2 making much more use of this than SSND3, as shown in Table 4.7 above. The most prominent category is 12b (logical connection→Material process). Of the six instances of this category in SSND1, five are concerned with consequential relations and four of these are located within the first five clauses of the text. The other consequential logical metaphor is located in clause fifteen, which is the PHENOMENON EXEMPLIFICATION. These metaphors then, are used in the initial stages of the explanation when the nature of the causal relations is not differentiated. The task of specifying the causal relations in terms of agency is also one of de-metaphorizing these consequential logical metaphors.

But this is not the case in SSND2. In this text there are six instances of logical metaphor where the logical relation of consequence is realised by the Material process "produce" (category 12b). These are distributed through the text and are not restricted to the beginning of any of the phases of the explanation (They occur in clauses 02, 04, 04e, 04g, 05, 12.). The occurrence in the PHENOMENON EXEMPLIFICATION in clause 04 does mark the highly metaphorical beginning of an explanation phase:

> 04 Fig 8.31 shows how pressure differences are produced in the air around a vibrating hacksaw blade.

The repetition of the process "produce" in the subsequent clauses maintains the metaphorical realisation of the consequential relation and means that the explanation has a much lower delicacy of focus with less articulation of underlying implication sequences.

In SSND3 there are only two instances of logical metaphor. These are both instances of the logical relation of consequence being realised by the Material Process "produce". They both occur early in the explanation (clauses 4 and 5).

Overall then, although the density of metaphor is greatest in SSND1, the deployment of the various categories of metaphor in this text effect a pattern corresponding to the progressive reconstrual of constituent events as participants in more abstract events across a three level rank scale of technicality. The first rank involves technical but concrete participants and non-metaphorical Material Processes. The kind of metaphor associated with this rank is the Process →Classifier (5a). Category 5a is much more prominent in SSND1 than in the other two texts. The second level on the rank scale of technicality necessitates the deployment of the metaphors involving shift to Thing. SSND1 and SSND2 contain relatively equal proportions of this type but SSND3 is somewhat lower. The reconstrual of the rank two sequences to rank three necessitates the recursion of events at level two to be nominalised as a participant in a meta-event at the next level of abstraction. In SSND1 this was achieved by the logical metaphor nominalising the temporal recursion ("series"). Only this text deployed this type of metaphor to effect this reconstrual. It was noted that both of the other texts required the explicit inclusion of "repair strategies" to correct the possible misinterpretation of the explanation as they had "semioticized" it. The failure of SSND2 to clearly articulate this reconstrual across the three levels of technicality is also reflected in the much higher use and wider distribution of the metaphorical realisation of the consequential conjunctive relation as a Process than occurs in the other two texts.

4.1.6 The relationship between causal conjunction, "depth" of explanation and relative technicality of the texts

As noted in Chapter three (3.1.6) the notion of "depth" of treatment of a topic is constructed through the interaction of choices at a number of levels of semiosis. At the level of genre in these sound texts, it may be affected by the inclusion of optional aspects in the CLOSURE element. At the level of semantics the "depth" may be affected by the extent of inclusion of nuclear and elaborative meanings. At the level of lexicogrammar "depth" may be regarded as the extent to which meanings are actually constructed in technical terms by the grammatical selections. The question is whether the choices that construct "depth" of treatment entail a greater orientation to reasoning based on causal rather than sequential relations.

At the level of genre it has been shown that the CLOSURE element in SSND1 includes Extension and Generalisation components that do not occur in the other texts, "deepening" the treatment of the topic to address why sound travels in all directions and that it also travels though liquids and solids.

The relationship between the relative orientation to temporal and consequential conjunctive relations and depth of treatment at the level of ideational semantics and lexicogrammar can be addressed by comparing these aspects of the texts in the common PHENOMENON EXEMPLIFICATION and IMPLICATION SEQUENCES elements, as well as the Conclusion component of the CLOSURE element. The frequency of external temporal and consequential conjunctive relations (including metaphorical realisations) and of internal conjunctive relations is shown in Table 4.8.

TEXTS	External conjunction per Conjunctively related unit		Consequential conjunction per total external conjunction	Internal conjunction per Conjunctively related unit
	Temporal	Consequential	Consequential	
SSND1	0.53	0.27	0.34	0.27
SSND2	0.31	0.54	0.64	0.08
SSND3	0.47	0.21	0.31	0.11

Table 4.8 Technicality and conjunction in secondary sound texts

This table indicates that external consequential conjunction is more prominent in SSND2. But this text omitted the nuclear meaning of recursion relating to air molecules compressed by the movement of the vibrating object in one direction compressing adjacent air molecules and so on. It also omitted the nuclear meaning of the movement back of these air molecules with the movement of the vibrating object in the opposite direction. Furthermore, it did not include the meaning in the final phase of the IMPLICATION SEQUENCES in which the series of compressions and rarefactions sent out from the vibrating object is equated with a sound wave. It was also shown that, although this text included relevant technical terms, the technicality was not actually constructed in the text through the resources of the lexicogrammar and discourse semantics. So those aspects of the Field that were included in these elements of schematic structure deployed lexicogrammatical resources which realised events at a high level of technicality related, to a large extent, by causal conjunction. But the nuclear meanings were not dealt with comprehensively and the sustained use of logical metaphor meant that the delicacy of focus in the construction of Field was quite gross. This text also has a very significantly lower proportion of internal conjunction, indicating the paucity of reasoning essential to the reconstrual of technical events at progressively higher levels of abstraction.

SSND3 has the lowest proportion of external causal conjunction and also a very low proportion of internal conjunction. It also omits some nuclear meanings, including the final reconstrual of a series of compressions and rarefactions as a sound wave, and the grammatical construction of technicality has been shown to generate a good deal of ambiguity compared with SSND1.

It could be argued then, that for these sound texts, the key relationship between depth of explanation and causal conjunction is to be found in SSND1. Here we have the most comprehensive account of nuclear meanings. The meanings are realised at a high delicacy of focus, constructing technicality within the text through systematic and explicit reconstrual of events at progressively greater levels of abstraction through effective choices within the transitivity system, the resources of grammatical metaphor and conjunction. Central to this reconstrual is the greater deployment of effective Material processes with explicit agency in realising rank one technical events; differential deployment of particular types of grammatical metaphor in realising events at different levels on the rank scale of technicality; and the combination of external conjunctive relations of simultaneity (which can also be read as consequential) with internal consequential relations thus effecting a linking of events realised at different levels of abstraction in a kind of Token/Value relationship. In SSND1 the depth of explanation is a comprehensive treatment of nuclear meanings with explicit reconstrual of events at greater levels of abstraction, realised through the grammatical and discourse semantic construction of technicality. The relationship of this depth of explanation with causal conjunction is primarily through the rhetorical reasoning constructed by relatively greater deployment of internal consequential conjunctive relations.

4.2 Comparing primary and secondary sound texts

4.2.1 Schematic structure in primary and secondary sound texts

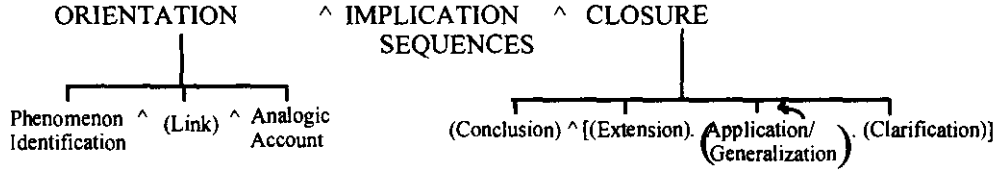
The schematic structure of the primary texts has a good deal of similarity with that of the secondary texts. The most striking difference is that none of the primary texts have a PHENOMENON EXEMPLIFICATION element. Instead, the attenuated IMPLICATION SEQUENCES element is linked directly to the ANALOGIC ACCOUNT. In two of the texts this is achieved by a metaphorical conjunctive relation of internal comparison.

13 A similar thing happens
14 when an object vibrates (PSND1).

03 This is what happens to the air
04 When sounds are made (PSND 2).

The Conclusion element in the CLOSURE occurs in only one primary text, and in another the Application element is iterative.

The proposed schematic structure potential is as follows:



The organisation of the primary sound texts in terms of this structure is shown in Table 4.9.

	PSND1	PSND2	PSND3
ORIENTATION Phenomenon Identification	Sound waves	Making sounds	How sound travels
Link	01 When we bang two pieces of wood together 02 we make them vibrate. 03 When we hit a drum 04 we make the surface, or skin, of the drum vibrate. 05 If you touch the skin of a drum 06 while it is being hit 07 you will feel [[the skin vibrating]].		
Analogic Account	08 If we throw a rock into a pond 09 we can watch the 'waves' [[that spread out from the point [[at which the rock lands]]]] 10 The bigger the rock, 11 the bigger the waves 12 and the further they travel. 13 A similar thing happens 14 when an object vibrates.	01 If you shake a "slinky" up and down on a table top 02 it squashes together and stretches out again in a regular pattern. 03 This is what happens to the air 04 when sounds are made.	01 Sound travels through the air 02 by spreading out in a series of ripples, like ripples on a pond.
IMPLICATION SEQUENCES	15 When an object vibrates 16 it causes particles, or molecules, in the air to bounce against each other 17 thereby causing other molecules to do the same. 18 These waves of moving molecules travel through the air 19 until they no longer have the strength [[to move the next molecule]]. 20 They are called *sound waves* 21 As the sound waves get weaker 22 the sound gets softer 23 until it disappears completely. 24 The strength of the initial vibration affects the distance [[the sound waves will travel]].	05 The sounds squash or press together a package of air 06 and when this expands or stretches out again 07 it squashes the air next to it. 08 This happens over and over again 09 producing a whole series of squashes and stretches 10 as the sound is passed through the air.	03 These ripples are called "sound waves" 04 and are caused by the air vibrating
CLOSURE Conclusion		11 Because sounds have a regular pattern or frequency, like the waves on the sea 12 they are called sound "waves".	
Clarification		13 But sounds are really very small changes in the pressure of the air.	
Extension	25 Sound waves travel at different speeds through different materials. 26 Sound waves travel slowly through air, quickly through water and even more quickly through steel. 27 This is [[because sound waves rely on [[molecules in the material [[through which they are travelling]] to knock against each other to pass the sound waves along]]]] 28 The molecules in steel are very close together 29 and therefore pass the sound waves a lot more quickly [[than air]]. 30 Air has molecules [[that are spaced further apart]].		
Generalisation			05 In fact, sound can travel through any substance. 06 This means that you can hear sounds underwater. 07 You can even hear a sound travelling through wood 08 if you put your ear to a table-top 09 and tap a spoon on the table.
Application		14 We cannot see sounds 15 but we can hear them 16 when our ears pick up the changes in air pressure (see pages 22-25) 17 When you clap 18 you smash air between your hands 19 and the changes in air pressure make the sounds you hear.	10 On the moon or in space, there is no air (or any other substance) 11 to carry the vibrations. 12 This means that the moon is completely silent 13 as sound cannot travel. 14 Consequently, astronauts in space use radios 15 to talk to each other. 16 In an emergency, however, they could communicate 17 by pressing their space-suit helmets together. 18 This would allow sound to travel as vibrations through their helmets and through the air inside

Table 4.9 Schematic structure of primary sound texts

The ORIENTATION includes the title or sub-heading as Phenomenon Identification in all texts. Only PSND1 contains the Link element and this functions as a link to everyday or

commonsense experience rather than a previous text segment. The Analogic Account draws an analogy between sound waves and a visible, everyday event sequence, but it does not have the same discrete status of a preliminary explanation, as in the secondary texts. As noted above, in the primary texts there is no PHENOMENON EXEMPLIFICATION and the IMPLICATION SEQUENCES relate technical events that realise sound waves in terms which parallel the observable events in the Analogic Account:

09 we can watch the 'waves' [[that spread out from the point [[at which the rock lands]]]]

....

18 These waves of moving molecules travel through the air. (SSND1)

02 it squashes together and stretches out again in a regular pattern

....

05 the sounds squash or press together a package of air (SSND2)

The CLOSURE is something of a misnomer, being quite lengthy in these primary texts. Only PSND2 includes a Conclusion, but rather than summarising or distilling technical implication sequences as a definition, it simply concludes that sound has been shown to have a regular pattern like waves on the sea and hence is referred to as sound waves. This text also includes a Clarification element:

13 But sounds are really very small changes in the pressure of air (PSND2).

An Extension element is included in PSND1, introducing an additional aspect of sound waves i.e. that they move at different speeds through different materials. The Generalisation that sound can travel though any substance is included in PSND3 (but no new element of different speeds is introduced here).

Finally, Application elements are included in PSND2 and PSND3. These indicate how concepts about sound waves already introduced, are exemplified in particular situations.

Comparing the schematic structures of primary and secondary texts

A comparison of the occurrence of elements of schematic structure across primary and secondary texts is shown in Table 4.10.

Elements of Structure		SSND1	SSND2	SSND3	PSND1	PSND2	PSND3
ORIENTATION	Phenomenon Identification						
	Link						
	Analogic Account						
PHENOMENON EXEMPLIFICATION							
IMPLICATION SEQUENCES							
CLOSURE	Conclusion						
	Extension						
	Generalisation						
	Application						
	Clarification						

Table 4.10 Comparison of schematic structure in primary and secondary sound texts

The main differences are in the deployment of the Link component, the absence of PHENOMENON EXEMPLIFICATION in all primary texts, and the conceded Conclusion element in one primary text only. However SSND2 resembled the primary texts in that it did not include Link or Conclusion elements and did include an Application element. Extension and Generalisation elements occurred in only one secondary and one primary text. Only one of the six texts did *not* include an Analogic Account.

4.2.2 Theme and schematic structure in primary and secondary sound texts

In the secondary texts the sub-heading functioning as Phenomenon Identification in the ORIENTATION stage of schematic structure, also functioned as a Macro-Theme, predicting the PHENOMENON EXEMPLIFICATION as a Hyper-Theme, which, in turn predicted the Thematic patterning in the IMPLICATION SEQUENCES. This hierarchy of periodicity did not occur in the primary texts. The Theme analyses of the primary texts (again following Martin, 1992:435 & 440) and the relationship to schematic structure are shown in Figures 4.10a - 4.12a in Appendix 4.

What was similar in the method of development for the secondary texts was the progression through the component events of the commonsense activity sequence i.e. the vibration of the object, with each movement of the object realised in a thematic β clause. This does not happen in the primary texts. Commonsense events are realised by Thematic β clauses in the primary texts PSND1 and PSND2:

01 When we bang two pieces of wood together

03 When we hit a drum

05 If you touch the skin of a drum

08 If we throw a rock into a pond

15 When an object vibrates (PSND1)

01 If you shake a "slinky" up and down on a table top

17 When you clap (PSND2)

But the Theme selection does not scaffold the deconstruction of an observable event and the construction of consequent constituent technical events.

In the secondary texts also (especially SSND1 and SSND3), new information from previous clauses, realising uncommonsense implication sequences, was condensed and Thematized to update the Given as the relevant point of departure for the further condensing of new information in the subsequent Rheme. There was only one clear occasion in which this kind of progression occurred in the primary texts and this was in clause 18 of PSND1. This occurrence is compared with the more systematic "updating" in SSND1 in Figure 4.24.

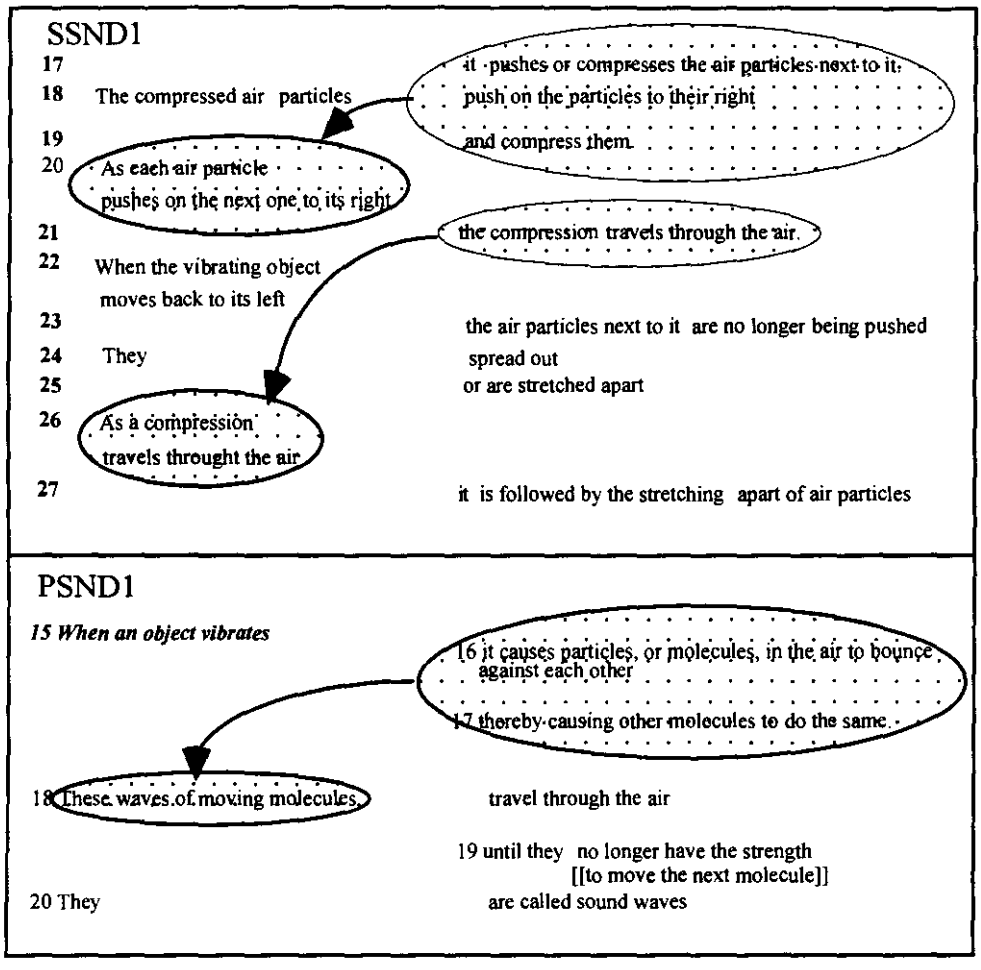


Figure 4.24 Examples of Rheme to Theme progression in SSND1 and PSND1

In the secondary texts SSND1 and, less clearly, SSND3 it was in the progression of new information in the Rhemes where the events in the technical implication sequences were condensed and reconstrued as macro-events, which were ultimately condensed and reconstrued as a nominalised meta-event - a sound wave. So the progressively introduced new technical information was finally accumulated as Hyper-New, which functioned as the Conclusion in the CLOSURE element of schematic structure. PSND2 is the only primary text to include a Conclusion element and there is this progressive accumulation of new information in this text, as indicated in Figure 4.25.

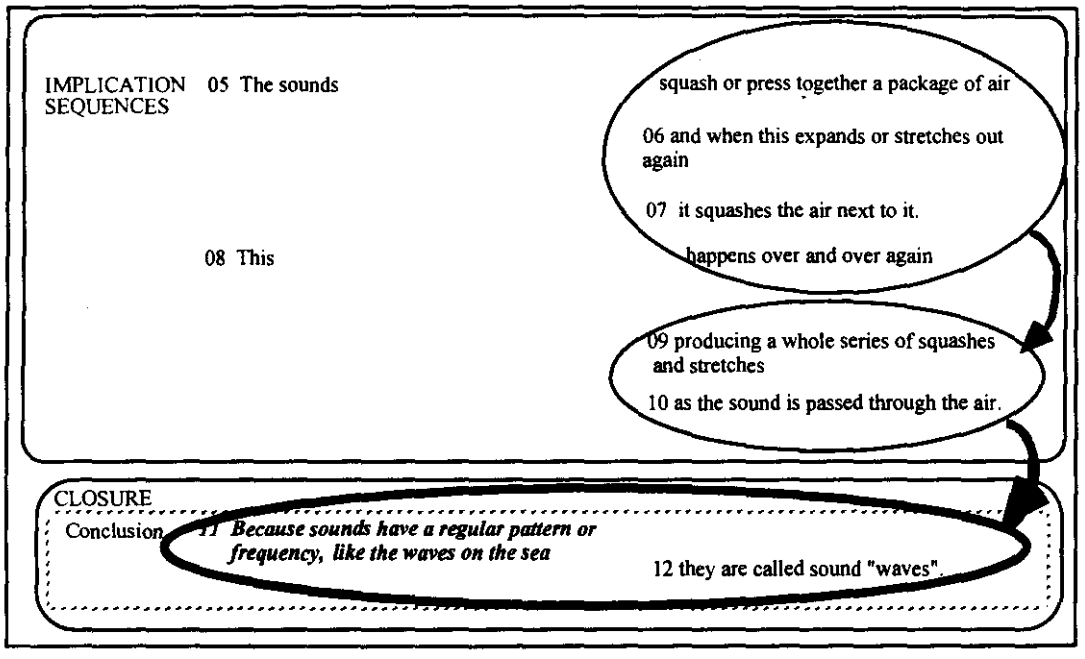


Figure 4.25 Accumulation of new information in PSND2

The relationship between patterns of Theme selection and schematic structure in the secondary texts was very clear. The Phenomenon Identification functioned as Macro-Theme, the Phenomenon Exemplification as Hyper-Theme and the Conclusion as Hyper-New (except that SSND2 did not include a Conclusion element). In these texts the method of development in the Phenomenon Exemplification and IMPLICATION SEQUENCES was progressively moving the point of departure from constituent events to macro events in terms of both commonsense and uncommonsense implication sequences. No such relationship with schematic structure or method of development occurred in the primary texts. The progressive accumulation and distillation of technical implication sequences, which occurred Rhematically in the secondary texts, occurred only minimally in one primary text. PSND2 did show some accumulation of commonsense realisations like "squash" and "stretch" as nominalisations, which were then participants in a macro-event ("a whole series of squashes and stretches") and this was again reconstrued in the Hyper-New as "a regular pattern or frequency". This was the only instance of the patterning of information focus in the primary texts that showed any resemblance to that in the secondary texts.

4.2.3 Conjunction in primary and secondary sound texts

The analyses of conjunction in the primary sound texts are shown in Figures 4.13a - 4.15a in Appendix 4 and are summarised in Table 4.11, which compares the results of the conjunction analyses for primary and secondary texts.

Text	Clauses	CRUs	Conjunctive relations				
			Internal	External	Metaphorical	Implicit	Explicit
SSND1	37	36	10	25	07	14	14
SSND2	21	20	03	15	05	09	04
SSND3	23	23	02	13	02	04	09
PSND1	30	30	03	24	08	05	12
PSND2	19	19	03	13	02	05	09
PSND3	18	18	04	12	04	04	08

Table 4.11 Conjunction in secondary and primary sound texts

At this global level the results show broadly similar patterns for primary and secondary texts with the significant exception being the extensive internal conjunction in SSND1. As with the secondary texts, the distribution of conjunctive relations reflects the demarcation of the elements of schematic structure, but a comparison of the deployment of conjunction in the central IMPLICATION SEQUENCES element reveals substantial differences across the primary texts and between the primary and secondary texts.

4.2.3.1 Conjunction and schematic structure in primary and secondary sound texts

The relationship between conjunction and schematic structure in the primary texts is shown in Figures 4.13a - 4.15a in Appendix 4. External conjunctive relations cluster within and do not extend across elements of schematic structure. Internal reformulation relates the IMPLICATION SEQUENCES to the Analogic Account in PSND1 and PSND2, whereas in the secondary texts this internal reformulation linked the IMPLICATION SEQUENCES to the PHENOMENON EXEMPLIFICATION (there is no PHENOMENON EXEMPLIFICATION as such in the primary texts). In PSND3 the internal reformulation in unit 05 (Figure 4.26) does not rework prior text through a more exhaustive restatement as in other texts but rather adjusts the previous text through correction (Martin, 1992:212-214). This does not scaffold the schematic stages of PHENOMENON IDENTIFICATION ^ IMPLICATION SEQUENCES or even Analogic Account ^ IMPLICATION SEQUENCES as does the reformulation: rework: exhaust type of internal conjunctive relation. Rather, it adjusts the previous element by generalising "air" to "any substance".

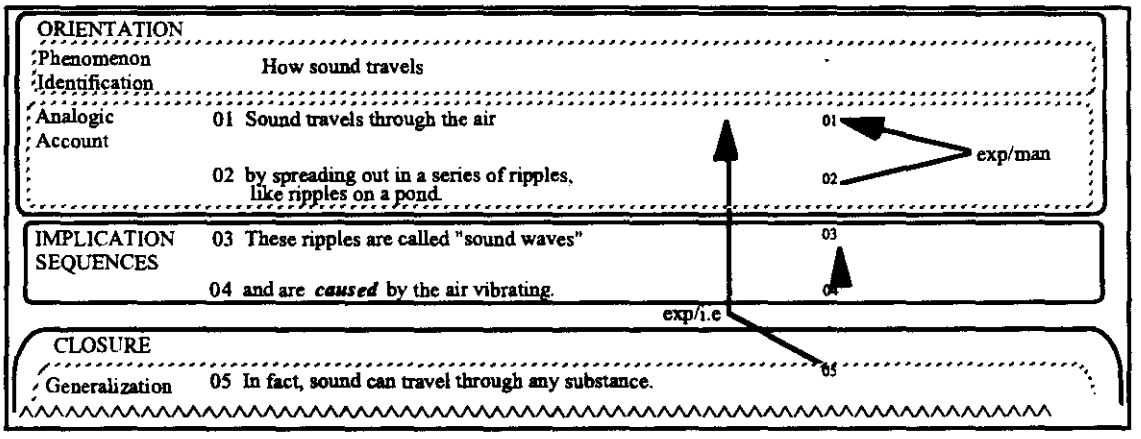


Figure 4.26 Internal reformulation in PSND3

4.2.3.2 Conjunction and reasoning

A comparison was made across primary and secondary texts of conjunction occurring in the PHENOMENON EXEMPLIFICATION, IMPLICATION SEQUENCES and the Conclusion element of the CLOSURE stage. In the absence of PHENOMENON EXEMPLIFICATION in the primary texts, the segment of the Analogic Account reformulated by the IMPLICATION SEQUENCES was included in the comparison. The only Conclusion element in the primary texts was in PSND2. The results of this comparison are shown in Table 4.12.

Text	CRUs	Conjunctive relations		
		Internal	External	External Metaphorical
SSND1	15	04	12	03
SSND2	13	01	13	04
SSND3	19	02	12	01
PSND1	12	01	11	04
PSND2	10	01	08	02
PSND3	02	00	02	01

Table 4.12 Conjunction in IMPLICATION SEQUENCES in primary and secondary sound texts

It should first be noted that, as in SSND2, the only occurrences of internal conjunction in these segments of the primary texts are single instances of internal reformulation in PSND1 and PSND2. The absence of internal consequential relations means that the "sandwich structure" resulting from the elaborated reasoning constructed by the internal conjunction in SSND1 and, to a lesser extent in SSND3, does not occur in SSND2 and nor does it occur in any of the primary texts.

There are three significant variations in the relative deployment of external temporal and consequential conjunction across the primary and secondary texts as indicated in Table 4.13. PSND3 included only one external conjunctive relation of addition and one metaphorical realisation of external consequence in the two clauses constituting the IMPLICATION SEQUENCES. The greater proportion of metaphorical forms of consequential conjunction in SSND2 and PSND1 (and to a lesser extent the other primary texts) reflects a grosser delicacy of focus in the realisation of implication sequences.

Text	CRUs	Conjunctive relations			
		Temporal		Consequential	
		Congruent	Metaphorical	Congruent	Metaphorical
SSND1	14	6	2	3	0
SSND2	12	7	0	2	3
SSND3	16	6	0	3	0
PSND1	10	4	0	1	4
PSND2	6	3	1	1	1
PSND3	2	0	0	0	1

Table 4.13 External temporal and consequential conjunction in IMPLICATION SEQUENCES in primary and secondary sound texts

There are also differences between the primary and secondary texts in the instances of external conjunctive relations of simultaneity conflating with external consequence. In the secondary texts these relations are involved in linking events at different levels of abstraction. For example, commonsense, observable events to unobservable technical events:

16 As the object moves to the right
17 it pushes or compresses the air particles next to it. (SSND1)

- and technical events to macro technical events:

20 As each particle pushes on the next one to its right
21 the compression travels through the air. (SSND1).

But in the primary texts the simultaneity/consequence conflation is only related to such a shift in abstraction at the first level - from commonsense to unobservable technical events:

15 When an object vibrates
16 it causes particles, or molecules, in the air to bounce against each other (PSND1).

In other instances the conflation can still be read but there is no shift in abstraction from congruent technical events to metaphorical macro technical events:

21 As the sound waves get weaker
22 the sound gets softer (PSND1)

06 and when this (a package of air) expands or stretches out again
07 it squashes the air next to it. (PSND2)

So, in the primary texts the external conjunction does not contribute to the explanation of sound waves through the progressive reconstrual of congruent technical events at greater levels of abstraction. Furthermore, as previously noted, the absence of internal consequential conjunctive relations means that the second key aspect of conjunction contributing to this process does not occur.

4.2.4 "Depth" of treatment and variation across texts in the selection of, and reader access to, ideational meanings.

The investigation of variation in the selection of ideational meanings in the secondary texts was focussed on the IMPLICATION SEQUENCES because this obligatory element of schematic structure is the core of the explanation of sound waves and is the most extensive common element of schematic structure across the secondary texts. In the primary texts the IMPLICATION SEQUENCES are much less extensive, and in fact minimal in PSND3. Nevertheless, the ideational meanings in the primary texts were compared by projecting the relevant meanings in each primary text in turn onto the semantic map showing the aggregated instantial meanings of the secondary texts for this element of schematic structure. This comparison indicated the extent to which the nuclear and elaborative meanings of the secondary texts also occurred in the primary texts.

The means of reader access to the meanings in the primary texts were categorised as literal or inferential and then subcategorised in the same manner as those of the secondary texts, according to the system summarised in Chapter two in Figure 2.8 in section 2.2.4.2. Variation in types of reader access in secondary and primary texts were compared.

Finally, a comparison was made of the correspondence across secondary and primary texts of the inclusion of additional meanings, which are not among the aggregated nuclear and elaborative meanings of the IMPLICATION SEQUENCES in the secondary texts.

The text of the IMPLICATION SEQUENCES in PSND1 and the projection of nuclear meanings onto the semantic map are shown in Figure 4.27. The meanings in the first four

clauses (15-18) only are relevant, since the dissipation of sound waves, and the effect of the strength of the initial vibration on this, are not mentioned in any other primary or secondary text. Nuclear meanings occurring in PSND1 are shown in thick black lines and elaborative meanings in regular black lines. Meanings not occurring in PSND1 are shown in "hatched" lines. Additional meanings in PSND1 are shown in solid faint lines.

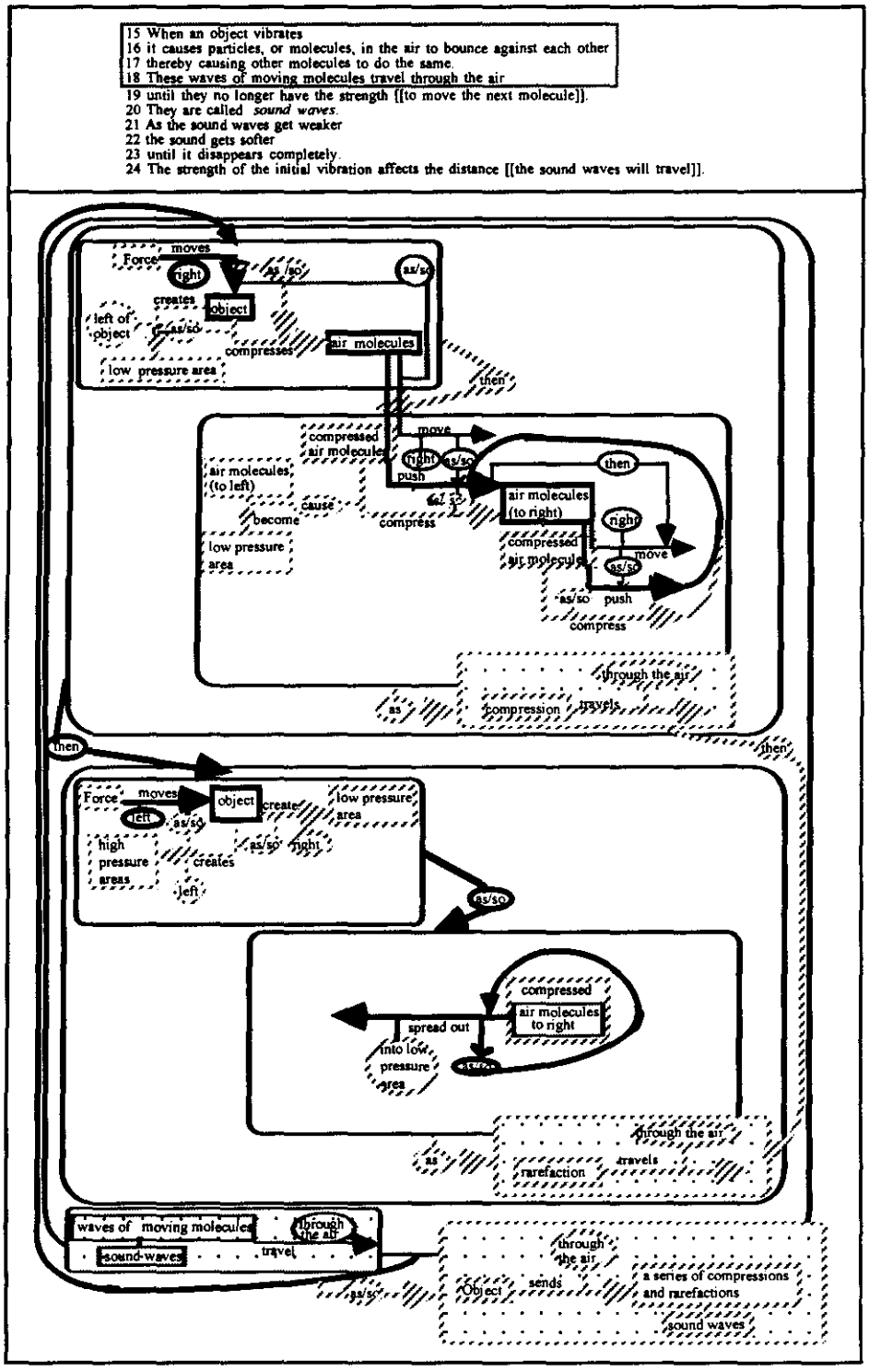


Figure 4.27 Semantic map of the IMPLICATION SEQUENCES element in PSND1

The meanings *waves of moving molecules (sound waves) travel through the air* is an abstraction of the previous recursive movements of air molecules, but cannot be mapped onto the meanings of the final phase of abstraction in the semantic map because the meanings *compression* and *rarefaction* have not been developed; there is no direct link to the vibrating object as Agent; and there is no logical link constructing the Value/Token relationship between the prior recursive technical events and the abstract reconstrual of them. This seems to prompt the need for the "repair strategy" in the extended caption for the diagram accompanying the text:

33 The molecules knock into each other
34 vibrating backwards and forwards in a regular manner.
35 The waves go through the air
36 but the air as a whole does not move.

The text of the IMPLICATION SEQUENCES in PSND2 and the projection of nuclear meanings onto the semantic map are shown in Figure 4.28. The most surprising aspect of these implication sequences is the lack of any reference to a vibrating object as bringing about the movement of air particles and the agentive role of "sound" in clause five:

05 The sounds squash or press together a package of air

Some of the meanings in the final phase of abstraction in the semantic map do occur in this text. The meanings *a series of compressions and rarefactions* is realised by "a series of squashes and stretches" but these are "produced" by the *sound*, "as the sound is passed through the air"! The problem of course, is that the "squashes and stretches" are the sound and can therefore hardly be produced by it. Although this text includes the meaning *compress*, which did not occur in PSND1, PSND2 is actually a more confusing and misleading explanation of sound waves than PSND1.

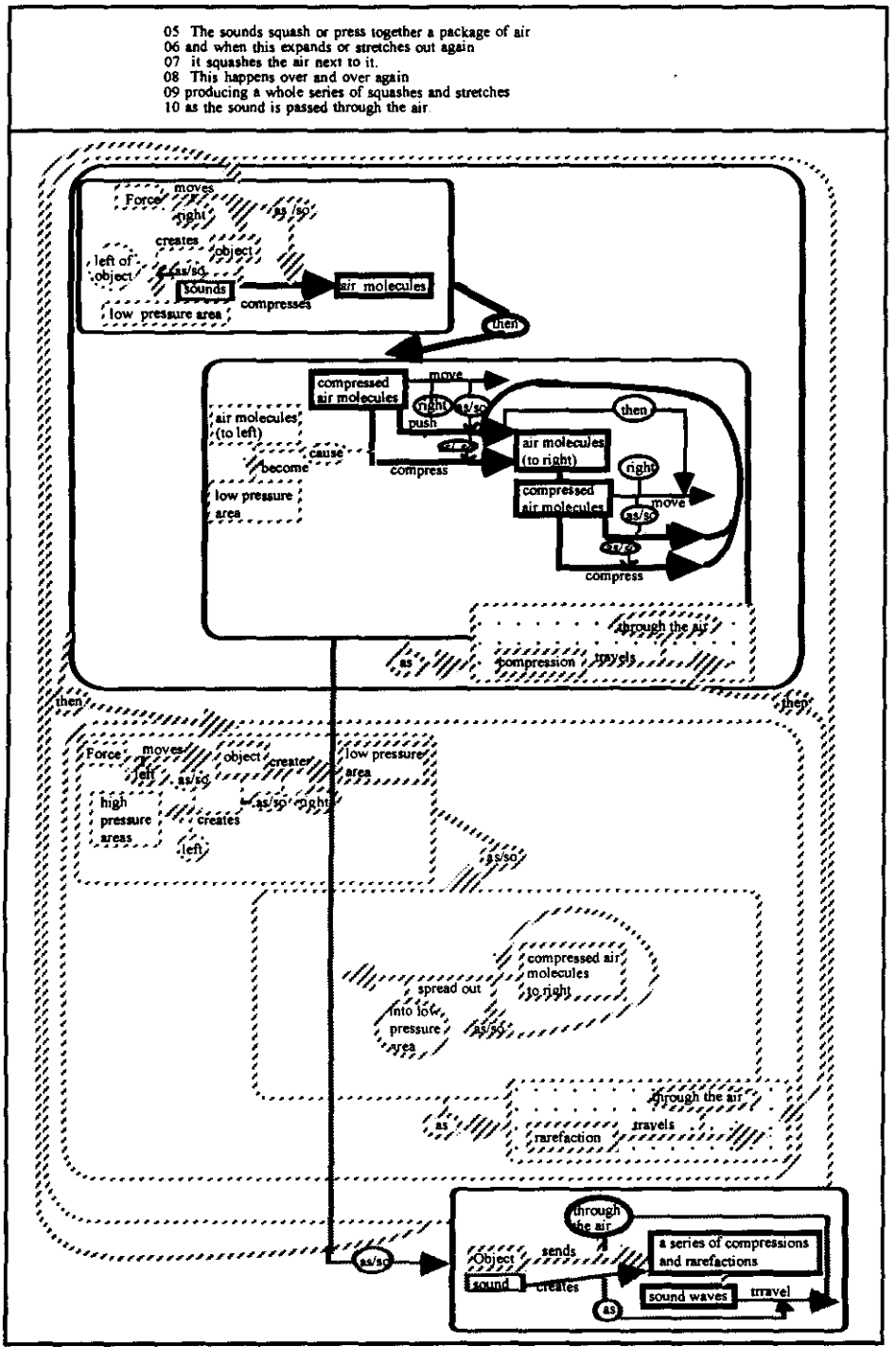


Figure 4.28 Semantic map of the IMPLICATION SEQUENCES element in PSND2

The meanings of the IMPLICATION SEQUENCES element of PSND3 were not projected onto the semantic map because of their negligible approximation to the meanings represented on the map. An unrelated semantic map and the text of the IMPLICATION SEQUENCES element in PSND3 are shown in Figure 4.29.

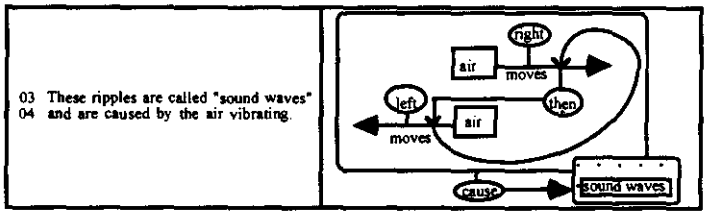


Figure 4.29 Semantic map for IMPLICATION SEQUENCES element in PSND3

This simply asserts the cause of sound waves and does not explain how they occur at all.

The analysis of types of reader access to nuclear meanings in PSND1 and PSND2 are included in Table 4.6a in Appendix 4. The analysis revealed little difference between the two texts as indicated in Table 4.14. The percentage of literal meanings in the primary texts was lower than that of the secondary texts.

SECONDARY TEXT	SSND1	SSND2	SSND3
% Nuclear Meanings Literal (Explicit + Implicit)	85	83	76
PRIMARY TEXT	PSND1	PSND2	
% Nuclear Meanings Literal (Explicit + Implicit)	69	67	

Table 4.14 Proportion of literal nuclear meanings in IMPLICATION SEQUENCES of primary and secondary sound texts

Additional meanings concerning sound waves beyond those accounted for in the semantic map of the IMPLICATION SEQUENCES element derived from the secondary texts, were summarised and compared across both primary and secondary texts as shown in Table 4.15.

Additional meanings	SSND1	SSND2	SSND3	PSND1	PSND2	PSND3
dissipation of sound waves				X		
The strength of the initial vibration affects the distance the sound wave will travel				X		
sound waves travel through different materials	X			X		X
at different speeds				X		
sound cannot travel through a vacuum	X					X
sound waves move out in all directions from the vibrating object	X					

Table 4.15 Additional meanings concerning sound waves in primary and secondary sound texts

Overall then the secondary text SSND1 deals most comprehensively with the nuclear meanings, has the greatest proportion of these accessible literally and is the only secondary text to include additional meanings not specified in the semantic map of the IMPLICATION SEQUENCES element. While all primary texts include a very low

proportion of the nuclear meanings identified on the semantic map, PSND3 offers no explanation of sound waves at all, simply asserting their cause, and PSND2 provides a confusing, illogical account of the agency involved in events comprising the production of sound waves. PSND1 does not provide greater "depth" of treatment of the explanation, but it has the least distorted account of nuclear meanings in the IMPLICATION SEQUENCES element and includes more "additional" meanings than any of the other primary or secondary texts.

4.2.5 Variation in the linguistic construction of technicality in primary and secondary sound texts

4.2.5.1 Transitivity

The transitivity analyses for primary texts are shown in Figures 4.16a - 4.17a in Appendix 4. A comparison for primary and secondary texts of the proportion of each process type in a text to the total number of processes in that text is summarised in Table 4.16.

TEXT	Material		Relational		Mental	Verbal	Behavioural
	Effective	Middle	Identifying	Attributive			
SSND1	.52	.26	.19	.02	.00	.00	.00
SSND2	.52	.37	.00	.07	.00	.04	.00
SSND3	.27	.33	.13	.07	.13	.00	.07
PSND1	.30	.33	.10	.20	.03	.00	.05
PSND2	.32	.23	.18	.05	.18	.00	.05
PSND3	.30	.25	.20	.05	.10	.10	.00

Table 4.16 Comparison of selection of process types across primary and secondary sound texts

The distribution of Mental, Verbal and Behavioural processes in the primary texts and in SSND3 contrasts with their almost complete absence in the first two secondary texts. This and the increase in the number of human participants as Agent or Medium with Material processes in the primary texts reflects the greater concern of these texts and, to a lesser extent SSND3, with reader involvement in activities and hence with a more commonsense orientation to the Field.

Material processes dominate both primary and secondary texts. In the secondary texts middle Material processes realised the commonsense observable events in the IMPLICATION SEQUENCES as well as unobservable technical event sequences reconstrued at a higher level of abstraction as macro technical events. Effective Material processes realising the unobservable, technical event sequences constructed an effective "agentive chain" (at least in SSND1) between the middle clauses realising the initiating

commonsense events and the middle clauses realising consequent macro technical events. This could not occur in PSND2 and PSND3 because there was no realisation of initiating commonsense events in the IMPLICATION SEQUENCES in these texts and the only middle Material process realising an observable, commonsense event occurred in the Application component of the CLOSURE element in PSND2:

17 When you clap

The IMPLICATION SEQUENCES in PSND1 did begin with a middle Material clause realising an initiating commonsense, observable event:

15 When an object vibrates
16 it causes particles, or molecules, in the air to bounce against each other
17 thereby causing other molecules to do the same.

Clauses 16 and 17 are the realisation of technical events at the first level on the rank scale of technicality, and there is the beginning of an "agentive chain" as the Medium from clause 15 becomes the Agent in clause 16. However, the use of the lexical metaphor "bounce" obviates the realisation of the constituent events in the implication sequence by effective Material clauses. This means that "molecules" do not have an agentive role and there is no development of the agentive chain.

The inappropriate deployment of the Agent role in realising rank one technical events in a long caption underneath an accompanying diagram actually adds its own distortion to the explanation in the main text of PSND1:

31 Sound waves disturb the molecules
32 as they pass through the air.
33 The molecules knock into each other
34 vibrating backwards and forwards in a regular manner.
35 The waves go through the air
36 but the air as a whole does not move. (PSND1- caption text)

The relationship between the event sequences involving the movement of molecules and the nominalised event realised as "sound wave" is further confused in this caption text. In clause 31 "sound waves" is the Agent and "molecules" is the Medium. This subverts the reasoning of the internal consequential relation linking 33-34 with 35-36. It is as if the sound waves are distinct from the molecules "vibrating backwards and forwards in a regular manner". So the reasoning does not illuminate the nature of sound waves. It simply argues that since the molecules move backwards and forwards the air does not move as a whole while the reified sound waves are disturbing it.

The same kind of problem occurs in PSND2:

05 The sounds squash or press together a package of air

This construction of the participant "The sounds" as an Agent, bringing about the very event sequences which constitute it, is an absurdity.

These problems do not occur in PSND3 because this text does not construct technical event sequences constituent of sound waves, much less deal with their reconstrual at progressively higher levels of abstraction. Constituent technical events are realised only by grammatical metaphor. This occurs first in the context of naming and defining sound waves in Relational: identifying clauses:

03 These ripples are called sound waves
04 and are caused by the air vibrating.

and subsequently in clauses 11 and 18, which contain the only effective Material processes concerned with technical events.

10 On the moon or in space, there is no air (or any other substance)
11 to carry the vibrations.

18 This would allow sound to travel as vibrations through their helmets and through the air inside.

This text asserts that sound waves are vibrations which are carried by a number of media, but it does not explain how these vibrations occur and how they constitute sound waves.

Of all the texts at both primary and secondary level, only SSND1 successfully grammaticalises the reconstrual of the constituent technical events of sound waves at progressively higher levels of abstraction, finally equating a metaphorical technical "meta" event with the familiar realisation of "sound waves". The other two secondary texts and the primary text PSND1 include rhetorical "repair" strategies to counter the misconception, inherent in the construction of their explanations, that air molecules actually travel away from the vibrating object. The problem is largely that these texts do not adequately grammaticalize the agency in constituent implication sequences at level one on the proposed rank scale of technicality. In SSND2 this attenuation is linked to the sustained high level of abstraction and low delicacy of focus on technical events realised through grammatical metaphor. In SSND3, PSND1 and PSND2 the use of commonsense lexical

metaphors and logical metaphor obfuscates the agency in technical event sequences. But PSND2 (and the caption text in PSND1) include the absurd grammaticalisation of "sound" or "sound waves" as Agent and "air" or "air molecules" as Medium, explicitly constructing a misconception. PSND3 avoids these problems by simply asserting that sound travels as vibrations through media and then illustrating the consequences of this.

4.2.5.1.1 *Naming and defining technical terms in primary and secondary sound texts*

The analysis of the use of resources for naming and defining technical terms in primary texts was carried out as for the secondary texts. The instances of defining, naming or assuming technical terms are shown in Table 4.17.

Category	PSND1	PSND2	PSND3
GROUP RANK			
1 Nominal group parataxis	particles, or molecules,	a regular pattern, or frequency	
1.1 Thing ^ Qualifier			
2 Verbal group parataxis		expands or stretches out	
3 Embedded clauses			
CLAUSE RANK			
4 Relational intensive identifying clause	They (these waves of moving molecules) are called sound waves.	they are called sound "waves" But sounds are really very small changes in the pressure of the air.	These ripples are called sound waves.
5 Relational possessive attributive clause			
CLAUSE COMPLEX			
6 Projection			
7 Paratactic elaborating clause			
DISCOURSE SEMANTICS			
8 Reference			
DISCOURSE SEMANTICS AND LEXICOGRAMMAR			
9 Reference and relational identifying clause			
UNDEFINED TECHNICAL TERMS		pressure	

Table 4.17 Defining, naming or assuming technical terms in primary sound texts

Three instances of nominal or verbal group parataxis are used to rename Participants and Processes in technical terms in the primary texts compared with six instances in the secondary texts, and there was no commonality of renamed Participants or Processes across the primary and secondary levels. The Token in all Relational: intensive: identifying clauses in the primary texts was "sound waves" or "sound", whereas in the secondary texts these clauses were used to define "a vacuum", "a compression", "a rarefaction" as well as

"sound waves/sound". The definition in PSND1 is the only instance in the primary texts in which "sound waves" is constructed as a technical term which distils technical event sequences realised in the text. In PSND2 and PSND3 this is clearly not the case. The "definition" in PSND3 is simply the renaming of a commonsense term derived from an analogy:

01 Sound travels through the air
02 by spreading out in a series of ripples, like ripples on a pond.
03 These ripples are called "sound waves".

In PSND2 the two definitions that occur are in clauses 12 and 13:

11 Because sounds have a regular pattern or frequency, like waves on the sea
12 they are called sound "waves".
13 But sounds are really very small changes in the pressure of the air.

The referent for the Value "they" in 12 is "sounds" in 11. This means that 12 defines sound as "waves" in terms of a comparison with commonsense observable features of waves on the sea. In fact 12 is little more than a redundancy - sounds are called sound waves. The definition in 13 is accurate but does not relate to the prior text at all. The "very small changes in the pressure of air" are not related to the "squashes" and "stretches" introduced in the first section of the text. In addition the Token/Value relationship in 13 is somewhat undercut in clause 19:

17 When you clap
18 you smash air between your hands
19 and the changes in air pressure make the sounds you hear.

The analysis of 19 is problematic. From the perspective of its construction of scientific knowledge, it would be analysed as a Relational: identifying clause ("make" = constitute), but it may well be read as a Material clause by young readers inexperienced in terms of the Field. So the definitions in PSND2 do not effectively apprentice young readers into the technical discourse of the Field because the technicality that is included is "isolated" and interpolated into the text rather than being grammatically constructed through the text.

The primary texts do not make effective use of resources for naming and defining technical terms. This was also the case for the secondary text SSND2 (as discussed in 4.1.5.1.1).

4.2.5.2 Grammatical metaphor in primary and secondary sound texts

The analyses of grammatical metaphor in the primary sound texts is shown in Tables 4.7a - 4.9a in Appendix 4. The types and density of grammatical metaphor in the primary and secondary texts are summarised in Table 4.18.

Text	Clauses	Type of Metaphor										
		1a	1e	2b	**5a**	5d	6a	6b	12a	**12b**	12d	Total
SSND1	37	**.44**	.03		**.28**			.14	.06	**.17**		1.03
SSND2	22	**.41**		.05	**.05**		.06	.05		**.27**	.05	0.96
SSND3	23	**.28**			**.09**	.04	.04	.13		**.09**		0.61
PSND1	30	**.03**		.07	**.03**				.03	.13	.03	0.30
PSND2	19	**.26**							.05	.05		0.37
PSND3	18	**.11**							.11	.22		0.39

Table 4.18 Density of grammatical and logical metaphor in primary and secondary sound texts

Although there was a good deal of variation across the secondary texts, they made much more use of grammatical metaphor than the primary texts. The variation in density of grammatical metaphor in the primary texts was not very great. The differences among the primary texts and between the primary and secondary texts in the deployment of grammatical metaphor was most significant in categories 1a (Material Process →Thing) and 5a (Material Process →Classifier).

Category 5a (e.g. "the *vibrating* object", "the *compressed* air particles") were identified in the discussion of grammatical metaphor in the secondary texts (4.1.5) as integral to the construction of event sequences at level one on the rank scale of technicality. Category 5a occurs most frequently in SSND1, where these rank one events are most elaborated. Only one instance of such a metaphor occurs in only one of the primary texts (PSND1), and this is the only primary text to deal with rank one technical events in terms of molecular movement.

The shift from Material Process to Thing (category 1a) is integral to the reconstrual of rank one technical events as macro technical events (e.g. "compresses"→"compression"). This kind of metaphor was prominent in SSND1, SSND2 and, to a lesser extent in SSND3, but the only primary text in which these frequencies were approximated was PSND2 (column one in Table 4.18). But three of the five instances of this category are the nominalisation "changes" (in air pressure), which are not reconstruals of previously congruently realised technical events. The other two instances, however, are the nominalisations "stretches"

and "squashes" and these do indicate, in recontextualizing for younger readers, an attempt to deal with the role of grammatical metaphor involving shift to Thing in explaining sound waves as the reconstrual of technical events at progressively higher levels of abstraction.

05 The sounds squash or press together a package of air
06 and when this expands or stretches out again
07 it squashes the air next to it.
08 This happens over and over again
09 producing a whole series of squashes and stretches
10 as the sound is passed through the air. (PSND2)

Only the secondary text, SSND1 and this primary text, PSND2 included the logical metaphor ("series"), which is integral to the reconstrual of macro events at rank two as a meta technical event at rank three. Unfortunately in PSND2 the selection of "The sounds" as Agent in clause 05 and "the sound" as Goal in 10 undercuts the understanding of the "squashes and stretches" as constitutive of the sound. In fact there is no explicit grammaticalisation of this, which is necessary to the reconstrual of the recursion of the technical macro event complex as the meta event of sound waves passing through the air. In this text it still seems as though "the sound" on the one hand, and the "squashes and stretches" on the other, are separate entities.

In PSND1 there is only one instance of category 1a ("vibration"), so there is no reconstrual, through the use of nominalisation, of rank one technical events at a higher level of abstraction as macro technical events (i.e as the compressed molecules compress the molecules in front of them, which in turn compress the next molecules and so on, the compression travels through the air). Instead this rank of technicality is bypassed and the move is directly to the third rank of the "meta" technical event of the sound wave moving through the air:

18 These waves of moving molecules travel through the air
19 until they no longer have the strength to move the next molecule.
20 They are called sound waves.

The nominal group, "These waves of moving molecules", is a reconstrual as a Participant, of event sequences realised congruently in clauses 16 and 17:

16 it causes particles, or molecules, in the air to bounce against each other
17 thereby causing other molecules to do the same (PSND1)

This is achieved partly by the grammatical metaphor involving shift to quality ("moving" - Process➔Classifier; "of...molecules" - Participant➔Qualifier), which is more typical, in

secondary texts, of the realisation of events at level one on the rank scale of technicality. It is also achieved by the extended reference of the demonstrative "These" and the creation of the technical participant "waves". But the Thing "waves" is not a metaphorical form directly derived from a previous non-metaphorical realisation. The nominal group structure of the Medium in clause 18 then, could be misread by the inexperienced reader, taking "These waves" as a kind of pre-numerative (Martin, 1992:133) and hence interpreting the molecules as travelling through the air. Such an interpretation is given some support by the anthropomorphic metaphor in clause 19.

The analysis of SSND1 made clear the differential deployment of categories of grammatical metaphor integral to the progressive reconstrual of technical event sequences at higher levels of abstraction. The other two secondary texts did not achieve effective differential deployment of grammatical metaphor for this purpose. The only primary text to address the need for metaphor involving shift to Thing to achieve this reconstrual was PSND2, and the limited effectiveness of this has been noted.

The predominant form of logical metaphor was the realisation of the logical relation of consequence as a Process (category 12b). This is associated with a gross delicacy of focus in the realisation of technical events, involving grammatical as well as logical metaphor, for example

04 and (sound waves) are caused by the air vibrating (PSND3).

In SSND1 and SSND3 these kinds of realisations occur early in the text and are subsequently "unpacked" as constituent technical implication sequences (achieving a greater delicacy of focus) and then re-metaphorized in the process of defining such implication sequences as technical terms. In SSND2 the logical metaphors are sustained throughout the text and the delicacy of focus remains quite gross. Similarly, in the primary texts the use of logical metaphors of cause are associated with the lack of a detailed explication of the constituent technical implication sequences. In fact PSND3 has the highest proportion of logical metaphor and this text provides the least satisfactory explanation of how sound travels, simply asserting that it travels as vibrations and providing illustrations of the everyday logical consequences of this assertion.

4.2.6 The relationship between causal conjunction, "depth" of explanation and relative technicality of the texts

In section 4.1.6 it was argued that the only clear relationship between causal conjunction and depth of explanation and the construction of technicality in the secondary texts occurred in SSND1. In this text depth of explanation is a comprehensive treatment of nuclear meanings with explicit reconstrual of events at greater levels of abstraction, involving the construction of technicality through a combination of appropriate transitivity selections and the differential deployment of types of grammatical metaphor. The relationship of this depth of treatment of the topic with causal conjunction is primarily through the rhetorical reasoning constructed by relatively greater deployment of internal consequential conjunctive relations and their orchestration with external conjunctive relations of simultaneity conflated with consequentiality.

None of the primary texts dealt comprehensively with the nuclear meanings and the deployment of internal conjunction was minimal in all of these texts, with the only internal consequential relation being one of concession in PSND2. So there is no relationship in the primary texts between internal consequential conjunctive relations and depth of treatment as occurred in SSND1.

Nor is depth of treatment simply related to the relative proportion of external consequential conjunction. As indicated in section 4.2.3, the highest incidence of external consequential conjunction in the IMPLICATION SEQUENCES occurred in the secondary text SSND2 and primary texts PSND1 and PSND3, and the realisation of these conjunctive relations was predominantly metaphorical, reflecting a grosser delicacy of focus in the realisation of implication sequences. It was these texts that had the least comprehensive treatment of nuclear meanings at the primary and secondary levels. Among the secondary texts SSND2 made the least use of resources for defining technical terms; there was minimal use in PSND1 and no effective definition of technical terms in PSND3.

While depth of explanation in secondary texts does seem to be related to greater use of internal consequential conjunctive relations, it does not seem possible to simply relate the decreased depth of treatment and technicality of primary texts to a more sequential rather than causal orientation to explanation.

4.3 Educational implications

This section presents a contrastive outline summary of the results of analyses of the secondary and primary texts, as a means of addressing research question seven, which involves summarising the variation in the linguistic dimensions of recontextualization specified in research questions one through six. In so doing, progress toward addressing the global research question and the educational linguistic purpose of the study is indicated.

EDUCATIONAL LINGUISTIC PURPOSE

How can the generic structure and discourse semantic and lexicogrammatical realization of causal explanations in upper primary and junior secondary school science books be further explicated in order to:

(i) provide an account of linguistic options in recontextualizing explanations at these levels of schooling;

(ii) evaluate such texts as resources for apprenticing children to the discourse of scientific English?

GLOBAL RESEARCH QUESTION

What linguistic choices are functional in the realization of alternative recontextualizations of explanations of the same phenomenon within and across junior secondary and upper primary science books? How do these choices vary with Field?

The convergence of results from the range of analyses undertaken clearly identifies one secondary text (SSND1) as the most effective explanation for students at this level. Parallel analyses of the primary texts indicate that all are inadequate recontextualizations for primary school children in that they either construct misconceptions about how sound waves are formed or avoid actually explaining how they are formed. In using the results of these analyses to work toward an account of the linguistic options available in constructing effective recontextualizations of explanations in this Field, a first step is to identify aspects of variation that contribute to the construction of the most effective secondary text. Where these are also features of the primary texts, there is a basis for the renovation of texts at this level. Similarly, the identification of dysfunctional aspects of secondary texts, which, to some extent, may be shared with primary texts, indicates what is to be avoided. The functionality of distinctive features of primary texts accounting for the remaining variation across levels, then needs to be examined. These steps will be related to each of the aspects of semiosis investigated.

Genre

At the level of genre only one integral element of schematic structure distinguished SSND1 from one of the other texts - The Conclusion component of the CLOSURE element did not occur in SSND2. This element did not occur in two of the primary texts, and in the other it was little more than a redundancy (as shown in 4.2.1). The absence of the Conclusion component then, was a limitation at both primary and secondary levels.

SSND1 was the only secondary text to include the optional components Extension and Generalisation in the CLOSURE element and was distinguished from SSND2 because the latter text did not include the Link component in the ORIENTATION element. While two of the primary texts included an Extension and a Generalisation component respectively, none included the Link. As indicated in chapter two (2.2.1) the absence of the Link is not surprising since explanations in factual books for children of this age are more likely to occur as discrete texts rather than as part of an extended treatment of a topic as is the case in secondary texts. The optional Extension and Generalisation components are not essential to the development of effective explanations of how sound waves are formed.

The feature of schematic structure distinctive to the primary texts is the absence of the integral PHENOMENON EXEMPLIFICATION element. This absence is clearly dysfunctional. It is surprising that all of the explanations for older secondary school children are anchored to a specific instance of a vibrating object producing sound waves, but no specific exemplars were used as a basis for explication of the chain of events in the IMPLICATION SEQUENCES of the explanations for younger children. The Analogic Account in the primary texts is co-opted to fill the gap and the IMPLICATION SEQUENCES relate technical events that constitute sound waves in terms which parallel observable, commonsense events in the Analogic Account. But the problem is not with the Analogic Account, which also occurs in SSND1. Rather it is with the loss of its status as a discrete, preliminary explanation as is the case in the secondary texts.

Effective recontextualizations of explanations of this topic at primary level will require a PHENOMENON EXEMPLIFICATION and a Conclusion component of the CLOSURE element in their schematic structure.

Texturing: Patterns of Theme and Information Focus

The relationship between patterns of Theme selection and information focus and schematic structure in the secondary texts was very clear. The Phenomenon Identification functioned as Macro-Theme, the Phenomenon Exemplification as Hyper-Theme and the Conclusion as Hyper-New (except that SSND2 did not include a Conclusion element). The Hyper-themes predicted a method of development which involved progression through the component events of the commonsense activity sequence, each selected as marked Theme i.e. the vibration of the object, with each movement of the object realised in a thematic β clause. What distinguished SSND1 from the other secondary texts was the clarity and consistency of this patterning and the cumulation of the component events in a final marked Theme as well as the selection of additional marked Themes which accumulated from previous clauses condensed new information realising uncommonsense implication

sequences, hence progressively updating the Given as the point of departure for the further condensing of new information in rhematic α clauses. The absence of the PHENOMENON EXEMPLIFICATION as Hyper-Theme obviated this hierarchy of periodicity and method of development in the IMPLICATION SEQUENCES element of the primary texts.

In all secondary texts the technical events are introduced Rhematically and are also progressively distilled as macro-events through the Rhemes. This patterned development is clearest and complete in SSND1, with the progressively introduced new information finally accumulated as Hyper-New, which functions as the Conclusion in the CLOSURE element. PSND2, being the only primary text with a Conclusion component in the CLOSURE element, is the only primary text to approximate this patterning.

The inclusion of the PHENOMENON EXEMPLIFICATION element and the Conclusion component of the CLOSURE element into primary texts then, would allow Theme selections which would facilitate the texturing of information flow in a manner approximating that in SSND1. However, the inclusion of elements of schematic structure alone is not sufficient to achieve this kind of texturing as indicated by the analyses showing that SSND3 compares poorly with SSND1 in this respect despite the similarity in schematic structure.

Reasoning: Patterns of conjunctive relations

SSND1 had much more elaborated reasoning constructed by internal conjunction. But what was most significant about this was the orchestration of internal consequence with external conjunctive relations in which simultaneity was conflated with cause. This combination of internal and external conjunction was crucial to the construction of the "dynamic" constituency relationship between technical events and their reconstrual as macro technical events realised at a higher level of abstraction. In this way, understanding what caused sound waves, involved understanding this Token/Value relationship between events at different levels of abstraction. It was the lack of this "dynamic" constituency which invoked the misconception that air molecules actually moved though the air and necessitated the "repair" strategies to correct this in the other two secondary texts and in the first primary text. This orchestration of internal and external conjunction then, is a key aspect of the linguistic choices constructing effective explanations of this phenomenon.

The metaphorical realisations of external conjunction in SSND1 (and SSND3) are concentrated in the Link component of the ORIENTATION and in the PHENOMENON EXEMPLIFICATION, and congruent realisations occur in the IMPLICATION SEQUENCES with greater delicacy of focus on the technical events. However in SSND2

and the primary texts the metaphorical forms are sustained throughout the text, maintaining a grosser focus. A further key issue then, in the deployment of conjunction in these explanations is to ensure the "unpacking" of logical metaphor which may be used in introducing the phenomenon.

Ideational Semantics: The selection of nuclear, elaborative and peripheral meanings

The production of sound waves is semanticized as commonsense observable implication sequences (i.e. a vibrating object) producing unobservable, technical implication sequences involving the activity of air molecules. These technical implication sequences are progressively reconstrued as macro technical events and then these as a "meta" technical event, so the implication sequences form a kind of rank scale of technicality. Through the "mapping" of the instantial semantics of the production of sound waves as represented in all of the secondary texts, it was possible to establish the "main path" from "goal state" back to "start state" (after Paris and McKeown, 1987) and to define nuclear meanings as those essential to the progression of the main path, elaborative meanings as those not essential to traversing the main path and peripheral meanings as those not related to the events involved in the production of the sound waves.

The semantic mapping of the IMPLICATION SEQUENCES element indicated that SSND1 dealt comprehensively with nuclear meanings, but included very few elaborative meanings and no peripheral meanings. In this text the selection of nuclear and elaborative meanings resulted from addressing only what occurred to the right of the vibrating object as it moved back and forth and ignoring simultaneous events to the left of the object. This seemed to be an effective simplification strategy, which was also followed in SSND3. In SSND1 comprehensive treatment of this selection of events produced an "unbroken" "main path" of nuclear meanings. The omission of certain nuclear meanings in the other secondary texts produced less effective, more ambiguous explanations. But in the primary texts the minimal selection of nuclear meanings resulted in a distorting misrepresentation of events. The omission of nuclear meanings is not a viable strategy for simplifying these explanations for primary school children.

Lexicogrammatical realisation of technicality

What was distinctive about SSND1 was the clear articulation of the three levels on the rank scale of technicality and the relationship among them. The role of conjunction in realising the progressive reconstrual of events at greater levels of abstraction has already been addressed. But SSND1 was also distinguished from the other texts in the transitivity selections and deployment of different kinds of grammatical metaphor in realising the technical events at these different levels.

SSND1 had the greatest proportion of effective Material processes, which were deployed in the IMPLICATION SEQUENCES element to link the commonsense event of the object vibrating, realised by a middle Material clause, to the metaphorical technical event of sound waves travelling through the air, realised again by a middle Material process, through the construction of an "agentive chain" in which the Medium from one clause became the Agent in the next. In the other secondary texts this agentive link was obfuscated by the selection of middle, non-finite or agentless, passive clauses.

The density of grammatical metaphor was also greatest in SSND1 and was deployed so that different forms of grammatical metaphor were integral to the realisation of implication sequences at successive levels on the rank scale of technicality. Whilst it was clear in all texts that nominalisation was central to the construal of implication sequences at rank two, SSND1 was the only secondary text to effectively deploy the shift from material process to Classifier in elaborating rank one implication sequences and to use logical metaphor to construct a nominalised realisation of the recursion of the technical macro event complex, which was central to the reconstrual of rank two sequences at rank three.

The use of effective Material processes with explicit agency in the realisation of level one technical implication sequences could be easily incorporated into both primary and secondary texts by eliminating lexical metaphors like "bounce" (PSND1). It should also be possible to address the deployment of the different types of grammatical metaphor to achieve the realisation of technical events at higher levels of abstraction, especially given that PSND2 used the nominalisations "squashes" and "stretches" realising level two macro-events and was the only text, besides SSND1, to include the logical metaphor "series", which is integral to the reconstrual of macro events at rank two as a meta technical event at rank three.

The use of lexicogrammatical and discourse semantic resources to bridge from commonsense language to the technical terminology seemed to be minimal and inconsistently deployed. For example SSND1 and SSND3 both used verbal group apposition to bridge from "compresses" to commonsense but neither text bridged from its use of "air particles" to include the more technical "air molecules", yet this was done in the primary text PSND1. SSND1 uses the technical nominalisation "compression" and the more commonsense nominalisation "the stretching apart of air particles", which it does not bother to name technically as a "rarefaction", yet both of the other secondary texts used the term "rarefaction". Texts at both primary and secondary level would benefit from a more systematic approach to this bridging from the language of commonsense to the technical language of science.