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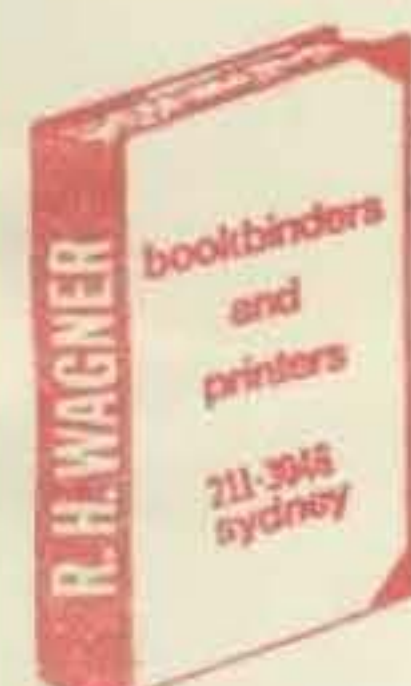
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How and why: Recontextualizing science explanations in school science books.

Volume 2

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Chapter 5

Explanations of the seasons

This chapter reports on analyses of explanations of the occurrence of the seasons in three secondary and three primary school science books addressing the research questions listed in Figure 5.1.

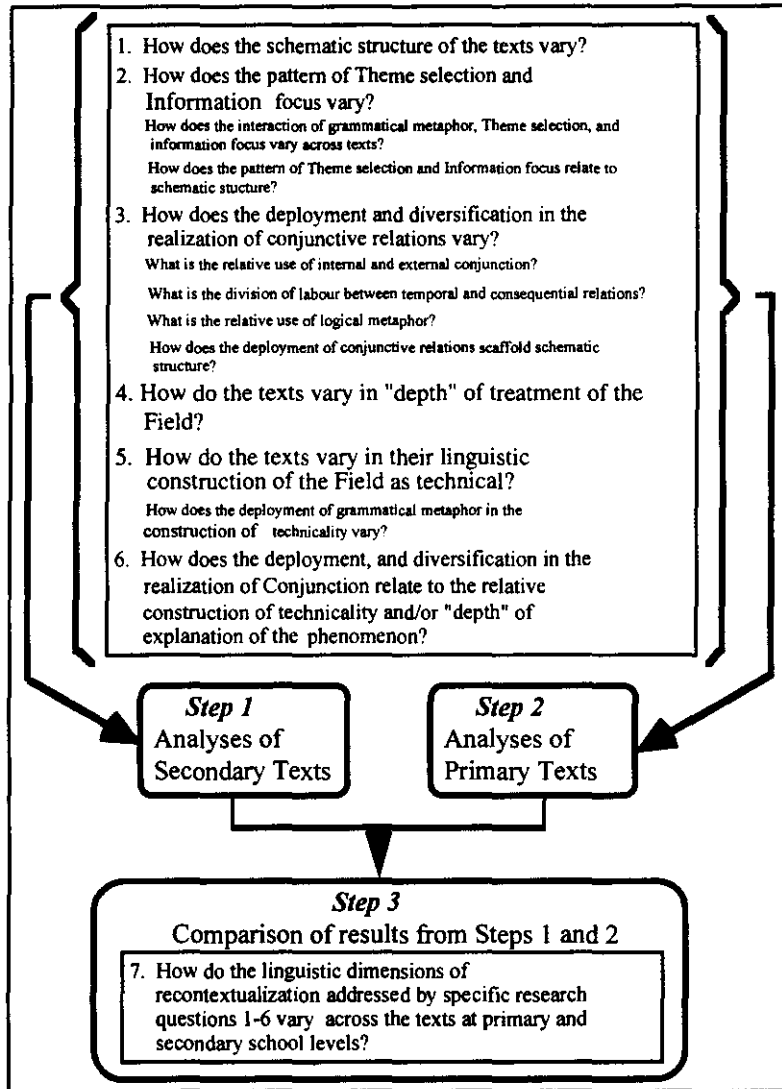


Figure 5.1 Research questions addressed in chapter five

As in previous chapters 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 dealing with research question seven, are summarised to address the global research question and the educational linguistic purpose of the study.

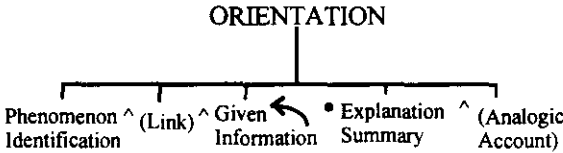
5.1 Secondary seasons texts

5.1.1 Schematic structure in secondary seasons texts

The proposed schematic structure for the secondary seasons texts is:

ORIENTATION ^ [DEDUCTION SEQUENCES ^ (CLOSURE)] ↶

The ORIENTATION prepares the reader for the text that follows. As with the texts in the other Fields, the strategies used to achieve this involve "layers of staging" (Martin, 1994; 1995). The layering within the ORIENTATION element is:



In all three texts the Phenomenon Identification occurs as the title/subheading :

- Seasons of the Earth (SSEAS1)
- Seasons and the Earth's movement (SSEAS2)
- The seasons (SSEAS3)

The Link relates the current text to previous text sections and occurs in SSEAS3 only:

- 01 You may have seen (Figure 2.6) that the Earth is drawn with its axis 'tipped over' or tilted. (SSEAS3)

The Given Information includes the premises on which the explanation is based viz. that the Earth rotates on its axis, which is tilted and remains so as the Earth revolves around the sun. In SSEAS1 the single Given Information element contains these premises only:

- 01 The Earth rotates about its axis
 - 01.1 which is not vertical but tilted at an angle of $23\frac{1}{2}^{\circ}$.
- 02 The angle and direction of tilt of the Earth's axis remain the same
- 03 as the Earth moves around the sun.

However, in SSEAS2, the Given Information also includes other elaborative and peripheral information. Furthermore, in this text there are two Given Information elements, which

occur before and after the Explanation Summary. This is indicated in the statement of schematic structure above by the "dot", indicating that the Given Information can occur before or after the Explanation Summary and the left facing arrow, indicating that the Given Information element can be recursive. These elements of structure in SSEAS2 are shown in Figure 5.2. The clauses dealing with the premises are in bold.

Given Information	01 As the Earth rotates 02 it also moves in space around the sun. 03 This movement is called revolution 04 and the path around the sun is called an orbit 05 It takes 365 1/4 days for each revolution. 06 This time interval is called one year. 07 To avoid having the inconvenience of a quarter of a day at the end of each year, 08 the calender has 365 days in a year. 09 To make up for the missing quarter day, 10 Every fourth year is called a leap year 11 and has 366 days.
Explanation Summary	12 It is the Earth's revolution around the sun that gives us our seasons: autumn, winter, spring, summer.
Given Information	13 As seen in figure 10.9, 14 The Earth's axis remains tilted in the same direction throughout its orbit.

Figure 5.2 Given Information elements in SSEAS2

In SSEAS3 the single Given Information element precedes the Explanation Summary and includes peripheral information as well as the premises.

The Explanation Summary further prepares the reader for the text that follows by providing a summary or abstract of the implication sequences or logical chain of events that will be detailed subsequently in the text. In SSEAS1 the Explanation Summary is in two parts - the first at a very high level of generality and the second providing a summary of the cause of two quite specific variables characterising seasonal change:

- 04 The tilt of the Earth's axis gives rise to the seasons and the varying lengths of day and night at different times of the year.
- 05 Day lengths and temperatures depend on [[how long the sun shines and the angle [[at which the sun's rays strike the Earth]]]] (SSEAS1)

This is related to the iteration of the DEDUCTION SEQUENCES and CLOSURE elements. The first DEDUCTION SEQUENCES element elaborates the more specific summary in 05, while the second elaborates the general summary in 04. In SSEAS2 the Explanation Summary is quite general but here the agency is different from that in SSEAS1:

- 12 It is the Earth's revolution around the sun that gives us our seasons; autumn, winter, spring, summer. (SSEAS2)

The Explanation Summary in SSEAS3 is different again:

- 08 The different distances to the Sun [[caused by the tilting axis of the Earth]] is not the cause of the seasons.
 09 They are due to the rays of light from the Sun being spread over much larger areas of the Earth's surface in winter when compared to summer (Figure 2.10). (SSEAS3)

In this text the relative concentration of the Sun's rays at the Earth's surface in the different seasons is elaborated in the subsequent text segment.

The Analogic Account functions as a preparatory explanation by drawing an analogy between some aspect of the events involved in the cause of the seasons and some observable everyday experience. Only SSEAS1 includes an Analogic Account:

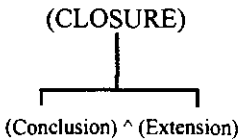
- 06 If you take a smooth shiny ball
 07 and shine a torch on it
 08 you will notice that the half [[facing the torch]] is lit up.
 09 The surface is lit most brightly directly in front of the torch.
 10 Although the remainder of that half is illuminated,
 11 it is not as bright as this rather small region.
 12 Similarly, the Earth's surface is most brightly lit
 13 where the sun's rays strike the surface perpendicularly
 14 (see figure 7.23). (SSEAS1)

This is preparatory to the first DEDUCTION SEQUENCES element in this text.

The DEDUCTION SEQUENCES element "unpacks" the Explanation Summary. In the first DEDUCTION SEQUENCES element in SSEAS1 this concerns the relative heating effect of the sun's rays at different angles of incidence on the Earth's surface. The second DEDUCTION SEQUENCES element in this text, and the single occurrence of this element in the other texts, indicates the logical relations among events that result in conditions we call the seasons. The second DEDUCTION SEQUENCES element in SSEAS1 is as follows:

- 23 As a result of the tilt of the Earth's axis the southern hemisphere is inclined towards
the sun in December and away from the sun in June
24 (see figure 7.24).
25 When the southern hemisphere tilts towards the sun,
26 it receives more of the sun's rays at an angle closer to 90°
27 and it experiences summer.
28 During this time the northern hemisphere points away from the sun
29 and is experiencing winter.
30 When the southern hemisphere tilts away from the sun,
31 most of the sun's rays strike the Earth obliquely
32 and their heating effect is less.
33 During this time the southern hemisphere has its winter.
34 The northern hemisphere at the same time points toward the sun and has its
summer. (SSEAS1)

The CLOSURE element functions to draw some conclusion to the text such that it steps outside of the detail of the processes causing the phenomenon. There was no CLOSURE element in SSEAS2 and two such elements in SSEAS1. The latter situation seems unusual, but it is explained by the interpolation of "activity 7.6" - a page length procedural text - prior to the second DEDUCTION SEQUENCES element. The layout of the main text under the same subheading "Seasons of the Earth", clearly indicates however, that this is one explanation. Nevertheless, a CLOSURE element before the interpolated activity was functional. The two CLOSURE elements in this text consist of two components - a Conclusion and an Extension, while the CLOSURE in SSEAS3 consists of an Extension only. The layering of the CLOSURE element then, can be represented as follows:



The Conclusion element here is similar to the summarise strategy described by Cross (1992). It is called a Conclusion because it is linked to the DEDUCTION SEQUENCES by the internal conjunctive relation - consequence:manner. The first Conclusion in SSEAS1 relates commonsense knowledge of summer and winter to the uncommonsense account in the DEDUCTION SEQUENCES:

- 21 In summer, the sun's rays strike the Earth more directly (i.e. at an angle closer to 90°) than in winter.

The second Conclusion relates commonsense knowledge of summer and winter to the reversal of the seasons in the northern and southern hemispheres and the relationship of this to their relative inclination to the sun at different times of the year:

- 36 The seasons in the southern and northern hemispheres are always the reverse of each other.
- 37 When one hemisphere points toward the sun,
- 38 The other must point away from the sun. (SSEAS1)

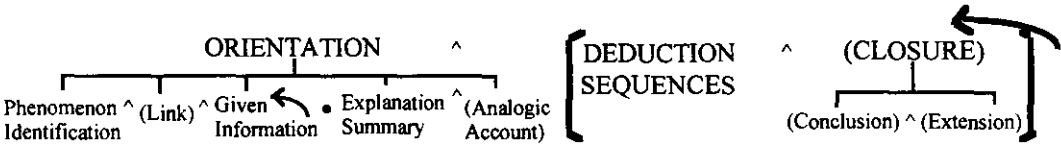
The first Extension element in SSEAS1 could also be thought of as a "consolidation" or a "rehearsal" element because it provides additional means of constructing the meanings in the DEDUCTION SEQUENCES using alternative forms of semiosis:

- 22 This relationship between the angle of the sun's rays and the heating effect is shown in Figure 7.23 and activity 7.6. (SSEAS1)

The second Extension element in SSEAS1, like that in SSEAS3, extends the explanation of the occurrence of summer and winter in the DEDUCTION SEQUENCES, to the seasons of autumn and spring:

- 39 Between the extremes of summer and winter, the two hemispheres are more or less equally heated by the sun
- 40 and they experience spring or autumn. (SSEAS1)
- 15 Autumn and spring occur
- 16 when the Earth is halfway between the summer and winter positions on its orbit. (SSEAS3)

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



The organisation of the secondary seasons texts in terms of the proposed schematic structure potential is shown in Table 5.1.

	SSEAS1	SSEAS2	SSEAS3
ORIENTATION			
Phenomenon Identification	Seasons of the Earth	Seasons and the Earth's movement	The seasons
Link			01 You may have seen (Figure 2.6) that the Earth is drawn with its axis 'tipped over' or tilted.
Given Information	01 The earth rotates about its axis 01.1 which is not vertical but tilted at an angle of $23\frac{1}{2}^{\circ}$. 02 The angle and direction of tilt of the Earth's axis remain the same 03 as the Earth moves around the sun.	01 As the Earth rotates 02 it also moves in space around the sun. 03 This movement is called revolution 04 and the path around the sun is called an orbit. 05 It takes $365\frac{1}{4}$ days for each revolution. 06 This time interval is called one year. 07 To avoid having the inconvenience of a quarter of a day at the end of each year, 08 the calendar has 365 days in a year. 09 To make up for the missing quarter day, 10 Every fourth year is called a leap year. 11 and has 366 days.	02 The angle of tilt is $23\frac{1}{2}^{\circ}$. 03 As the Earth moves around the Sun, 04 the axis always points to the same place in the sky. 05 This is called the celestial pole. 06 Straight above the north celestial pole is the star Polaris, 06.1 which is called the 'pole star'. 07 The south celestial pole is between the Southern Cross and the star Achernar (Figure 2.55).
Explanation Summary	04 The tilt of the Earth's axis gives rise to the seasons and the varying lengths of day and night at different times of the year. 05 Day lengths and temperatures depend on [[how long the sun shines and the angle [[at which the sun's rays strike the Earth]]]].	12 It is the Earth's revolution around the sun that gives us our seasons: autumn, winter, spring, summer.	08 The different distances to the Sun [[caused by the tilting axis of the Earth]] is not the cause of the seasons. 09 They are due to the rays of light from the Sun being spread over much larger areas of the Earth's surface in winter when compared to summer (Figure 2.10).
Given Information		13 As seen in figure 10.9, 14 The Earth's axis remains tilted in the same direction throughout its orbit.	
Analogic Account	06 If you take a smooth shiny ball 07 and shine a torch on it 08 you will notice that the half [[facing the torch]] is lit up. 09 The surface is lit most brightly directly in front of the torch. 10 Although the remainder of that half is illuminated, 11 it is not as bright as this rather small region. 12 Similarly, the Earth's surface is most brightly lit 13 where the sun's rays strike the surface perpendicularly 14 (see figure 7.23)		
DEDUCTION SEQUENCES	15 The heating effect of the sun's rays is also greatest 16 when they strike the Earth's surface perpendicularly 17 i.e. when the sun is directly overhead 18 When the sun's rays strike the surface obliquely, 19 they are spread over a larger area, 20 and the heating effect is less.		
CLOSURE			
Conclusion	21 In summer, the sun's rays strike the Earth more directly (i.e. at an angle closer to 90°) than in winter		
Extension	22 This relationship between the angle of the sun's rays and the heating effect is shown in figure 7.23 and activity 7.6		
DEDUCTION SEQUENCES	23 As a result of the tilt of the Earth's axis the southern hemisphere is inclined towards the sun in December and away from the sun in June 24 (see figure 7.24) 25 When the southern hemisphere tilts towards the sun, 26 it receives more of the sun's rays at an angle closer to 90° 27 and it experiences summer. 28 During this time the northern hemisphere points away from the sun 29 and is experiencing winter. 30 When the southern hemisphere tilts away from the sun, 31 most of the sun's rays strike the Earth obliquely 32 and their heating effect is less. 33 During this time the southern hemisphere has its winter. 34 The northern hemisphere at the same time points toward the sun 35 and has its summer.	15 This tilt is therefore sometimes towards the sun 16 while at other times away from the sun. 17 While the southern hemisphere experiences summer, 18 the northern hemisphere is experiencing winter. 19 It can also be seen in figure 10.10 that in our summer, the South pole is in constant daylight and the north pole is in constant darkness. 20 In winter the reverse is true. 21 Figure 10.10 shows that when the northern part of the Earth's axis is tilted away from the sun, the southern hemisphere faces the sun more directly. 22 In Winter the southern hemisphere faces the sun at a large angle. 23 The sun's rays are spread out over a large area.	10 This means [[that the part of the Earth closest to the Sun has more rays for a given area and experiences summer]]. 11 The area further away from the Sun has fewer rays for the same area 12 and is thus cooler. 13 experiencing winter. 14 The position is reversed each six months (Figure 2.9).
CLOSURE			
Conclusion	36 The seasons in the southern and northern hemispheres are always the reverse of each other 37 When one hemisphere points toward the sun, 38 the other must point away from the sun.		
Extension	39 Between the two extremes of summer and winter, the two hemispheres are more or less equally heated by the sun 40 and they experience spring or autumn.		15 Autumn and spring occur 16 when Earth is halfway between the summer and winter positions on its orbit.

Table 5.1 Schematic structure of secondary seasons texts

The obligatory elements appear to be the Phenomenon Identification, Given Information and Explanation Summary within the ORIENTATION and the DEDUCTION SEQUENCES. These occur in all three texts but there is nevertheless a good deal of variation in their schematic structure. Variation in the ORIENTATION is due to the optional Link and Analogic Account elements, each occurring only once and in different texts, and to the Given Information being iterative in SSEAS2. The main variation is the iteration of the DEDUCTION SEQUENCES and CLOSURE elements in SSEAS1 so that the first sequence of these two elements is a kind of preliminary explanation for the second sequence. Variation also occurs in the CLOSURE, which is not included in SSEAS2 and consists of a Conclusion and an Extension in SSEAS1 but an Extension only in SSEAS3.

5.1.2 Theme and schematic structure in secondary seasons texts

As in the previous two chapters the Theme analysis was focussed on an investigation of the "method of development" of the texts (Fries, 1983:135 quoted in Martin, 1992:434). Again, this analysis followed the procedures outlined in Martin (1992:435 & 440), in which 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 SSEAS1 is indicated in Figure 5.3. 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.

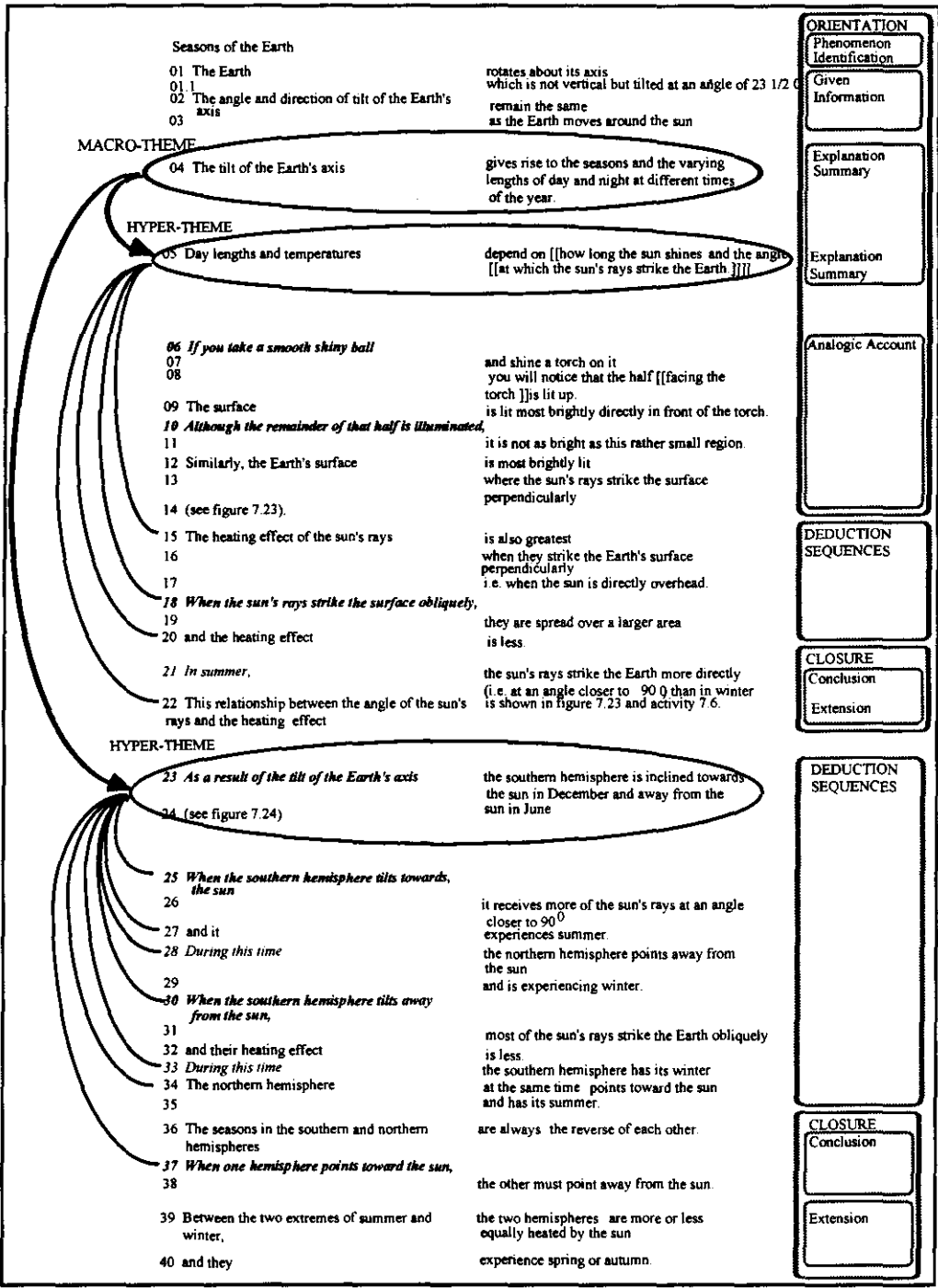


Figure 5.3 Theme and schematic structure in SSEAS1

The first clause in the Explanation Summary functions textually as a Macro-Theme predicting the second clause in the Explanation Summary as one Hyper-Theme to the first DEDUCTION SEQUENCES element, and then a further Hyper-Theme for the second DEDUCTION SEQUENCES element. These Hyper-Themes are then predictive of Theme selections in the DEDUCTION SEQUENCES.

Although the first DEDUCTION SEQUENCES element is not very extensive, the experiential content of the Themes is quite restricted, while the varied, new, technical information is introduced in the Rhemes. In the second DEDUCTION SEQUENCES element this patterning is clearer. The Themes are consistently the Earth's hemispheres and their tilt in relation to the sun and the seasons are consistently introduced Rhematically as News. There is a strong tendency for marked Themes to introduce each phase of the DEDUCTION SEQUENCES, i.e. the Thematic β clauses (25 and 30) introducing the implication sequences producing summer and winter in the southern hemisphere and the Circumstances of temporal location as marked Theme ("During this time") in clauses 28 and 33, indicating referential identity with the relevant β clauses and establishing this as the point of departure for the implication sequences producing the contrasting seasons in the northern hemisphere. The pattern is broken with the second Circumstance as marked Theme in clause 33. This maintains the implication sequence of the previous phase and the new phase of the northern summer is introduced by "The northern hemisphere" as unmarked Theme. The original pattern could have been maintained, as shown in Table 5.2.

Original Text		Modified Text	
30	<i>When the southern hemisphere tilts away from the sun,</i>	30	<i>When the southern hemisphere tilts away from the sun,</i>
31	most of the sun's rays strike the Earth obliquely	31	most of the sun's rays strike the Earth obliquely
32	and their heating effect is less.	32	and their heating effect is less.
33	<i>During this time</i> the southern hemisphere has its winter.	33	<i>Consequently the southern hemisphere</i> has its winter.
34	The northern hemisphere at the same time points toward the sun	34	<i>During this time</i> the northern hemisphere points toward the sun
35	and has its summer.	35	and has its summer.

Table 5.2 Thematic patterns in DEDUCTION SEQUENCES in SSEAS1

The new information introduced Rhematically in the DEDUCTION SEQUENCES forms sets of contrasts (closer to 90°/obliquely; summer/winter; away from the sun/toward the sun), which are accumulated and summarised in the Conclusion element (clauses 36 and 37) as Hyper-New, as indicated in Figure 5.4.

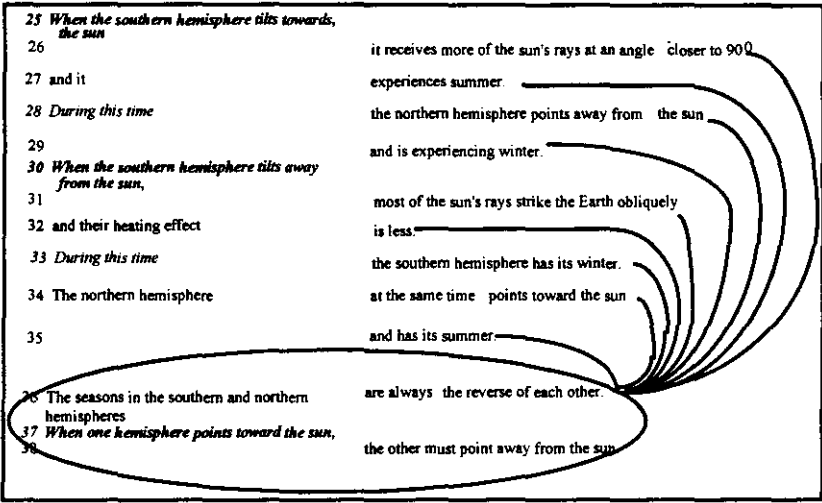


Figure 5.4 News and Hyper-New in DEDUCTION SEQUENCES in SSEAS1

The relationship between Theme selection and schematic structure in SSEAS2 is indicated in Figure 5.5.

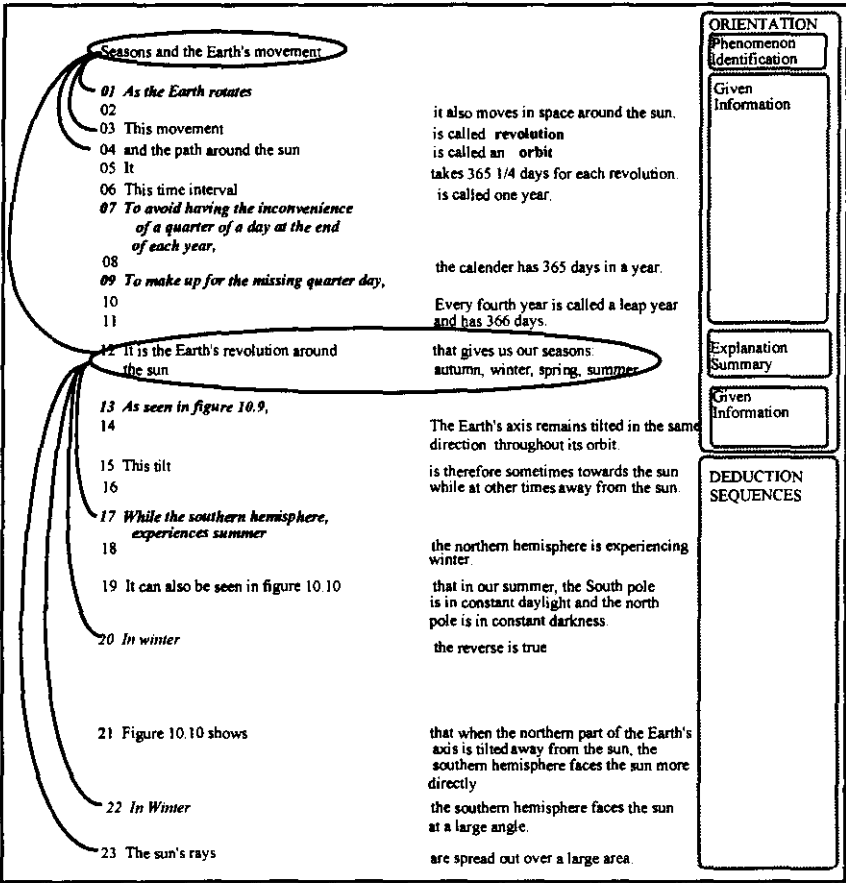


Figure 5.5 Theme and schematic structure in SSEAS2

The Phenomenon Identification functions as a Macro-Theme predicting as Hyper-Theme, the Explanation Summary, which in turn predicts some of the Theme selection in the DEDUCTION SEQUENCES (The Macro-Theme also predicts some Theme selection in the Given Information element). In contrast to SSEAS1, the seasons are frequent Themes in the DEDUCTION SEQUENCES. More specifically, it is the seasons in the southern hemisphere which are frequently selected as the points of departure. The marked Themes, "In Winter" emphasise the contrast with the situation in summer, but in both cases with respect to what occurs in the southern hemisphere. In addition the method of development of this element of structure is influenced by the selection of reference to illustrations as Theme, which is not predicted by the Hyper-Theme. The Thematic emphasis then, is on the text's diagrams and the seasons in the southern hemisphere, rather than the changes in the orientation to the sun of the Earth's hemispheres during the Earth's orbit, as in SSEAS1. In SSEAS2 there is no Conclusion element and no accumulation of new information in a Hyper-New.

The hierarchy of periodicity clearly developed in SSEAS1 through the Macro-Theme, Hyper-Theme and Theme selections, and less clearly but also evident in SSEAS2, was not developed in SSEAS3 at all, as can be seen in Figure 5.6. There was no Macro-Theme. The only contender for a Hyper-Theme was clause 08 in the Explanation Summary, and this was predictive of the Theme in clause 11 only. There is some progression from Rheme→Theme within and across elements of schematic structure. Again there is no Conclusion element and no accumulation of new information as a Hyper-New.

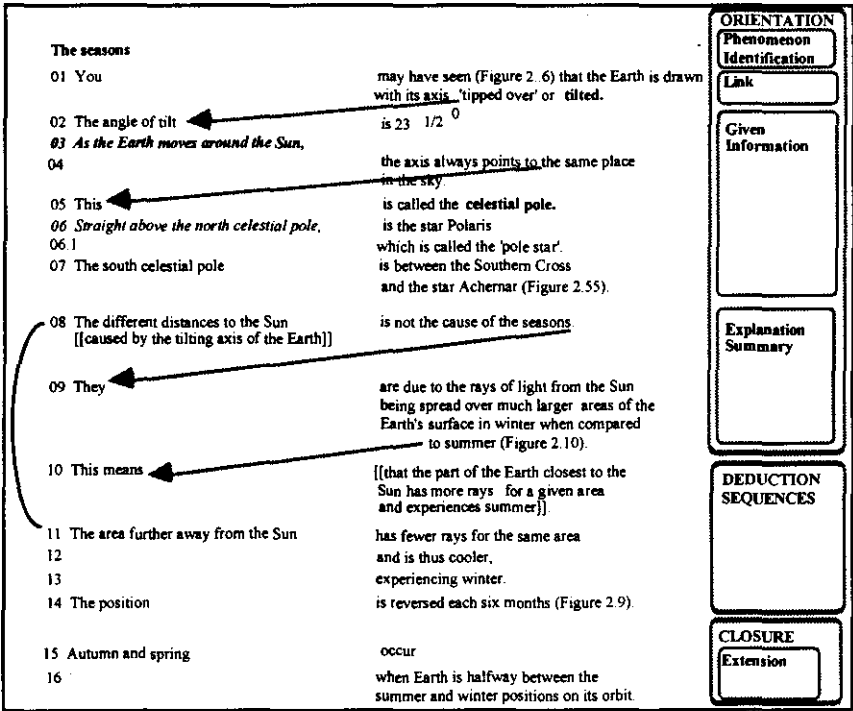


Figure 5.6 Theme and schematic structure in SSEAS3

The clearest patterning of Thematic choice in relation to schematic structure was in SSEAS1. The first clause in the Explanation Summary functioned as a Macro-Theme, predicting Hyper-Themes, which were predictive of Theme selections in the DEDUCTION SEQUENCES. Marked Themes tended to scaffold the introduction of phases in the second DEDUCTION SEQUENCES element. A similar patterning of Theme selection was evident in SSEAS2 but the deployment of marked Themes emphasised the seasons in the southern hemisphere as points of departure, rather than the changes in the orientation to the sun of the Earth's hemispheres during the Earth's orbit, as in SSEAS1. These patterns of Theme selection did not occur in SSEAS3. Only SSEAS1 showed accumulation of new information as a Hyper-New.

5.1.3 Conjunction in secondary seasons texts

The analyses of conjunctive relations in the secondary seasons texts are shown in Figures 5.1a - 5.3a in Appendix 5 and the results are summarised in Table 5.3.

Text	Clauses	CRUs*	Conjunctive relations				
			Internal	External	Metaphorical	Implicit	Explicit
SSEAS1	41	40	14	24	11	16	11
SSEAS2	23	23	04	08	02	03	07
SSEAS3	17	16	04	08	06	03	03

*CRUs = Conjunctively Related Units

Table 5.3 Conjunction in secondary seasons texts

This table indicates significant use of internal conjunction. Internal consequential relations are most prominent in SSEAS1 and make up half of the internal conjunction in the other texts, as indicated in Table 5.4.

TEXT	CLAUSES	CRUS	INTERNAL CONJUNCTIVE RELATIONS															total
			Comparative												Consequential			
			Similarity									Difference			Cause			
			Reformulation						Comparison			Contrast			Consequence			
			Exemplify			Exhaust			Similarity									
			i	e	m	i	e	m	i	e	m	i	e	m	i	e	m	
SSEAS1	41	40	1			2	1					1			9			14
SSEAS2	23	23				1				1					1	1		04
SSEAS3	17	16										1		1	1		1	04

Table 5.4 Incidence of internal conjunction in secondary seasons texts

In contexts where the distinction between internal and external consequence is problematic Martin (1992:226) suggests that paraphrasing (changing the dependency relationship between the messages from hypotactic to paratactic or "cohesive" or vice versa) will involve projecting one of the messages with a verbal or mental process in the case internal relations. This applies in two recurring contexts in these texts. In both cases the projection involves a mental process like "know" or "deduce" because the reader is required to reason from the information explicit in the text (using additional information not explicitly stated) to construct the consequential relationship with the explicit conclusion. The role of such projections in constructing the internal steps in scientific explanation was noted by Halliday (1993e:65-66) as an initial stage in the evolution of the use of verbs such as "prove", "show", "be explained by" and "indicate" expressing internal relations in scientific English, which he summarised as follows:

2 internally

from *a* happens; so we know *x* happens

because *a* happens, we know *x* happens

that *a* happens proves *x* to happen

happening *a* proves happening *x*

to happening *a* is the proof of happening *x*

(Halliday, 1993e:66)

In the first category of the recurring contexts in these explanations a technical implication sequence is the rhetorical means for concluding that it can be named using the terminology of familiar commonsense. This is illustrated by the segment from SSEAS1 in Figure 5.7.

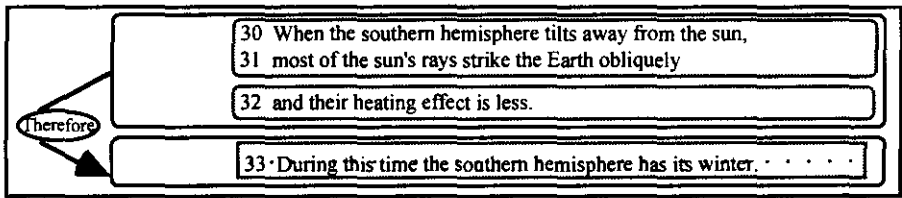


Figure 5.7 Internal consequence relating commonsense and technicality in SSEAS1

Here it is not that the meanings in clauses 30-32 materially cause those in 33. Readers use their prior knowledge of winter being cold, in combination with the explicit information in 30-32, to conclude that the commonsense experience of 33 is the way we name the uncommonsense of 30-32. The paraphrase would be something like "and so we say/conclude that during this time the southern hemisphere has its winter" - and the consequential relationship is internal.

The second problematic context is where the consequence in an implication sequence is constructed from explicitly stated information, again on the basis of previously constructed (or assumed) field knowledge. This is also regarded as internal consequence and is illustrated by clauses 30-32 from SSEAS1, shown again in Figure 5.8.

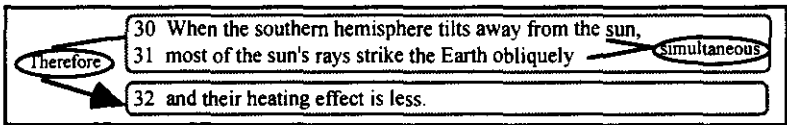


Figure 5.8 Exemplifying reasoning realised by internal consequence in SSEAS1

Clause 32 is the consequence of the readers' reasoning: "and hence we know/can say that their heating effect is less because we already know that if rays strike the Earth obliquely they spread out over a larger area than if they strike perpendicularly". This internal consequence constructing a logical deduction can be distinguished from external conjunction in an earlier text segment, shown in Figure 5.9, in which the consequential relation is constructing Field:

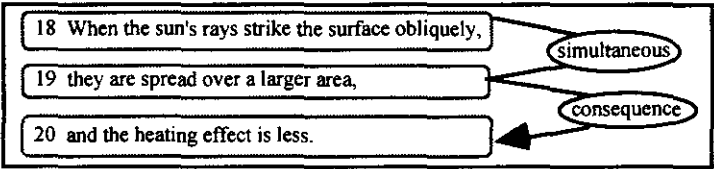


Figure 5.9 Exemplifying external consequential conjunction constructing field in SSEAS1

Here it is inappropriate to insert the projection into 20 ("and hence we know/can say...") because it is not a conclusion constructed rhetorically from explicitly stated information and previous or assumed information. Rather 20 is a material consequence of 19.

Internal consequential conjunction is concentrated in the DEDUCTION SEQUENCES. For example, seven of the nine internal consequential relations in SSEAS1 occur in this element as do both instances of internal consequence in the other texts.

The most prominent categories of external conjunction were simultaneity and consequence, as shown in Table 5.5.

TEXT	CL	CRUs	EXTERNAL CONJUNCTIVE RELATIONS																		total
			Temporal						Consequential						Comparison						
									cause						contrast						
			simultaneous			successive			consequence			contingency									
												condition							purpose		
i	e	m	i	e	m	i	e	m	i	e	m	i	e	m	i	e	m				
SSEAS 1	41	40		6	3	1			1		6		1	1			1	1	24		
SSEAS 2	23	23		2						1					2		1	1	1	08	
SSEAS 3	17	16		2					1	3							1		1	08	

*SSEAS1 - 1 explicit locative; 1 explicit concession; 1 explicit similarity

Table 5.5 Incidence of external conjunction in secondary seasons texts

The external consequence was almost entirely metaphorical. In all texts metaphorical realisations of cause occurred in the Explanation Summary and in SSEAS2 and SSEAS3 all instances occurred in this element of structure:

- 04 The tilt of the Earth's axis gives rise to the seasons and the varying lengths of night and day at different times of the year.
- 05 Day lengths and temperatures depend on [[how long the sun shines and the angle [[at which the sun's rays strike the Earth]]]]. (SSEAS1)
- 12 It is the Earth's revolution around the sun that gives us our seasons: autumn, winter, spring, summer. (SSEAS2)
- 08 The different distances to the sun [[caused by the tilting axis of the Earth]] is not the cause of the seasons.
- 09 They are due to the rays of light from the sun being spread over much larger areas of the Earth's surface in winter when compared to summer... (SSEAS3)

The realisation of the DEDUCTION SEQUENCES involves "unpacking" these logical metaphors in the Explanation Summary.

The distribution of external simultaneity varied significantly across the texts. In SSEAS1 it was again concentrated in the DEDUCTION SEQUENCES, with only one of the nine instances occurring outside this element. However, in SSEAS2 there was only one occurrence in the DEDUCTION SEQUENCES and none in SSEAS3.

The reasoning in the DEDUCTION SEQUENCES relies mainly on the orchestration of external simultaneity with internal consequence. The external simultaneity, conflating implicitly with consequence, constructs this temporal/causal relation between the material events from which the subsequent chain of deduction proceeds. This is clearest in SSEAS1:

- 25 When the southern hemisphere tilts towards the sun,
26 it receives more of the sun's rays at an angle closer to 90°
- 30 When the southern hemisphere tilts away from the sun,
31 most of the sun's rays strike the sun obliquely

Once these material events and the external relations between them are established, internal logical reasoning takes over. So, clause 27 for example, is related by implicit, internal consequence to clauses 25-26:

- 25 When the southern hemisphere tilts towards the sun,
26 it receives more of the sun's rays at an angle closer to 90°
27 and it experiences summer.

As noted above the causal link from 27 back to the material events (25-26) is a rhetorical link of logical deduction constructed by internal consequential conjunction. In SSEAS1

there are four such rhetorical links, dealing separately with the occurrence of summer and winter in both the southern and northern hemispheres. These are shown in Figure 5.10 in clauses 25-35.

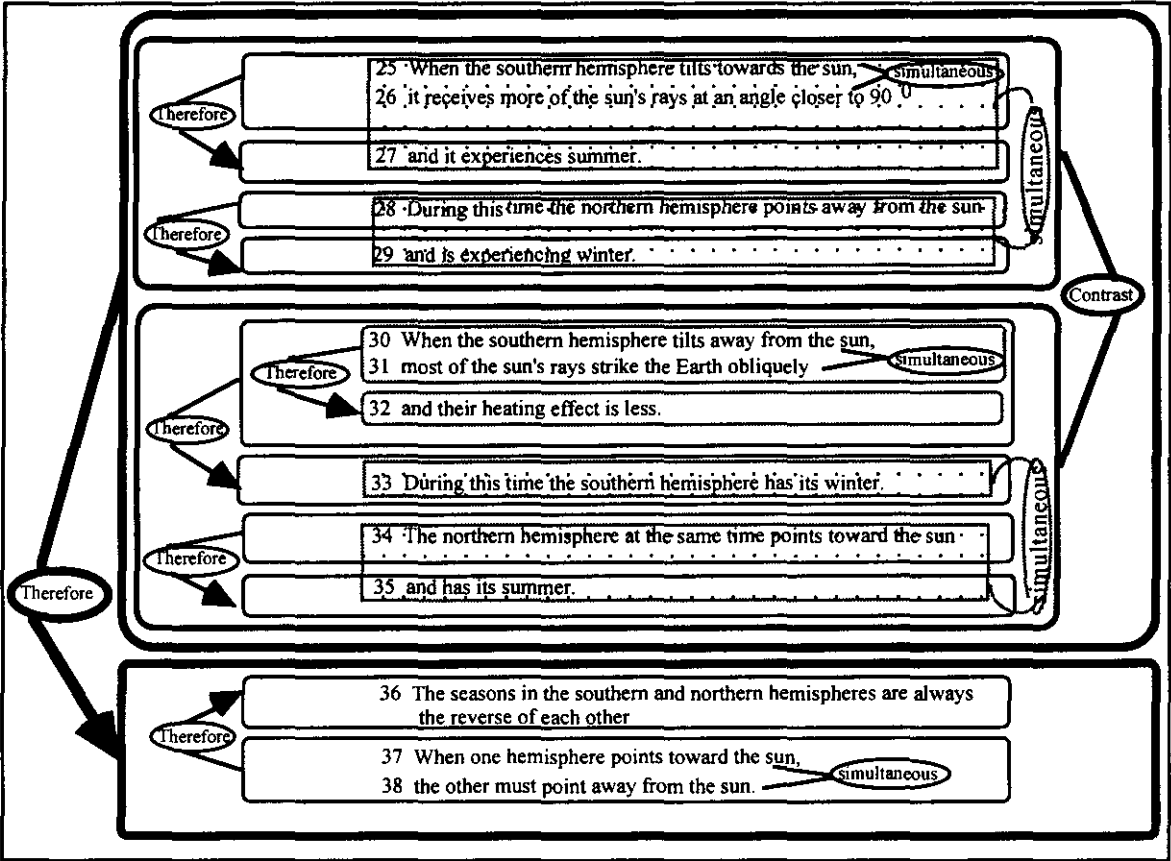


Figure 5.10 Reasoning in DEDUCTION SEQUENCES in SSEAS1

The first chain of reasoning dealing with summer in the southern hemisphere is linked by external simultaneity (realised metaphorically and not conflating with consequence) to the second chain dealing with winter in the northern hemisphere. (This is shown in Figure 5.10 by the vertical label of simultaneity linking the text segments on dotted background.) Chains three and four dealing with winter in the southern hemisphere and summer in the northern hemisphere are similarly related. Chains one and two are related to chains three and four by external contrast. Then this chain complex as a whole forms the rhetorical means for the Conclusion element and is related by implicit internal consequence to clauses 36-38.

The paucity of effective reasoning in SSEAS2 can be seen by comparing Figure 5.11 with Figure 5.10.

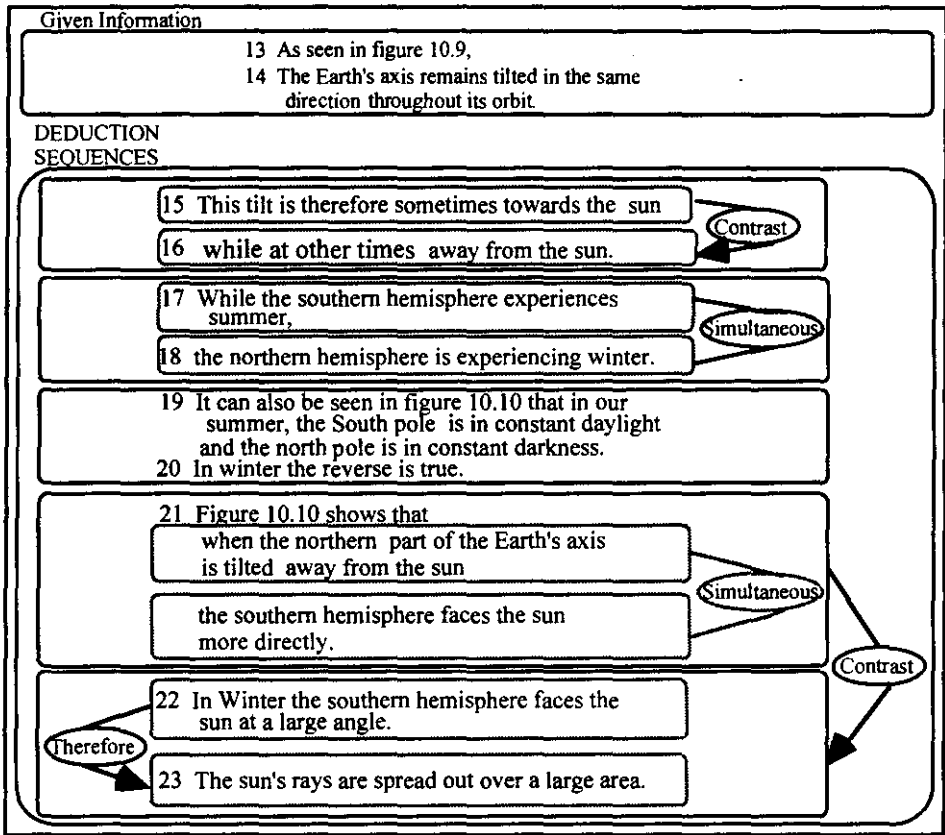


Figure 5.11 Reasoning in DEDUCTION SEQUENCES in SSEAS2

There is no explicit indication in the main text that the information in clause 21 relates to the northern winter and the southern summer, and there is no reasoning about how the fact that the northern hemisphere is tilted away from the sun is related to winter nor about how the southern hemisphere facing the sun directly is related to summer. The reasoning about the occurrence of the southern summer is in the caption accompanying Figure 10.10.

In our summer, the surface faces the sun directly.
 The rays of the sun are spread over a smaller area than in winter.
 This makes the ground hotter. (SSEAS2:caption text)

However the remainder of the caption simply reformulates clause 22:

In our winter, the surface faces the sun less directly than in summer.
 (SSEAS2:caption text)

This text requires a great deal of "re-assembly" and inference by the reader to construct any approximation to the systematic progression of reasoning in SSEAS1.

The reasoning in SSEAS3 also compares poorly with that of SSEAS1, as can be seen by comparing Figure 5.12 with Figure 5.10.

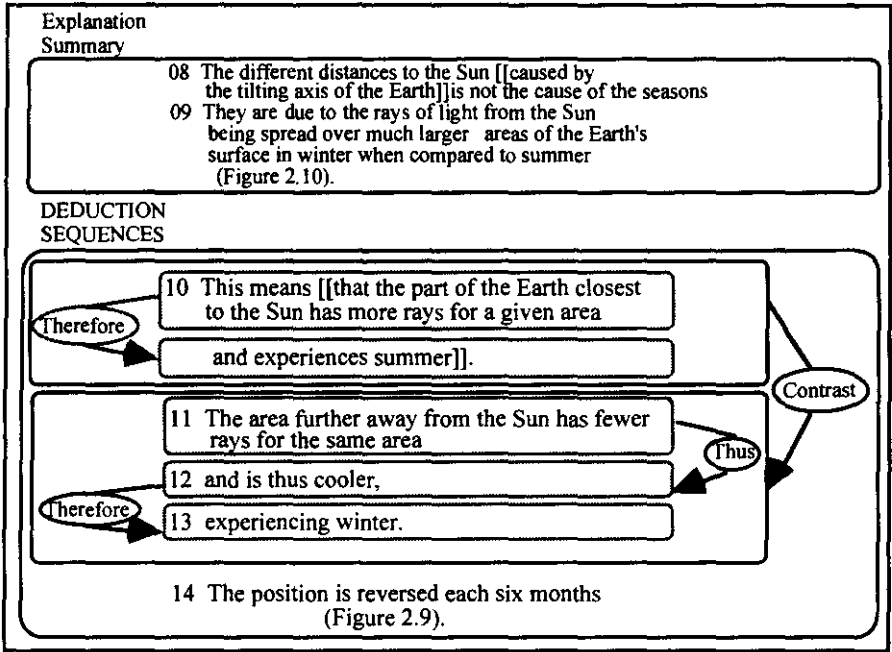


Figure 5.12 Reasoning in DEDUCTION SEQUENCES in SSEAS3

Here there is no mention of the angle of incidence of the sun's rays in the main text nor in the caption accompanying Fig. 2.10. Furthermore, it is difficult to distinguish in the diagram any difference in the angle of incidence of the sun's rays in the northern and southern hemispheres. So there is no logical link from the relative density of sun's rays for a given surface area to the inclination of that surface toward/away from the sun. The effect of this omission is exacerbated by clauses 10 and 11, referring to the part of the Earth that is "closest to the sun" (10) and "further away from the sun" (11), when clause 08 in the Explanation Summary indicates that

"The different distances to the Sun caused by the tilting of the Earth is not the cause of the seasons".

The problem here is the absence of the external simultaneity/consequence linking the inclination of the particular segment of the Earth's surface to the sun and the angle of incidence of the sun's rays to that segment. As shown in SSEAS1, these events and the external conjunctive relation between them are necessary for the construction of the subsequent logical deductions realised by internal consequential conjunction.

The relative emphasis on internal consequence in the DEDUCTION SEQUENCES was common across the texts, as was the minimal use of external consequence in this element.

But SSEAS1 deployed more internal consequential relations, more effectively in its account of reasons for the occurrence of summer and winter in both hemispheres. As far as external conjunction is concerned the crucial difference between SSEAS1 and the other texts was their failure to include the relation of simultaneity/consequence linking the inclination of the Earth to the sun and the angle of incidence of the sun's rays.

5.1.4 "Depth" of treatment: Variation in the selection of, and reader access to, ideational meanings.

Variation in the selection of ideational meanings across texts was investigated by applying the same techniques of semantic mapping used in the previous two chapters. A map of the instantial semantics of the causes of the seasons as evidenced in the three secondary texts was constructed and then the meanings in each of the texts were projected in turn onto the map of the aggregated ideational meanings.

Variation in types of reader access to ideational meanings was explored by categorising ideational meanings in the Given Information and DEDUCTION SEQUENCES elements according to the network of meaning access developed in Chapter two (2.2.4.2) and summarised in Figure 2.8.

5.1.4.1 A semantic map for the secondary seasons texts

The semantic map for the seasons texts focuses on the Given Information component of the ORIENTATION element and the DEDUCTION SEQUENCES element. The mapping of the meanings in the Given Information element is shown in Figure 5.13.

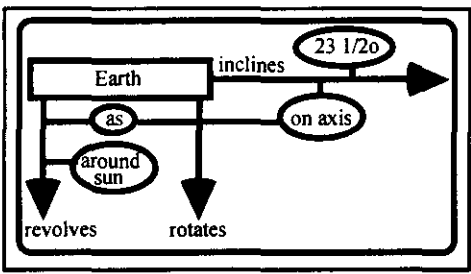


Figure 5.13 Semantic map for Given Information element in Seasons texts

This represents the Given Information in SSEAS1:

- 01 The Earth rotates about its axis
- 01.1 which is not vertical but tilted at an angle of $23\frac{1}{2}^{\circ}$.
- 02 The angle and direction of tilt of the Earth's axis remain the same
- 03 as the Earth moves around the sun.

This combination of events causes the inclination of particular hemispheres towards or away from the sun at particular positions in the orbit. However the Given Information in the other texts also contains peripheral meanings not related to the causes of the seasons:

- 04 the axis always points to the same place in the sky.
- 05 This is called the celestial pole.
- 06 Straight above the north celestial pole is the star Polaris,
- 06.1 which is called the 'pole star'.
- 07 The south celestial pole is between the Southern Cross and the star Achemar (Figure 2.55) (SSEAS3)
- 05 It takes $365\frac{1}{4}$ days for each revolution.
- 06 This time interval is called one year.
- 07 To avoid having the inconvenience of a quarter of a day at the end of each year,
- 08 the calendar has 365 days in a year.
- 09 To make up for the missing quarter day,
- 10 Every fourth year is called a leap year
- 11 and has 366 days. (SSEAS2)

These peripheral meanings are not mapped.

The causal relation between the combination of events in the Given Information and the inclination of the different hemispheres towards/away from the sun at a particular time of the year is mapped as shown in Figure 5.14.

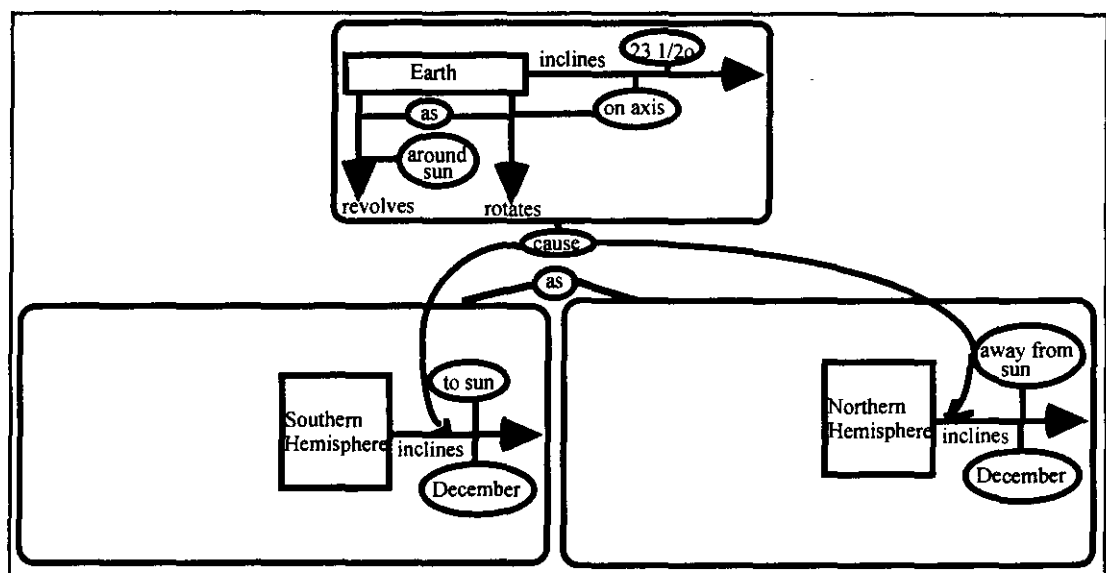


Figure 5.14 Causal relation between events in Given Information and events underlying the seasons in opposite hemispheres

When the southern hemisphere is tilted towards the sun in December the sun's rays strike the Earth perpendicularly. At the same time the sun's rays strike the northern hemisphere obliquely. Hence the rays are diffused over a larger area in the northern hemisphere than in the southern hemisphere. These meanings are mapped as shown in Figure 5.15.

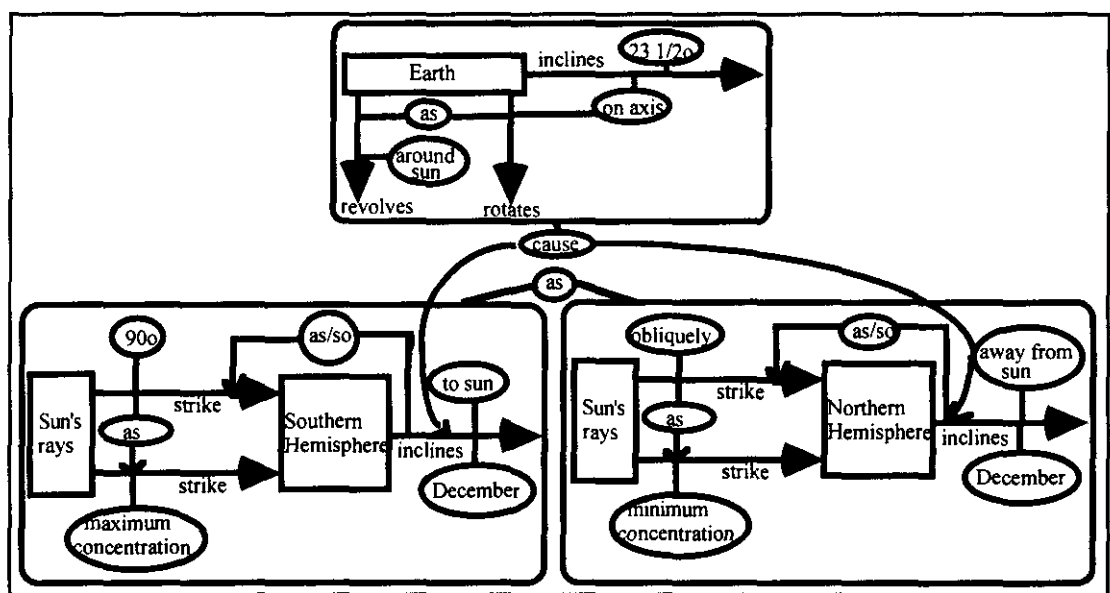


Figure 5.15 Effect of the inclination of the Earth to the sun on the angle of incidence and concentration of the sun's rays

The greater concentration of the sun's rays produces a greater heating effect and what we call summer, while the lower concentration produces a lower heating effect and what we call winter as represented in Figure 5.16.

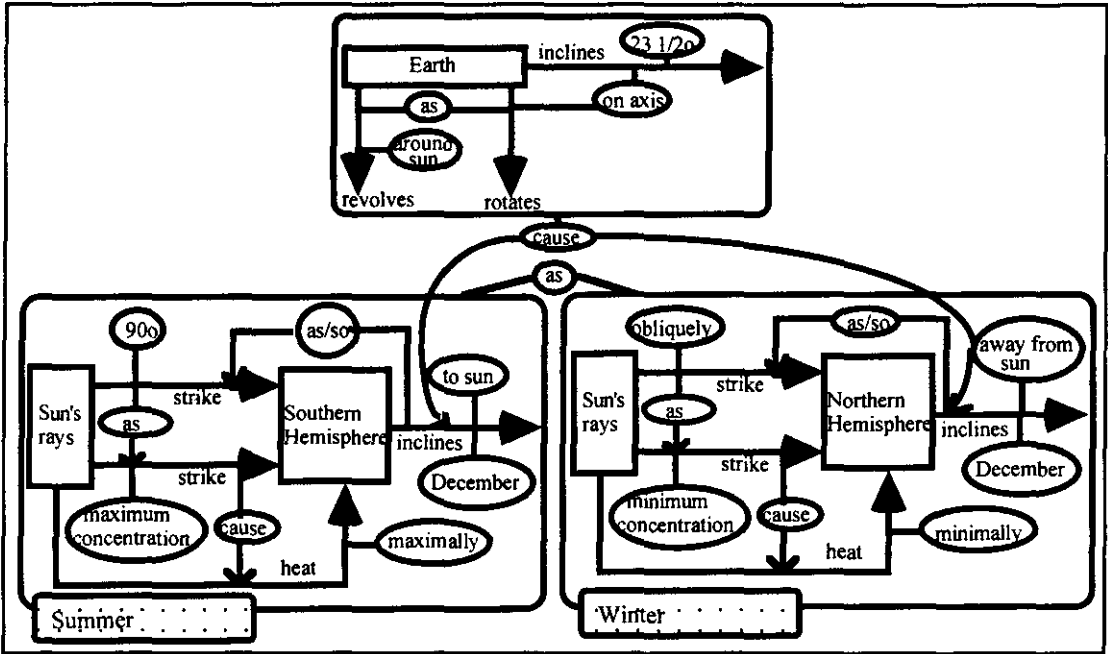


Figure 5.16 Summer in the southern hemisphere and winter in the northern hemisphere

Similarly, the combination of events in the Given Information causes the opposite seasons in the southern and northern hemispheres in June, as indicated on the complete map of the instantial semantics of the secondary seasons texts shown in Figure 5.17.

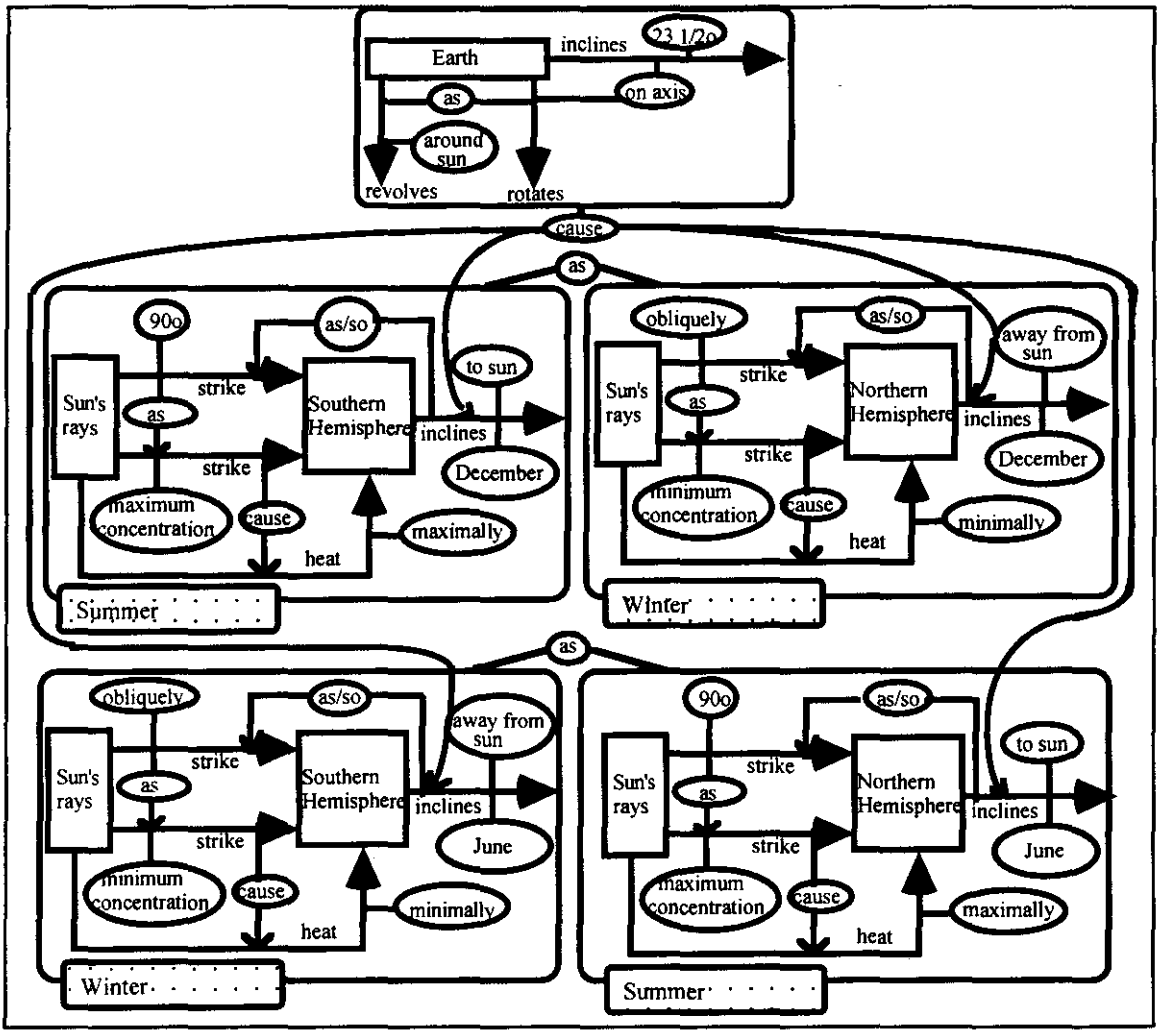


Figure 5.17 Instantial semantics of the causes of the seasons in secondary texts

The notion of a "main path" is quite problematic in this semantic map because in this Field there is no single definable "goal state" or "start state". The goal states are in a sense the seasons. These are indicated on the map on "dotted" backgrounds as abstractions from the underlying event sequences. It is possible then to imagine process lines, representing the meaning *experiences*, tracking back from the four seasons to the relevant hemisphere as participant in each case. Then all of the other process lines directed to this participant from the participant *sun's rays* mark out the main path in relation to each season. The causal relation lines from the Given Information element are actually linked to the process lines *inclines* in the event sequences underlying each season, so these process lines and the causal relation lines must be part of the main path linking back to the Given Information. Since it is the combination of event sequences in the Given Information that causes the events *Southern/Northern Hemisphere inclines toward/away from the sun* etc, all of the events in the Given Information must also be part of the main path. On this reasoning all

meanings represented on the semantic map are nuclear and there are no elaborative meanings.

5.1.4.2 Variation in ideational meanings in the Given Information and DEDUCTION SEQUENCES in secondary seasons texts

The variation in meaning selection and types of reader access was minimal in the Given Information (as indicated in Figure 5.4a in Appendix 5) but extensive in the DEDUCTION SEQUENCES. The extent of variation across texts in the inclusion of nuclear meanings in this element is illustrated and then the overall variation across the texts is shown in a comparison of the consolidated semantic maps of the Given Information and DEDUCTION SEQUENCES elements for each text. The extent of the variation in these elements is also reflected in separate semantic maps for the Explanation Summary element. The variation in categories of reader access to nuclear meanings is briefly discussed and summarised in Table 5.1a in Appendix 5.

In SSEAS1 some of the meanings relevant to the cause of each of the seasons are included in the first DEDUCTION SEQUENCES element as a kind of preliminary explanation. These meanings can then be inferred by ideational retrieval in each of the phases of the second DEDUCTION SEQUENCES element. The semantic map and text segment for the first DEDUCTION SEQUENCES element in SSEAS1 are shown in Figure 5.18.

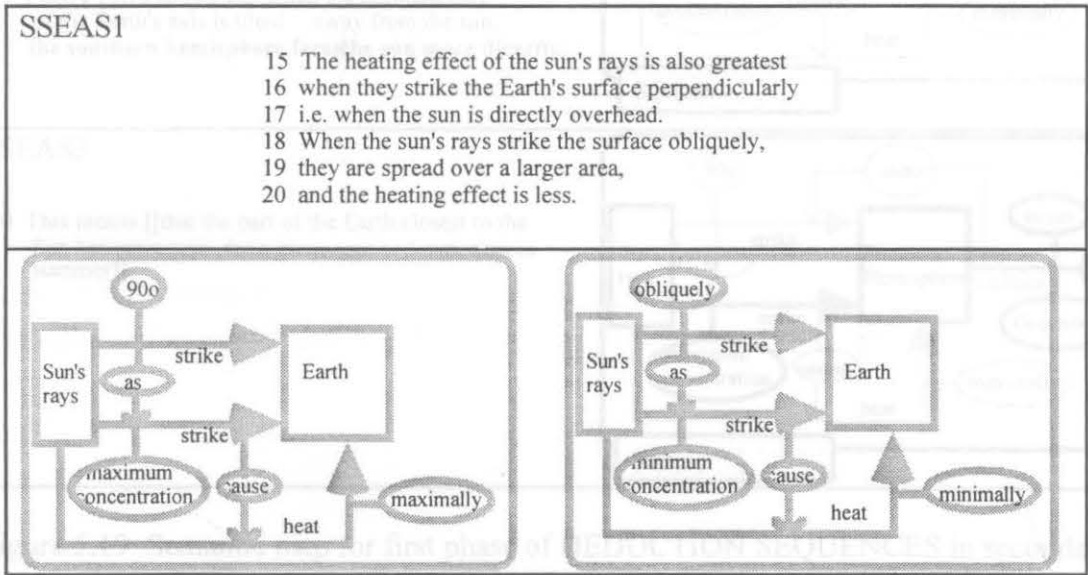


Figure 5.18 Semantic map for the first DEDUCTION SEQUENCES element in SSEAS1

The meanings *Sun's rays strike Earth with minimum concentration* are realised by the wording in clause 19 - "they spread over a larger area". It is the comparative reference in

this clause from which is inferred the meaning *Sun's rays strike Earth with maximum concentration*. The other meanings in this element are available literally.

The pattern of meaning selection and types of reader access to the meanings is fairly similar for each of the four phases of the DEDUCTION SEQUENCES. The relative inclusion of nuclear meanings is illustrated for the first phase in Figure 5.19. (Similar semantic maps and corresponding text segments for the other three phases are included as Figures 5.5a - 5.7a in Appendix 5).

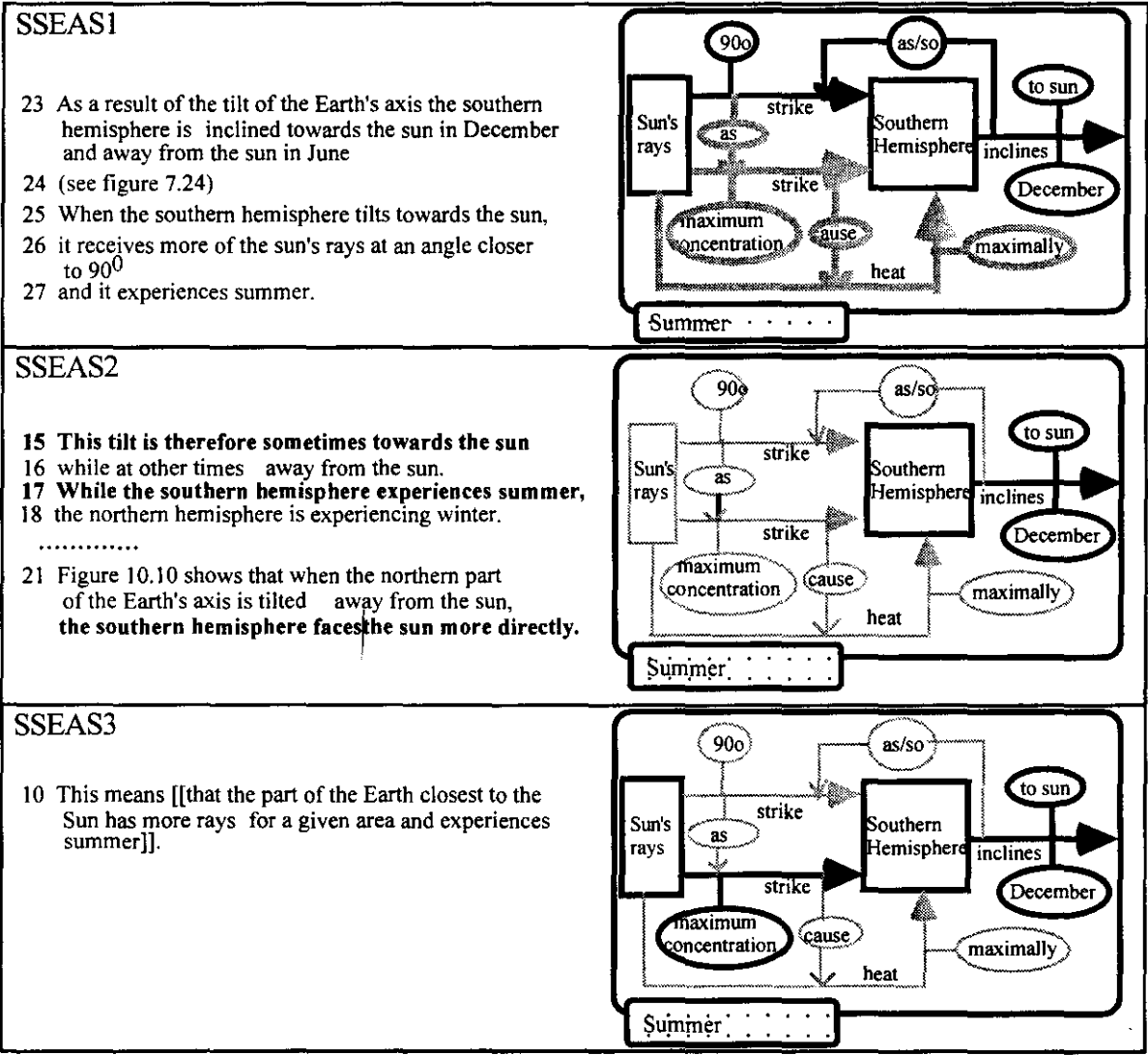


Figure 5.19 Semantic map for first phase of DEDUCTION SEQUENCES in secondary seasons texts

SSEAS1 deals comprehensively with the nuclear meanings involved. In each of the four phases in this text a number of meanings are inferred from the first DEDUCTION SEQUENCES element. These are shown as solid, thick, faint lines in the semantic maps (as represented in Figure 5.18 above). Where these meanings have been reiterated in the

second DEDUCTION SEQUENCES element, they are shown in solid, thick black lines as are the other nuclear meanings selected. Nuclear meanings not selected in particular texts are indicated by faint thin lines. SSEAS2 and SSEAS3 include fewer nuclear meanings and only SSEAS3 includes any of the nuclear meanings inferred in SSEAS1 from the first DEDUCTION SEQUENCES element. The final phase of the DEDUCTION SEQUENCES element dealing with the northern summer does not occur in SSEAS2 at all.

Some of the meanings in the text segments shown in each of the Figures are picked up in subsequent semantic maps. For example, the meanings from clause 23 in SSEAS1, *southern hemisphere inclines away from the sun in June*, is mapped in the third phase of the DEDUCTION SEQUENCES. The clauses relevant to the semantic map for the particular phase are in bold, as in SSEAS2 in Figure 5.19.

The meanings selected in all texts are predominantly literally available to the reader. The main exceptions are the retrieval of meanings from the first DEDUCTION SEQUENCES element by inference in SSEAS1 (although in phase three more are literally reinstated) and the construction of meanings for phases three and four of the DEDUCTION SEQUENCES in SSEAS3 relying on the reader inferring the reverse of phases one and two. The locations in time at which the Earth tilts towards/away from the sun are literal in SSEAS1 only. In the other texts these must be inferred. For example in phase one (Figure 5.19) the meaning *in December*, is only available through scriptal inference in SSEAS2 and SSEAS3, where textual cues are minimal - "some times" and "other times" in SSEAS2, and "The position is reversed each six months" in clause 14 in SSEAS3.

Overall, SSEAS1 provides the most comprehensive selection of nuclear meanings in these elements of structure, with a less comprehensive selection in SSEAS3 and a very low proportion selected in SSEAS2. Only SSEAS1 (through the first DEDUCTION SEQUENCES element) dealt with the role of the angle of incidence of the sun's rays. The overall variation across texts is indicated in Figure 5.20.

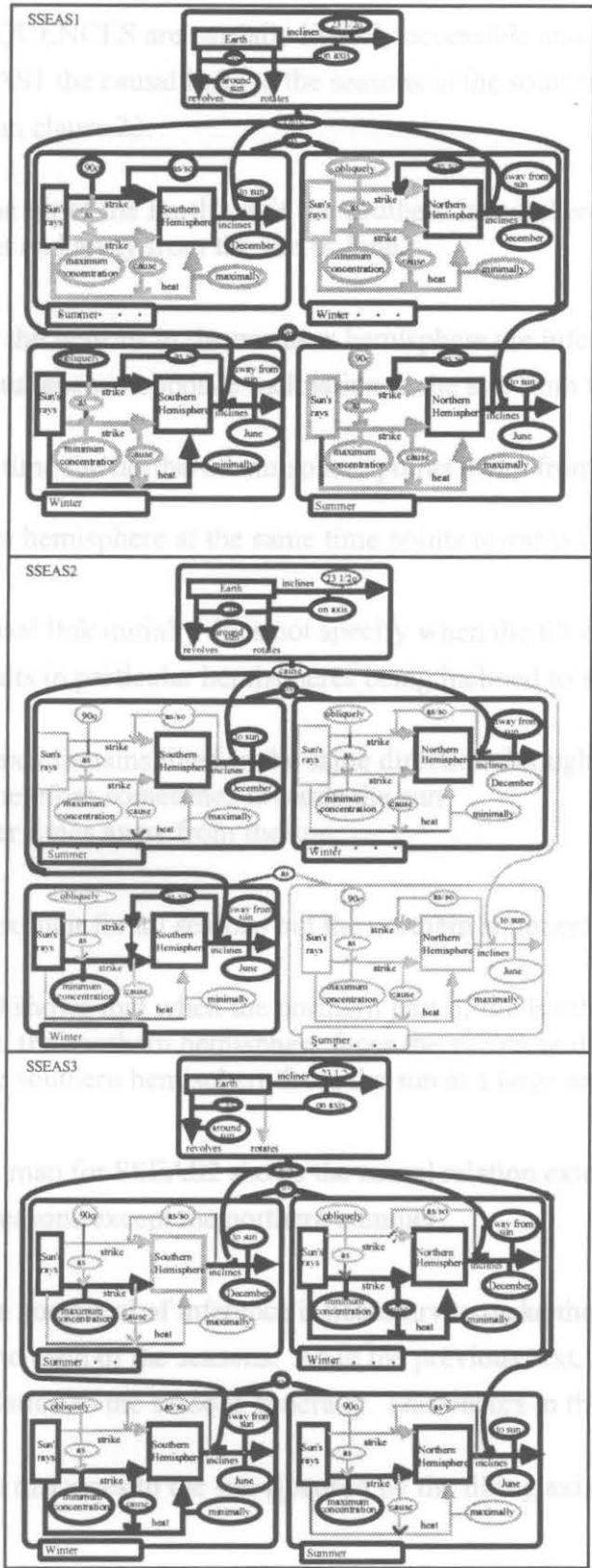


Figure 5.20 Comparison of the inclusion of nuclear meanings in secondary seasons texts

DEDUCTION SEQUENCES. The changes in this element that relate the different

The logical meanings represented by the causal relation lines linking the events in the Given Information to the events underlying the seasons in each of the phases of the

DEDUCTION SEQUENCES are partially literally accessible and partially reliant on inference. In SSEAS1 the causal links to the seasons in the southern hemisphere are literally accessible in clause 23:

As a result of the tilt of the Earth's axis the southern hemisphere is inclined towards the sun in December and away from the sun in June.

The causal links to the seasons in the northern hemisphere are inferred from the clauses indicating their simultaneous opposite inclination to the sun from the southern hemisphere:

28 During this time the northern hemisphere points away from the sun

.....

34 The northern hemisphere at the same time points towards the sun.

In SSEAS2 the causal link initially does not specify when the tilt of the Earth and its orbit around the sun results in particular hemispheres being inclined to/away from the sun:

14 The Earth's axis remains tilted in the same direction throughout its orbit.

15 This tilt is therefore sometimes towards the sun

16 while at other times away from the sun.

Later this is made explicit for all seasons but the northern summer:

21 Figure 10.10 shows that when the northern part of the Earth's axis is tilted away from the sun, the southern hemisphere faces the sun more directly.

22 In Winter the southern hemisphere faces the sun at a large angle.

Hence the semantic map for SSEAS2 shows the causal relation extending from the Given Information to all seasons except the northern summer.

Again in SSEAS3 a good deal of inference is necessary to make the causal link from the Given Information to each of the seasons. As in the previous text, initially the causal link is constructed in relation to the seasons generally. This occurs in the Explanation Summary:

08 The different distances to the sun [[caused by the tilting axis of the Earth]]...

The text reference item "This" in the clause 10 in the DEDUCTION SEQUENCES indicates that these retrieved meanings should be included in the semantic map of the DEDUCTION SEQUENCES. The clauses in this element then relate the different distances to the sun, and by inference therefore, the inclination of the Earth to or away from the sun, to each of the seasons:

- 10 This means [[that the part of the Earth closest to the Sun has more rays for a given area and experiences summer]].
- 11 The area further away from the Sun has fewer rays for the same area
- 12 and is thus cooler,
- 13 experiencing winter.
- 14 The position is reversed each six months (Figure 2.9).

Hence in SSEAS3 the causal relation extends from the events in the Given Information element to the events underlying each of the seasons.

The relative depth of treatment of the topic indicated by the extent of inclusion of nuclear meanings in the Given Information and DEDUCTION SEQUENCES elements (SSEAS1 > SSEAS3 > SSEAS2) is similarly reflected in the extent of meanings in the Explanation Summary. The text segments for this element and a corresponding semantic map for each are shown in Figure 5.21. The only common meanings are shown by the thick black lines.

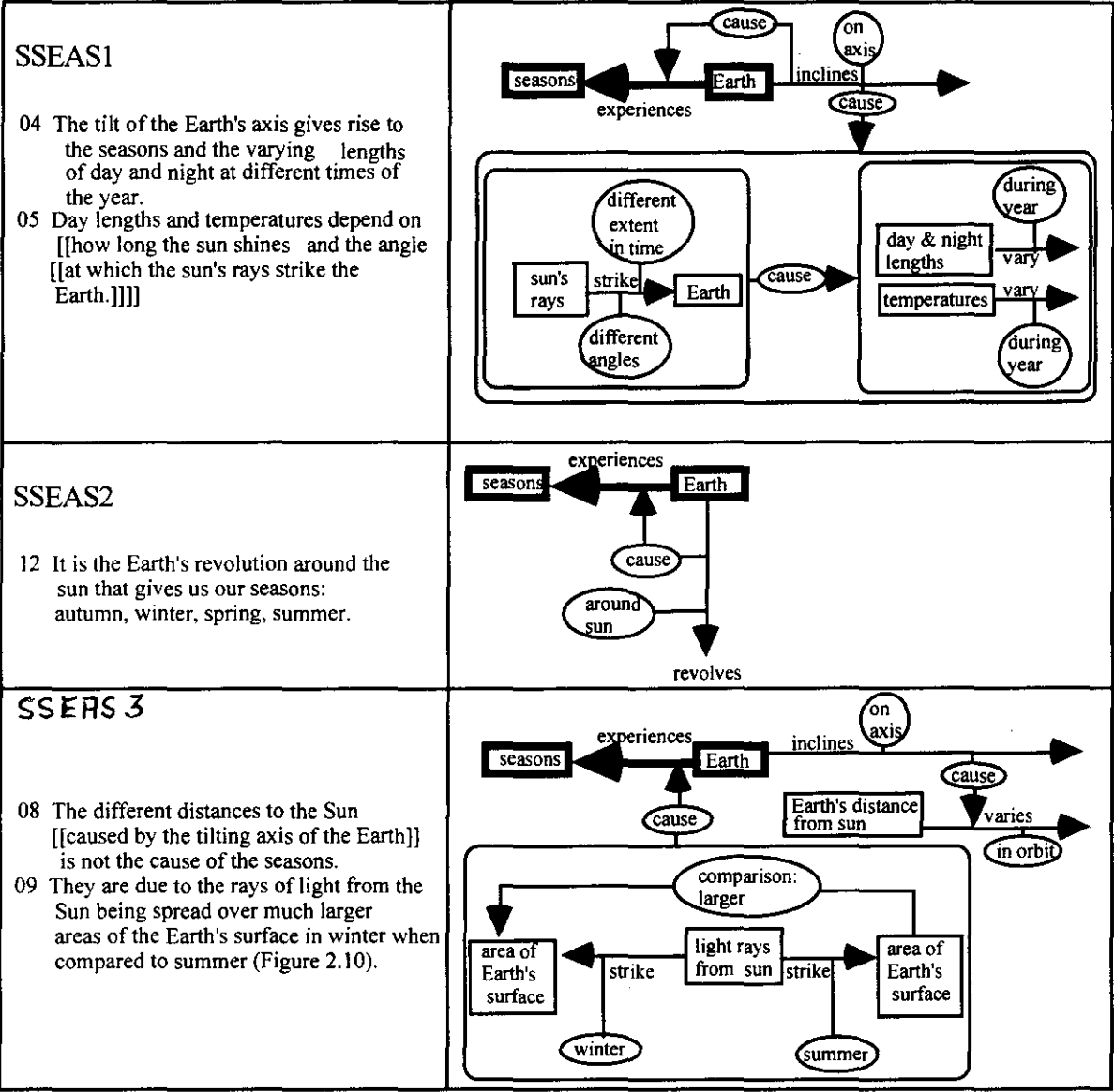


Figure 5.21 Comparison of meaning selection in the Explanation Summary element of secondary seasons texts

The lack of commonality here is the most notable feature of the Explanation Summaries. SSEAS2 indicates that the seasons are simply caused by the revolution of the Earth around the sun. But the Earth's revolution is not explicitly mentioned in either SSEAS1 or SSEAS3. SSEAS1 indicates that the seasons are due to the inclination of the Earth's axis and although this inclination is mentioned in SSEAS3, it is not shown to be causally related to the seasons.

5.1.4.3 Variation in types of reader access to ideational meanings

The main finding from the analysis of types of reader access to meanings was the higher proportion of literal meanings in SSEAS2, as shown in Table 5.6, and the low proportions in SSEAS1 and SSEAS3. A significant proportion of nuclear meanings in these texts were inferred by retrieval from previous text segments, while the lower proportion of nuclear meanings in SSEAS2 were predominantly literally accessible. (The proportions were calculated as the number of literal realisations per included nuclear meanings).

Text	SSEAS1	SSEAS2	SSEAS3
% Nuclear Meanings Literal (Explicit + Implicit)	65	87	43

Table 5.6 Proportion of nuclear meanings realised literally in secondary seasons texts

5.1.5 **Variation in grammatical realisation and construction of technicality**

5.1.5.1 Transitivity

The transitivity analyses (Figures 5.8a - 5.10a in Appendix 5) showed that Relational: attributive processes dominate all texts, that distinctive distributions of these with other process types distinguish the Given Information and DEDUCTION SEQUENCES elements, and that there is little variation in the realisation of common nuclear meanings. Variation across texts in the proportion of particular process types in the Given Information and DEDUCTION SEQUENCES is largely due to the omission of meanings from some texts or their construction through the resources of text reference and logical metaphor.

The dominance of Relational: attributive processes and the very low proportion of Material processes in two of the three texts is indicated in Table 5.7.

TEXT	CLAUSES	Material		Mental	Relational						Verbal	Behavioural
		Effective	Middle		Identifying			Attributive				
					int	circ	poss	int	circ	poss		
SSEAS1	41	13	3	1	1	2	0	10	7	0	1	7
SSEAS2	24	1	2	2	5	1	0	8	3	2	1	3
SSEAS3	17	1	2	1	5	2	0	8	2	2	0	2

Table 5.7 Summary of process types in secondary seasons texts

The relatively high number of effective Material processes in SSEAS1 is partially due to the six occurring in the Analogic Account, which is an element of schematic structure that does not occur in the other texts. One effective Material process also occurs in the

Extension element. Nevertheless four effective Material processes occur in the DEDUCTION SEQUENCES of this text and none in the other texts, because SSEAS1 is the only text to realise the event of the sun's rays striking the Earth's surface.

The largely common nuclear meanings in the Given Information are shown in Figure 5.22. The thicker lines indicate meanings common to all texts and the regular lines indicate meanings that occurred in two of the three texts.

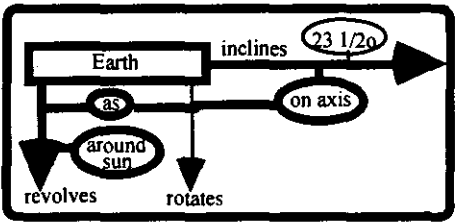


Figure 5.22 Commonality of ideational meanings in Given Information in secondary texts

The distribution of process types in the Given Information is shown in Table 5.8.

TEXT	CLAUSES	Material		Mental	Relational						Behavioural
		Effective	Middle		Identifying			Attributive			
					int	circ	poss	int	circ	poss	
SSEAS1	4		2					2			
SSEAS2	11		2	1	4		1	1	1	2	1
SSEAS3	7		1		3			2	1		

Table 5.8 Process types in Given Information elements in secondary seasons texts

There was little variation in the grammatical realisation of the common nuclear meanings. Similar middle Material clauses realised the meanings concerning the Earth's rotation on its axis and its revolution around the sun, as shown in Table 5.9.

	Rotation	Revolution
SSEAS1	01 The Earth rotates about its axis	03 as the Earth moves around the sun
SSEAS2	01 As the Earth rotates	02 it also moves in space around the sun
SSEAS3		03 As the Earth moves around the Sun

Table 5.9 Realisation of the Earth's rotation and revolution in secondary seasons texts

Relational: intensive: attributive clauses realised the Earth's inclination on its axis in SSEAS1 and SSEAS2:

- 01.1 which is not vertical but tilted at an angle of $23\frac{1}{2}^\circ$ (SSEAS1)
- 14 The Earth's axis remains tilted in the same direction throughout its orbit (SSEAS2).

In SSEAS3 these meanings were realised in the Relational: intensive: identifying clause 02 in the Given Information element in combination with demonstrative reference to the previous clause in the Link element:

- 01 You may have seen (Figure 2.6) that the Earth is drawn with its axis 'tipped over' or tilted.
- 02 The angle of tilt is $23\frac{1}{2}^{\circ}$ (SSEAS3).

The Relational: intensive: identifying clauses realise definitions which are not integral to these explanations of the occurrence of the seasons:

SSEAS2

- 03 This movement is called revolution
- 04 and the path around the sun is called an orbit
- 06 This time interval is called one year
- 10 Every fourth year is called a leap year

SSEAS3

- 05 This is called the celestial pole.
- 06.1 which is called the 'pole star'.

The term "orbit" is used again in the Given Information in SSEAS2, facilitating the use of a Circumstance of temporal extent rather than a Material clause and conjunctive simultaneity:

- 02 The angle and direction of tilt of the Earth's axis remain the same
- 03 as the Earth moves around the sun (SSEAS1).
- 14 The Earth's axis remains tilted in the same direction throughout its orbit (SSEAS2).
- 03 As the Earth moves around the sun,
- 04 The axis always points to the same place in the sky (SSEAS3)

The term "revolution" is also taken up in the Explanation Summary:

- 12 It is the Earth's revolution around the sun that gives us our seasons (SSEAS2)

But neither of these technical terms occurs in the DEDUCTION SEQUENCES.

The Relational: possessive clauses and the Behavioural clause in SSEAS2 realise peripheral meanings concerning the leap year. So it is essentially middle Material clauses and Relational: intensive: attributive clauses that construct the key meanings in the Given Information.

In the DEDUCTION SEQUENCES Relational: attributive processes dominate, Behavioural processes occur in each text and effective Material processes occur in SSEAS1 only. The distribution of these process types is summarised in Table 5.10.

TEXT	CLAUSES	Material		Mental	Relational						Verbal	Behavioural
		Effective	Middle		Identifying			Attributive				
					int	circ	poss	int	circ	poss		
SSEAS1*	6	2						4				
	13	2						2	4			5
SSEAS2	9			1				5	2		1	2
SSEAS3	5				1			4		2		2

*The first and second DEDUCTION SEQUENCES elements are listed separately

Table 5.10 Process types in DEDUCTION SEQUENCES in secondary seasons texts

The pattern of deployment of these process selections partly reflects the different experiential meanings in each of the steps of the four main phases of the DEDUCTION SEQUENCES, which address the occurrence of winter or summer in either the northern or southern hemisphere. The steps are outlined in Table 5.11.

STEPS	MEANINGS	PROCESS SELECTIONS	REALIZATIONS
Contextual STATE	Inclination of particular hemispheres to the sun	Relational: Intensive: Attributive Relational: Circumstantial: Attributive	the southern hemisphere is inclined towards the sun in December (SEAS1) ...the northern part of the Earth's axis is tilted away from the sun (SSEAS2) (.....) is closest to the sun (SSEAS3) the southern hemisphere tilts towards the sun (SSEAS1) the southern hemisphere faces the sun at a large angle (SSEAS2)
Simultaneous EVENT	Sun's rays strike the Earth's surface at an oblique or perpendicular angle	Material: effective	it receives more of the sun's rays at an angle closer to 90 0 (SSEAS1) Most of the sun's rays strike the Earth obliquely (SSEAS1)
Consequential STATE	Sun's rays are concentrated or spread out at the Earth's surface	Relational: Intensive: Attributive Relational: Possessive: Attributive	they are spread over a larger area (SSEAS1) the sun's rays are spread out over a large area (SSEAS2) The area further away from the Sun has fewer rays for a given area (SSEAS3)
Consequential EVENT	Ray's heating effect is relatively high or low (Relatively more or fewer light rays from the sun are absorbed by the Earth and converted to heat energy)	Relational: Intensive: Attributive	the heating effect is less (SSEAS1) and is thus cooler (SSEAS3)
Consequential Behavioural EVENT	Particular hemispheres experience summer or winter	Behavioural	and it experiences summer (SSEAS1) During this time the southern hemisphere has its winter (SSEAS1) While the southern hemisphere experiences summer (SSEAS2) and experiences summer (SSEAS3)

Table 5.11 Realisation of meanings in steps within phases of DEDUCTION SEQUENCES in secondary seasons texts

The selection of process types differentiates the steps and within steps there is little variation in the grammatical realisation of the meanings.

In some phases certain steps are omitted, as discussed in the comparison of nuclear meanings in 5.1.4. The meanings in step two (Sun's rays strike the Earth's surface at an oblique or perpendicular angle) occur in SSEAS1 only, and this is why effective Material processes occur in the DEDUCTION SEQUENCES of this text only. In the southern summer phase in SSEAS1 these meanings are literal and directly accessible by the reader, but in the northern winter phase they need to be inferred from the first DEDUCTION SEQUENCES element. Only the first and the final steps are explicit in the second DEDUCTION SEQUENCES element:

28 During this time the northern hemisphere points away from the sun
 29 and is experiencing winter (SSEAS1).

The meanings of the intervening steps are directly stated in the text in the first DEDUCTION SEQUENCES element but are located well prior to clauses 28 and 29, as indicated in Table 5.12:

STEPS	MEANINGS	REALIZATIONS
Contextual STATE	Inclination of particular hemispheres to the sun	28 During this time the northern hemisphere points away from the sun
Simultaneous EVENT	Sun's rays strike the Earth's surface at an oblique or perpendicular angle	<i>21 In summer the sun's rays strike the Earth more directly (at an angle closer to 90 0) than in winter. 18 When the sun's rays strike the surface obliquely</i>
Consequential STATE	Sun's rays are concentrated or spread out at the Earth's surface	<i>19 they are spread over a larger area</i>
Consequential EVENT	Ray's heating effect is relatively high or low (Relatively more or fewer light rays from the sun are absorbed by the Earth and converted to heat energy)	<i>20 and the heating effect is less</i>
Consequential Behavioural EVENT	Particular hemispheres experience summer or winter	29 and is experiencing winter.

Table 5.12 The northern winter phase of the DEDUCTION SEQUENCES in SSEAS1

Nevertheless the realisation of these intervening steps is consistent with the pattern of selection of process types outlined in Table 5.11.

As discussed in section 5.1.4, the relative extent of inclusion of nuclear meanings across the texts was $SSEAS1 > SSEAS3 > SSEAS2$. It is not surprising then, that SSEAS1 has more Relational: attributive clauses than the other texts. The fact that SSEAS3 deals more comprehensively with nuclear meanings in DEDUCTION SEQUENCES than SSEAS2 and yet has fewer Relational: attributive clauses (Table 5.10) is largely explained by the text reference constructed by "The position", and "is reversed" as the metaphorical realisation of the external conjunctive relation of contrast:opposition in clause 14.

- 10 This means [[that the part of the Earth [[closest to the Sun]] has more rays for a given area and experiences summer]].
- 11 The area [[further away from the sun]] has fewer rays for the same area
- 12 and is thus cooler,
- 13 experiencing winter.
- 14 The position is reversed each six months (Figure 2.9) (SSEAS3)

This involves quite complex information retrieval and manipulation. The parenthetical reference to the illustration suggests that this is intended to clarify the text.

Overall then, there is little variation in the transitivity selections realising meanings that are common across texts. Variation in the occurrence of different process types across texts is largely due to differences in meaning selection across texts or their realisation through the complex form of text reference noted above.

5.1.5.1.1 *Naming and defining technical terms in secondary seasons 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 5.13.

Category	SSEAS1	SSEAS2	SSEAS3
GROUP RANK			
1 Nominal group parataxis	not vertical but tilted		"tipped over" or tilted
1.1 Thing ^ Qualifier			
2 Verbal group parataxis			
3 Embedded clauses			
CLAUSE RANK			
4 Relational intensive identifying clause		The path around the sun is called an orbit. Every fourth year is called a leap year	
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		it also moves in space around the sun This movement is called revolution It takes 365 ¹ / ₄ days for each revolution This time interval is called one year	the axis always points to the same place in the sky This is called the celestial pole Straight above the north celestial pole is the star Polaris which is called the pole star
UNDEFINED TECHNICAL TERMS	rotates axis perpendicularly obliquely hemisphere	rotates axis hemisphere South Pole North Pole	axis Southern Cross Achemar orbit

Table 5.13 Defining, naming or assuming technical terms in secondary seasons texts

The naming and defining of technical terms is clearly not central to the explanations of the occurrence of the seasons in these texts. Very few of the grammatical resources for naming and defining are used and, as discussed above, the use of categories four and nine in the Given Information element of schematic structure produces definitions which are largely peripheral to the explanation. Only two of the technical terms ("orbit" and "revolution") occur subsequently in the text and then within the Given Information and Explanation Summary elements respectively. Furthermore, SSEAS1 provides the most comprehensive

explanation without using either of these terms. The undefined terms "rotates", "axis" and "hemisphere" occur across the texts and seem to be assumed as familiar to readers. The meaning of "perpendicularly" is not clarified by the illustration as suggested in clause 14 ("see Figure 7.23") because the representation of the sun's rays striking the Earth here is clearly not perpendicular. However clarification is made possible through the lexical relations of synonymy and antonymy ("perpendicularly", "90°", "obliquely").

5.1.5.2 Grammatical metaphor in secondary seasons texts

The analyses of grammatical metaphor are shown in Tables 5.2a - 5.4a in Appendix 5. (The analyses are based on the categories of grammatical metaphor summarised in Tables 2.12 and 2.13 in Chapter two). Table 5.14 compares the occurrence of categories of grammatical metaphor across the secondary seasons texts. The final column indicates the overall density of metaphor per clause in each text.

TEXT	Clauses	TYPE OF METAPHOR											Total	
		1a	1c	2b	5a	5d	5h	6a	12a	12b	12c	12d		
SSEAS1	41	0	1	5	4	1	0	1	5	2	0	4	23	0.56
SSEAS2	23	4	0	2	0	0	2	0	1	1	0	0	10	0.44
SSEAS3	17	0	0	1	0	0	0	0	1	4	1	0	7	0.41

Table 5.14 Types of grammatical and logical metaphor in secondary seasons texts

Although the density of metaphor in all texts is quite low, the somewhat greater use in SSEAS1 can be largely explained by some of the nuclear meanings included in this text and not in the others. For example, the four occurrences of category 5a (Material process→Classifier) and four of the five occurrences of 12a (logical connection→Thing) are accounted for by "the heating effect". This meaning is realised explicitly on only one other occasion (SSEAS3, clause 12 "and is thus cooler") and without grammatical metaphor. Similarly, three of the four occurrences of category 12d (logical connection→Circumstance - "During this time") result from the explicit account of the cause of summer and winter in both hemispheres, whereas SSEAS2 does not deal with summer in the northern hemisphere at all and SSEAS3 achieves its account of two of the four phases by indicating that "The position is reversed each six months" (clause 14).

Seventy percent of the grammatical metaphor in SSEAS2 is involved in the construction of meanings that are not integral to the explanation of the occurrence of the seasons. All four instances of the category 1a (Material process→Thing) are accounted for by "revolution" (3) and "movement" (1). The two instances of 5h (modality of process→Classifier) concern elaborative meanings not included in the other texts ("constant daylight"/ "constant darkness) and one instance of 2b (Quality of Thing→Thing) is concerned with "the

inconvenience of a quarter of a day at the end of each year" (clause 07). Only two instances of the deployment of metaphor in the construction of such meanings occur in the other texts (These are "Day lengths" and "varying lengths of day and night" in SSEAS1).

Categories 12 a-d, involving logical metaphor, are a significant proportion of the instances of metaphor in SSEAS1 (48%) and SSEAS3 (86%), whereas they make up only 20% in SSEAS2. The lower proportion of nuclear meanings in SSEAS2 and the emphasis in the deployment of metaphor noted above explain the low proportion of logical metaphor in this text. In the case of SSEAS1 and SSEAS3 there is a good deal of similarity in the deployment of logical metaphor. In both texts the metaphorical realisations of consequential relations cluster in the Explanation Summary and both make use of metaphorical realisations of external contrast: opposition ("the reverse"; "reversed"). The difference is that SSEAS1 also makes use of metaphorical realisations of external simultaneity and, as previously noted, includes four repetitions of "the heating effect", which means not only additional logical realisations of cause, but also the inclusion of another category of metaphor (Material process → Classifier). The inclusion of other categories of metaphor in this way in SSEAS1 and not SSEAS3 accounts for the variation in the proportion of logical metaphors in these texts.

Overall then, the use of metaphor is not central to the realisation of meanings constructing these explanations. As with variation in the transitivity selections, variation in the deployment of different types of grammatical and logical metaphor across texts is largely due to differences in meaning selection across texts or their realisation through the use of text reference and metaphorical forms of the external conjunctive relation of contrast: opposition.

5.1.6 Causal conjunction, "depth" of explanation and relative technicality

As noted in the previous two chapters, 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 seasons texts, it may be affected by the iteration of the DEDUCTION SEQUENCES and CLOSURE elements and the inclusion of the optional components of Conclusion and Extension in the latter element. At the level of semantics the "depth" may be affected by the extent of inclusion of nuclear 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 here 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 the inclusion in SSEAS1 of the first DEDUCTION SEQUENCES element deals with the relationship of simultaneity/consequence of the angle of incidence of the sun's rays at the Earth's surface and the relative concentration of the rays at that surface, which is not addressed in the other texts. The inclusion of the Extension component in the CLOSURE element in SSEAS1 and SSEAS3, marginally increases the depth of treatment of the topic by addressing the occurrence of Autumn and Spring.

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 Given Information and DEDUCTION SEQUENCES elements. The frequency of external temporal and consequential conjunctive relations (including metaphorical realisations) and of internal conjunctive relations is shown in Table 5.15.

TEXTS	External conjunction per Conjunctively related unit		Internal consequence per Conjunctively related unit
	Temporal	Consequential	
SSEAS1	.35	.17	.22
SSEAS2	.09	.00	.09
SSEAS3	.17	.08	.17

Table 5.15 Conjunction in Given Information and DEDUCTION SEQUENCES

Although all texts made more use of external temporal conjunction than external consequential conjunction, the greatest proportion of both external temporal and consequential relations occurred in SSEAS1. This text was the most comprehensive in terms of the inclusion of nuclear meanings as indicated in the semantic map analyses. In fact the ordering of the texts in terms of 'depth of treatment' on this measure was SSEAS1 > SSEAS3 > SSEAS2, and this is the ordering of the texts in relation to each of the categories of conjunction in Table 5.15, including internal consequence.

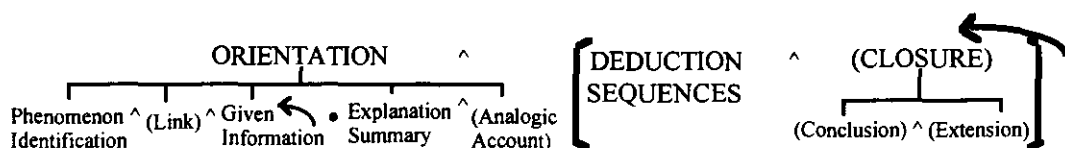
Although there was some variation in the deployment of grammatical and discourse semantic resources for naming and defining technical terms, it was shown in section 5.1.5 that this technicality was not integral to the construction of the explanations of the occurrence of the seasons.

On the basis of the relationship between the relative depth of treatment as indicated by the semantic maps, and the deployment of conjunction, it seems that greater use of external temporal and consequential relations and of internal consequential relations are all associated with greater depth of treatment. But the greater emphasis on external temporal relations in SSEAS1 indicates that greater depth of treatment is not incompatible with a more temporally oriented explanation.

5.2 Comparing primary and secondary seasons texts

5.2.1 Schematic structure in primary and secondary seasons texts

The schematic structure of the primary texts can largely be accounted for by the schematic structure potential proposed for the secondary texts:



The main differences concern the Given Information and Explanation Summary elements. There is no Given Information element in PSEAS2. In PSEAS1, as well as occurring after the Link element, Given Information is also interpolated into the DEDUCTION SEQUENCES. In the secondary text SSEAS2 this element occurred both before and after the Explanation Summary and in SSEAS1 the metaphorical realisation of the external consequential relation between events in the Given Information and the inclination of the Earth to/away from the sun at different times of the year, necessitated the reinstatement of meanings from the Given Information at the beginning of the second DEDUCTION SEQUENCES element:

23 As a result of the tilt of the Earth's axis the southern hemisphere is inclined

The varied distribution of Given Information in these texts exposes the tension imposed by attempting to account for its role in terms of the particulate analysis inherent in the synoptic approach to genre adopted here. In some texts Given Information seems to be more prosodic, with its interpolation based more on interpersonal considerations of maintaining solidarity with the reader by distributing prerequisite information as it is needed in the development of the explanation.

The Explanation Summary does not occur as a discrete element in PSEAS1, but does seem to be conflated with the Link element:

- 01 To discover the cause of the seasons
- 02 we must look again at the Earth in its orbit around the Sun. (PSEAS1)

None of the primary texts include the Analogic Account element or the iteration of the DEDUCTION SEQUENCES and CLOSURE elements that occurred in SSEAS1.

The organisation of the primary seasons texts in terms of the proposed schematic structure is shown in Table 5.16.

	PSEAS1	PSEAS2	PSEAS3
ORIENTATION			
Phenomenon Identification	The changing seasons	ALL THE YEAR ROUND	The seasons
Link	01 To discover the cause of the seasons 02 we must look again at the Earth in its orbit around the Sun.		
Given Information	03 The Earth travels once round the sun each year. 04 It is also spinning on its own axis, once every 24 hours.		02 The diagram shows [[how the Earth's axis is slanted]].
Explanation Summary		01 Seasons are the result of the tilt of the Earth as it orbits round the Sun.	01 The seasons are caused by the Earth's orbit around the Sun.
Given Information			
Analogic Account			
DEDUCTION SEQUENCES	05 As it spins, 06 one side of the globe is lit by the Sun 07 and is in daylight; 08 the other side is turned away from the Sun 09 and is in darkness. 10 If the Earth's axis were upright, compared with its path around the sun, 11 day and night would be the same length all over the world, 12 and there would be no seasons. 13 But the Earth's axis is not upright. 14 It is tilted over at $23\frac{1}{2}$ degrees 15 so that the globe is unevenly lit. 16 In midsummer, <<17>>the northern hemisphere is tilted towards the Sun. 17 <<when the Earth is at one end of its annual journey>> 18 The days are long 19 and the nights are short. 20 North of the Arctic Circle the Sun never sets. 21 In winter, at the opposite end of the journey, the northern regions are tilted away from the Sun. 22 Nights are long, 23 and the days are short and cool.	02 At one end of the Earth's orbit, the North Pole is pointing towards the Sun 03 and the Northern Hemisphere has its hot summer 04 and the Southern Hemisphere has its cold winter. 05 Six months later, the opposite is true. 06 In between, the weather changes during spring and autumn. 07 These seasons happen 08 because the Sun's rays are spread more thinly in parts of the world [[tilted away from the Sun (in winter)]]. 09 Also, the length of each day is shorter. 10 The opposite is true 11 when that part of the Earth is tilted towards the Sun in summer.	03 During summer, in the northern world, the midday sun is over a region north of the equator, 04 so its rays are more concentrated 05 and feel hotter. 06 During winter the Sun is over a region south of the equator, 07 and the rays [[reaching the north]] spread out over a larger area. 08 They are less concentrated.
CLOSURE			
Conclusion			09 Places south of the equator have their summer 10 when places north of the equator have winter.
Extension	24 The tropical regions, close to the Equator, are evenly lit at all times of the year 25 and so have hardly any seasonal changes.	12 (Compare this to the reason [[why the poles are cold on page 8]])	

Table 5.16 Schematic structure of primary seasons texts

The sub-heading in PSEAS2 does not function effectively as a Phenomenon Identification, however this sub-heading and the subsequent explanation occur within a larger text segment under the main heading of "THE SEASONS". The section prior to the explanation analysed here deals with the effect of the seasons on plant and animal life. The Given Information element is much briefer in the primary texts, containing none of the elaborative

or peripheral meanings that occur in SSEAS2 and SSEAS3. The Explanation Summary elements in PSEAS2 and PSEAS3 are similar, except that PSEAS3 does not include "the tilt of the Earth":

01 Seasons are the result of the tilt of the Earth as it orbits around the Sun. (PSEAS2)

01 The seasons are caused by the Earth's orbit around the Sun. (PSEAS3)

In fact PSEAS2 is the only primary or secondary text to include the effect of both the tilt of the Earth and its orbit around the Sun in the Explanation Summary. The DEDUCTION SEQUENCES in PSEAS1 are concerned with the cause of day and night and their varying lengths in correspondence with the changing seasons. In the other two primary texts and the three secondary texts, the DEDUCTION SEQUENCES are concerned with the cause of the different heating effect of the sun's rays on the two hemispheres at different times of the year and with this variation in heating effect as the basis for identifying the different seasons. In SSEAS1 and SSEAS3 the Extension element extends the explanation of summer and winter in both hemispheres, which was dealt with in the DEDUCTION SEQUENCES, to the seasons of autumn and spring. In PSEAS1 the Extension is concerned with the cause of the lack of variation in the length of night and day in the Tropics and the association of this with the lack of seasonal variation:

24 The tropical regions, close to the Equator, are evenly lit at all times of the year

25 and so have hardly any seasonal changes. (PSEAS1)

In PSEAS2 the Extension is an instruction:

12 (Compare this to the reason [[why the poles are cold on page 8]]). (PSEAS2)

The Conclusion element occurs in SSEAS1 and PSEAS3 only, and the ideational meanings in this element are similar in both texts, although more elaborated in the secondary text:

09 Places south of the equator have their summer

10 when places north of the equator have winter. (PSEAS3)

36 The seasons in the southern and northern hemispheres are always the reverse of each other.

37 When one hemisphere points toward the sun.

38 the other must point away from the sun. (SSEAS1)

A comparison of the elements of schematic structure across primary and secondary texts is summarised in Table 5.17.

	Elements of Structure	SSEAS1	SSEAS2	SSEAS3	PSEAS1	PSEAS2	PSEAS3
ORIENTATION	Phenomenon Identification						
	Link						
	Given Information						
	Explanation Summary						
	Analogic Account						
DEDUCTION SEQUENCES							
CLOSURE	Conclusion						
	Extension						
DEDUCTION SEQUENCES							
CLOSURE	Conclusion						
	Extension						

Table 5.17 Comparison of schematic structure in primary and secondary seasons texts

SSEAS1 is the only text to include an Analogic Account and the iteration of the DEDUCTION SEQUENCES and CLOSURE elements. Apart from this the primary and secondary texts are similar in that they all include a Phenomenon Identification and DEDUCTION SEQUENCES, but only one text at each level includes a Link and a Conclusion element. All of the secondary texts include the Given Information and Explanation Summary elements. The primary text PSEAS2 is the only one not to include a Given Information element and PSEAS1 is the only one not to include an Explanation Summary. The secondary text SSEAS2 is the only one to omit the CLOSURE element altogether. Overall, there is more variation in the ORIENTATION of the primary than the secondary texts and this is the area of greatest variation in schematic structure between the primary and secondary levels.

5.2.2 Theme and schematic structure in primary and secondary texts

The Theme analysis of the primary texts was again focussed on an investigation of the "method of development" of the texts and followed the procedures outlined in Martin (1992:435 & 440). All of the texts were quite brief and there were no Macro-Themes. Rather the sub-headings, as the Phenomenon Identification element in the schematic structure, and the Explanation Summary element, functioned textually as a Hyper-Theme predicting thematic selections in the Given Information and DEDUCTION SEQUENCES elements. The most clear and consistent pattern of Thematic selection occurred in PSEAS3. This is indicated in Figure 5.23. Themes are shown on the left and Rhemes on the right. Marked Themes are shown in *italics*. The faint lines and arrowheads indicate Rheme→Theme and Theme→Theme progression.

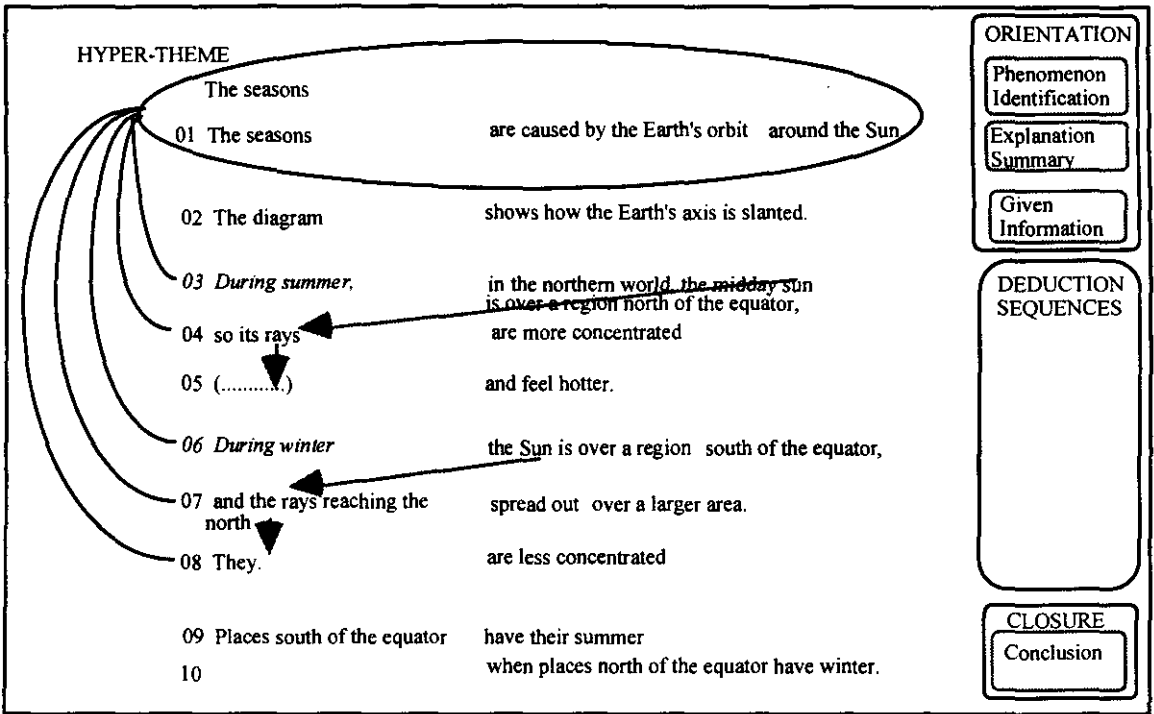


Figure 5.23 Theme and schematic structure in PSEAS3

As in the secondary text SSEAS1 and, to a lesser extent SSEAS2, marked Themes scaffolded the introduction of phases in the DEDUCTION SEQUENCES element. However, in contrast to SSEAS1 and like SSEAS2, the seasons and not the inclination of particular hemispheres to the sun, were selected as the points of departure. Although there is a Conclusion element in PSEAS3, it is information that is deduced from clauses 03 - 08 and is not an accumulation of new information introduced Rhematically, hence the Conclusion does not function textually as a Hyper-New.

In PSEAS2 the Phenomenon Identification and Explanation Summary also function as a Hyper-Theme, which is predictive of Theme selection at least in the first part of the DEDUCTION SEQUENCES. There is a tendency in the first part of the DEDUCTION SEQUENCES also for marked Themes to introduce new phases, but this is not sustained. There is a tendency for the position of the Earth in its orbit to be selected as the point of departure and, as in SSEAS1, for the seasons to be introduced Rhematically. In this text there is no Conclusion element and no accumulation of new information as a Hyper-New. The Theme selection and schematic structure in PSEAS2 is shown in Figure 5.24.

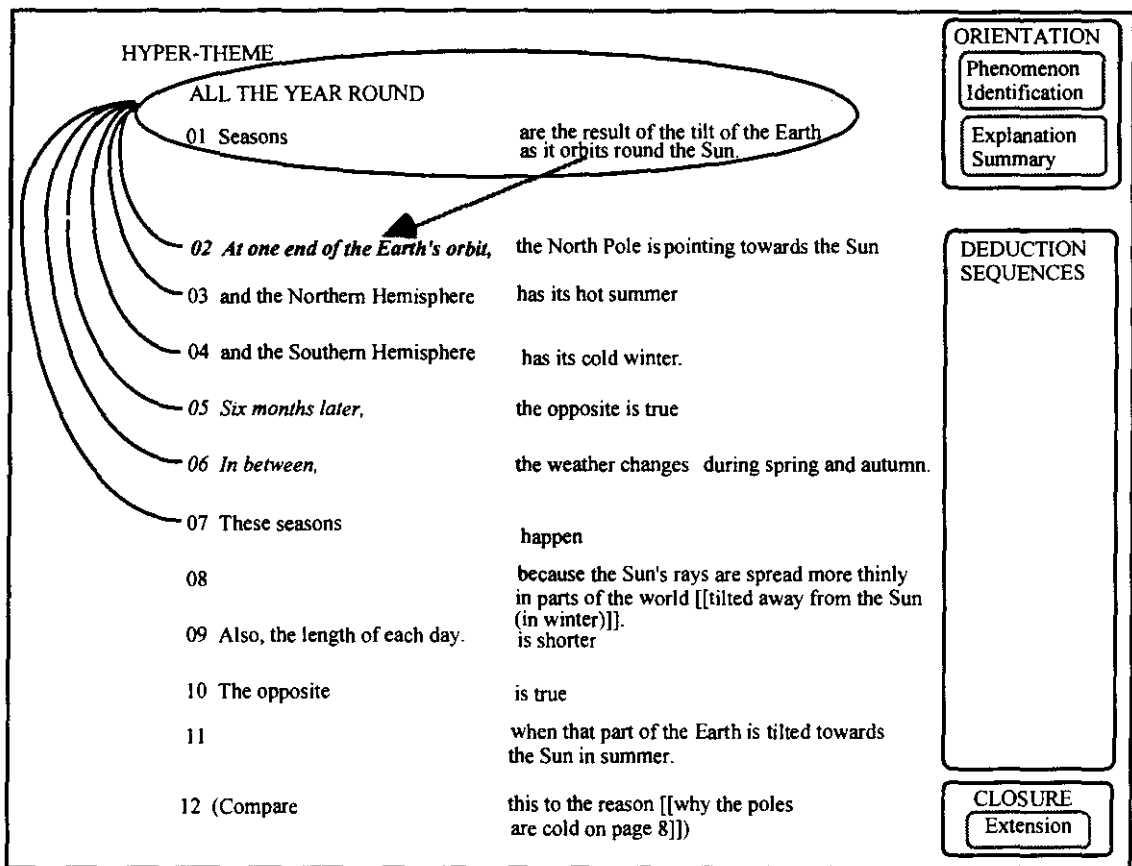


Figure 5.24 Theme and schematic structure in PSEAS2

In PSEAS1 the Explanation Summary is conflated with the Link element, which functions together with the Phenomenon Identification as a Hyper-Theme predicting Theme selection in the Given Information element and in the DEDUCTION SEQUENCES, but not as consistently as occurred in the other texts. The main problem here is that "The days" and "Nights" are frequent Themes which are not predicted by the Hyper-Theme. Marked Themes do introduce new phases in the DEDUCTION SEQUENCES as occurred in SSEAS1, SSEAS2 and the other two primary texts. Again, in this text there is no Conclusion element and no accumulation of new information as a Hyper-New. The Theme selection and schematic structure in PSEAS1 is shown in Figure 5.25.

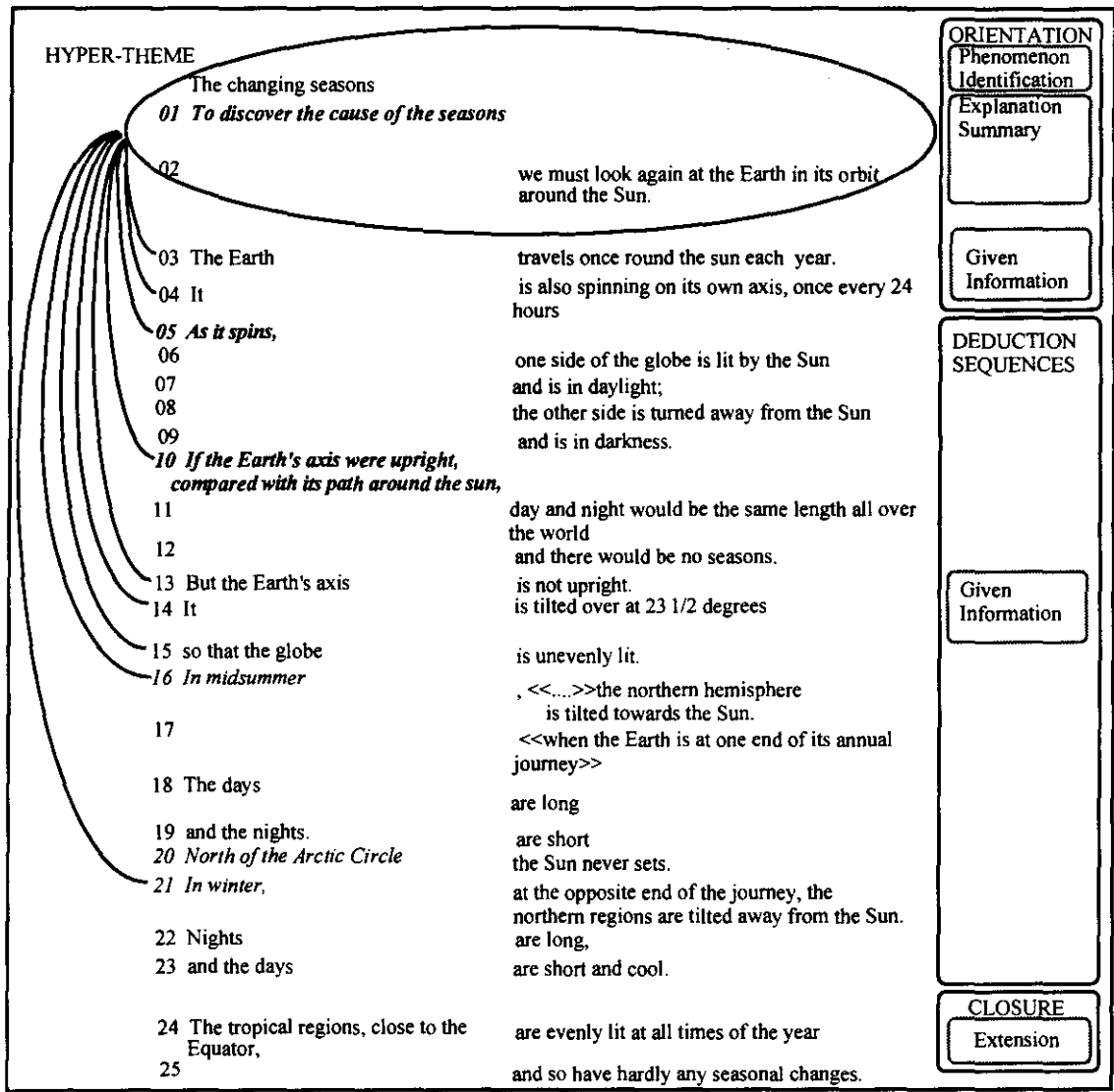


Figure 5.25 Theme and schematic structure in PSEAS1

The clearest patterning of Thematic choice in relation to schematic structure occurred in SSEAS1. The first clause in the Explanation Summary functioned as a Macro-Theme, predicting Hyper-Themes, which were predictive of Theme selections in the DEDUCTION SEQUENCES. Marked Themes tended to scaffold the introduction of phases in the second DEDUCTION SEQUENCES element. There were no Macro-Themes in the primary texts but the occurrence of Hyper-Themes and the use of marked Themes were similar to SSEAS1, with the clearest pattern of this type in PSEAS3. The pattern of Theme selection in SSEAS1 was also evident to a lesser extent in SSEAS2 but did not occur in SSEAS3. Only SSEAS1 showed accumulation of new information as a Hyper-New.

5.2.3 Conjunction in primary and secondary seasons texts

The analyses of conjunction in the primary seasons texts are shown in Figures 5.11a - 5.13a in Appendix 5 and are summarised in Table 5.18, which compares the results of the conjunction analyses for primary and secondary texts.

Text	Clauses	CRUs	Conjunctive relations				
			Internal	External	Metaphorical	Implicit	Explicit
SSEAS1	41	40	14	24	11	16	11
SSEAS2	23	23	04	08	02	03	07
SSEAS3	17	16	04	08	06	03	03
PSEAS1	25	25	07	14	01	13	07
PSEAS2	12	12	02	07	04	03	02
PSEAS3	10	10	05	04	01	06	02

Table 5.18 Conjunction in secondary and primary seasons texts

As with the secondary texts, there is significant use of internal conjunction, more so in PSEAS1 and PSEAS3. Internal consequence and reformulation are the predominant categories as shown in Table 5.19. Internal reformulation linked the Explanation Summary element of schematic structure to the DEDUCTION SEQUENCES and in the only primary text to include a Conclusion element (PSEAS3), this was linked to the DEDUCTION SEQUENCES by internal consequence. All other instances of internal reformulation and consequence were concentrated in the DEDUCTION SEQUENCES.

TEXT	CLAUSES	CRUs	INTERNAL CONJUNCTIVE RELATIONS										total
			Comparative			Consequential							
			Reformulation			Consequence			Concession				
			Exhaust										
			i	e	m	i	e	m	i	e	m		
PSEAS1	25	25	3			2			1	1		7	
PSEAS2	12	12	1			1						2	
PSEAS3	10	10	2			2	1					5	

Table 5.19 Incidence of internal conjunction in primary seasons texts

As with the secondary texts the most prominent categories of external conjunction were consequence, simultaneity and contrast, as shown in Table 5.20.

TEXT	CL	CRUs	EXTERNAL CONJUNCTIVE RELATIONS																		total								
			Temporal									Consequential												Comparison					
												cause									contrast								
												condition			purpose														
			i	e	m	i	e	m	i	e	m	i	e	m	i	e	m	i	e	m									
PSEAS 1	25	25		2					3	2	1		1			1		4				14							
PSEAS 2	12	12		1		1				1	2										2	07							
PSEAS 3	10	10		1					1		1							1				04							

Table 5.20 Incidence of external conjunction in primary seasons texts

In the secondary texts almost all of the external consequence was metaphorical and in SSEAS2 and SSEAS3 it was all concentrated in the Explanation Summary. In the primary texts metaphorical realisations also occurred in the Explanation Summary. In the secondary texts very few external consequential relations occurred in the DEDUCTION SEQUENCES element in SSEAS1 and SSEAS3 and none in SSEAS2. But in PSEAS1 a significant number of non metaphorical realisations of external consequence occur in the DEDUCTION SEQUENCES, which distinguishes this text from the other primary texts and from the secondary texts. PSEAS1, in contrast to the other texts at both levels, is not concerned to explain the occurrence of the seasons in terms of the differential heating effect of the sun's rays on different hemispheres at different times of the year. Rather, it explains the different lengths of night and day as a result of the Earth's rotation and inclination on its axis and then distinguishes the changes in the seasons in particular hemispheres at different times of the year in terms of the corresponding variation in the length of night and day as the Earth's revolution causes those hemispheres to be tilted toward or away from the sun. The deployment of external consequential relations tends to be focussed in the first part of the DEDUCTION SEQUENCES dealing with the Earth's inclination on its axis and its rotation causing differences in the length of days and nights. Internal consequence occurs in the second part of the DEDUCTION SEQUENCES, where the seasons are distinguished in terms of the relative lengths of day and night at those times of the year. This can be seen in Figure 5.26. Consequential relations are shown in bold with internal relations on the left of the reticulum and external relations on the right.

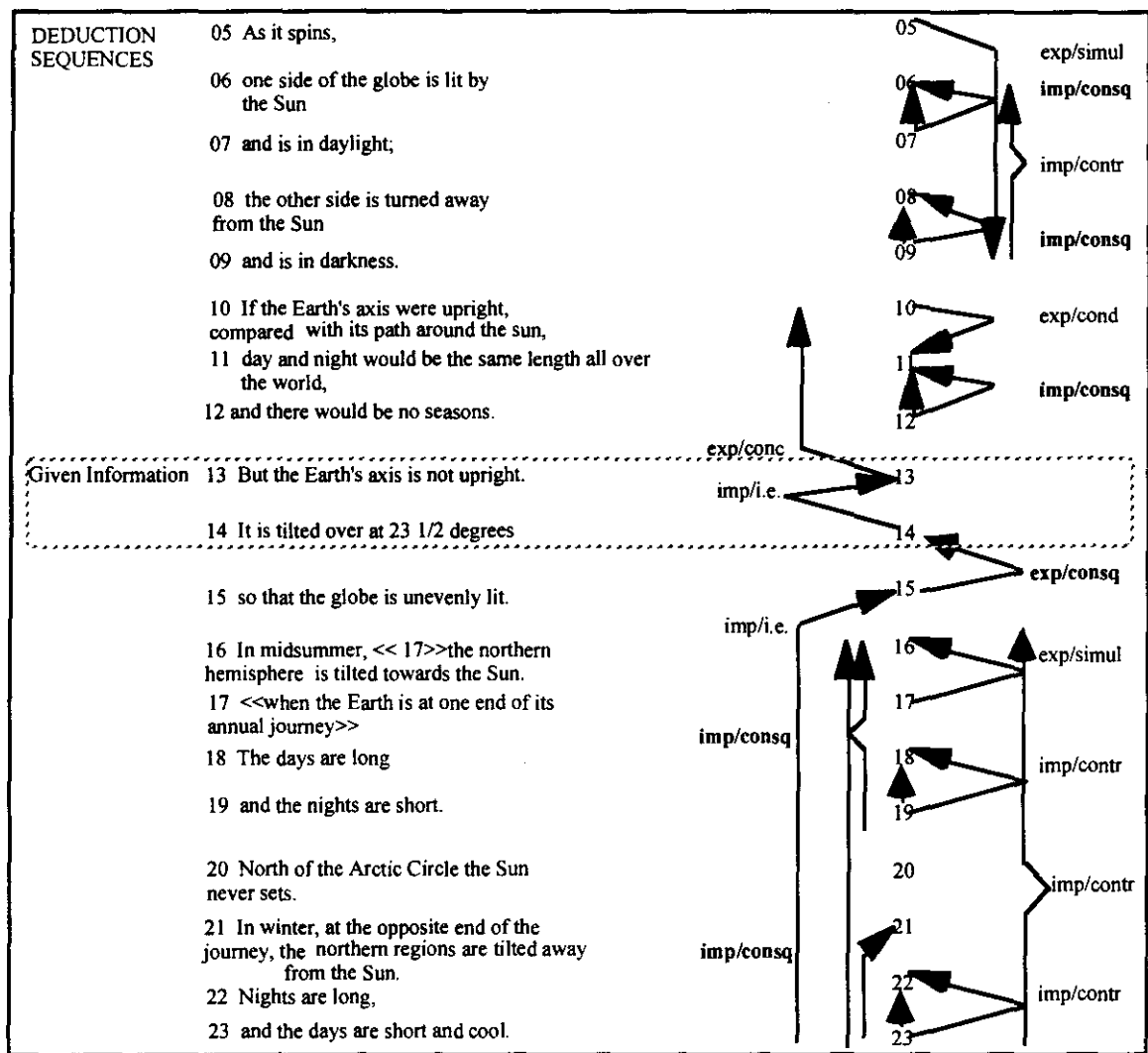


Figure 5.26 Internal & external consequence in DEDUCTION SEQUENCES in PSEAS1

The other two primary texts explain the occurrence of the seasons in terms of the different heating effects of the sun's rays on the different hemispheres at different times of the year, as was the case with the three secondary texts. It was argued that SSEAS1 showed the most effective reasoning in the DEDUCTION SEQUENCES due mainly to its orchestration of internal consequence with external simultaneity producing four logical chains, which, in combination, provided the rhetorical means for the Conclusion element (see Figure 5.10). The only primary text which made some approximation to this pattern of reasoning was PSEAS3. The reasoning in the DEDUCTION SEQUENCES for this text is shown in Figure 5.27.

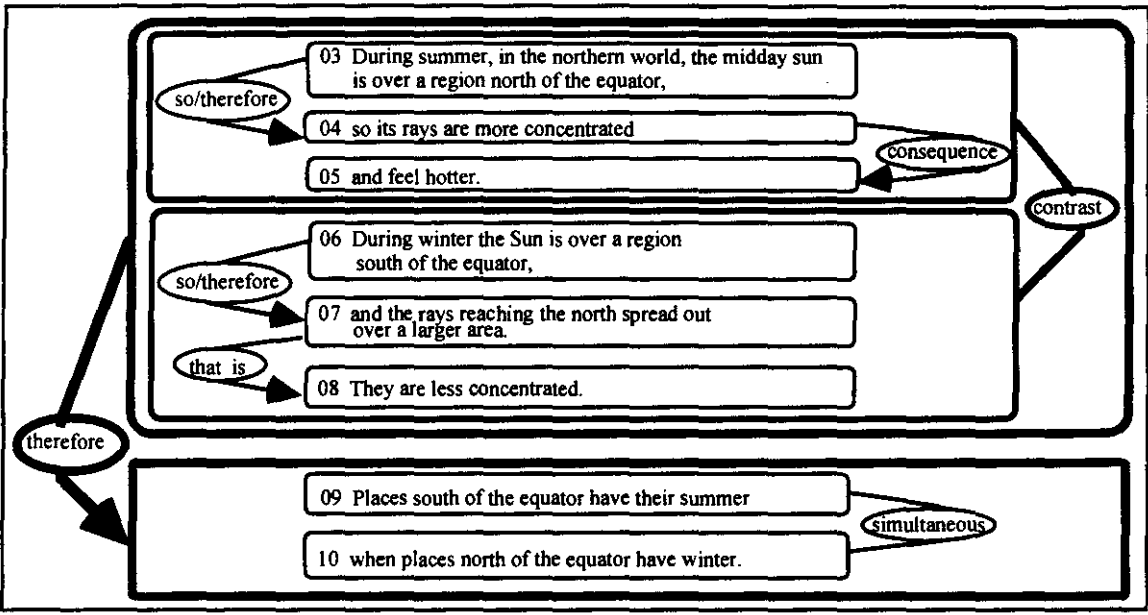


Figure 5.27 Reasoning in DEDUCTION SEQUENCES in PSEAS3

The similarities between the reasoning in the DEDUCTION SEQUENCES in SSEAS1 and PSEAS3 can be seen in Figure 5.28. There are two main differences. The first is that PSEAS3 deals with only two of the four phases in the DEDUCTION SEQUENCES in SSEAS1 i.e. summer and winter in the northern hemisphere and not in the southern hemisphere. Therefore the simultaneity of the contrasting seasons in the southern and northern hemispheres is not realised in the DEDUCTION SEQUENCES in PSEAS3, whereas this external conjunctive relation is so realised in SSEAS1. In both texts this is realised in the Conclusion. The second main difference is that SSEAS1 takes the inclination of the particular hemispheres to the sun, the consequent angle of incidence of the sun's rays to those hemispheres, the consequent concentration of the sun's rays at those hemispheres and the consequence of this for their heating effect, as the rhetorical means for concluding why we name particular times of the year summer and winter. This is reflected in the additional internal consequential relations linking the uncommonsense event sequences to the more commonsense experience of the seasons in each hemisphere. On the other hand, in PSEAS3 the named seasons are the point of departure rather than the Conclusion. They are realised as locations in time in which the uncommonsense events occur.

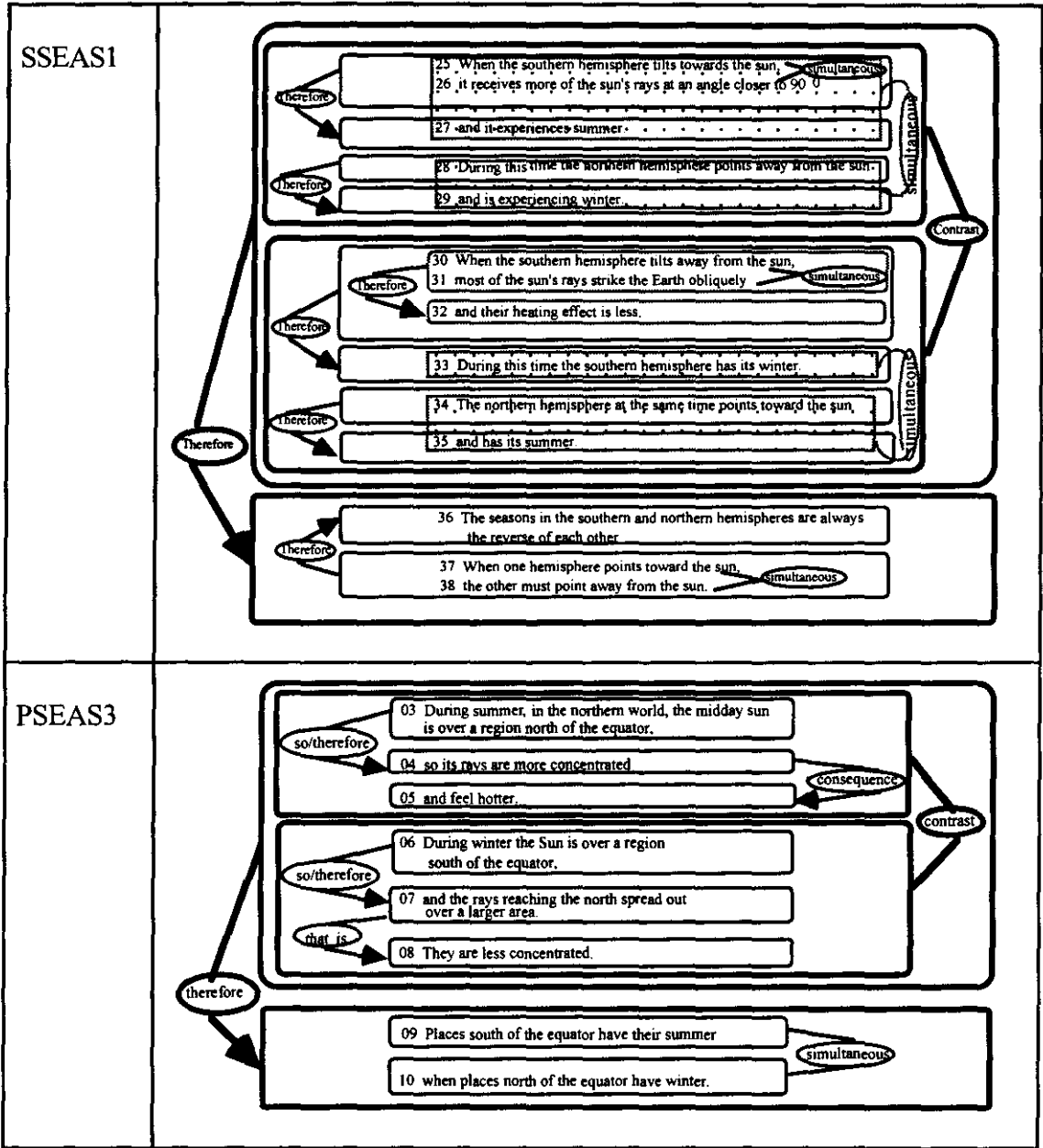


Figure 5.28 Comparison of conjunction in DEDUCTION SEQUENCES and Conclusion elements in SSEAS1 and PSEAS3.

The reasoning in the DEDUCTION SEQUENCES in PSEAS2 is significantly masked by the use of embedding and metaphorical realisations and a reliance on the readers' inferring of consequential relations. The conjunctive relations are indicated in Figure 5.29.

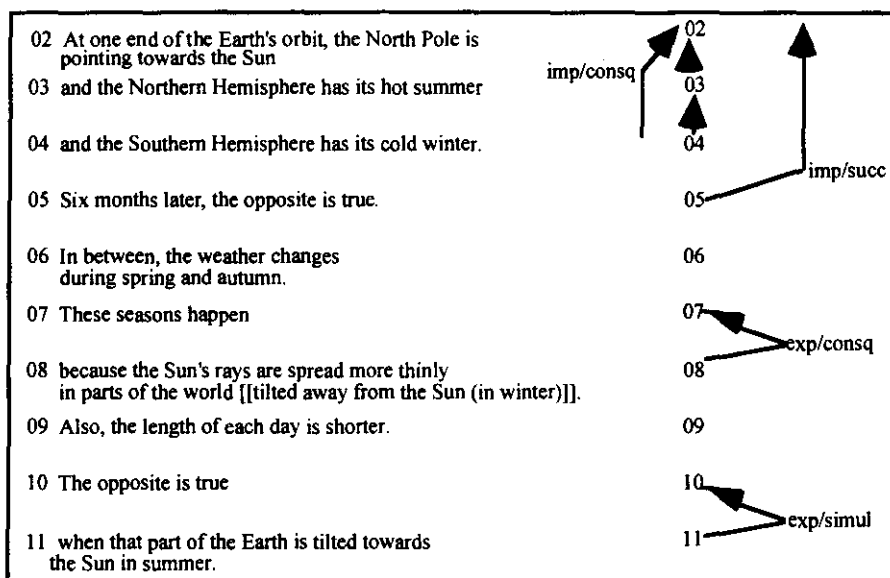


Figure 5.29 Conjunction in DEDUCTION SEQUENCES in PSEAS2

The embedded clause as Qualifier in clause 08 effaces the internal consequential conjunctive relation necessary to conclude that since the particular part of the Earth is tilted away from the Sun in winter, the sun's rays would be less concentrated at that part of the Earth's surface. This involves internal conjunction because the reader has to reason to supply the intervening logical events i.e. that the angle of incidence of the sun's rays must be large. There is also no explicit consequential link in this text between the relative concentration of the sun's rays at a particular part of the Earth's surface and the heating effect of the rays on that surface area. In PSEAS 3 on the other hand these internal and external conjunctive relations are quite clear, as indicated in Figure 5.30.

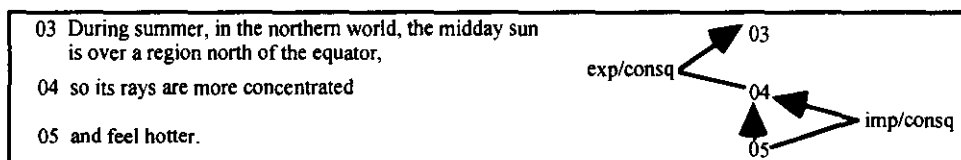


Figure 5.30 Internal and external consequence within DEDUCTION SEQUENCES in PSEAS3

The metaphorical realisation of external contrast in clauses 05 and 10 of PSEAS2 also masks external simultaneity and internal and external consequential relations which are "buried" through the resources of nominalisation and text reference in the use of "the opposite". The reader needs to do a good deal of "unpacking" to track the conjunctive relations necessary to the reasoning in the DEDUCTION SEQUENCES in this text.

The use of internal reformulation and consequence and external simultaneity, consequence and contrast was common to all texts at both levels. Variation across texts in the incidence of each category was partly due to the omission of particular ideational meanings in some texts. For example, more external consequential conjunction occurred in SSEAS1, and to a lesser extent SSEAS3, because SSEAS1 dealt with the angle of incidence of the sun's rays as the cause of their relative concentration at the Earth's surface and both texts dealt with the latter as the cause of their heating effect, and these meanings were not included in SSEAS2. The external consequential relations in PSEAS1 concerned the causes of day and night and their different lengths at different times of the year. These causal relations were not explored in the other texts. The use of metaphorical realisations of external contrast in combination with text reference in SSEAS3 and PSEAS2 also masked conjunctive relations in the DEDUCTION SEQUENCES in these texts. The deployment of internal consequence with external simultaneity and contrast in SSEAS1 produced the clearest progression of reasoning in the DEDUCTION SEQUENCES. In comparison the reasoning in all other texts was problematic. PSEAS3 was the only primary text to show some approximation to the pattern of reasoning in SSEAS1.

5.2.4 "Depth" of treatment: Variation in the selection of, and reader access to, ideational meanings in primary and secondary seasons texts.

The investigation of variation in the selection of ideational meanings in the secondary texts focussed on the Given Information and DEDUCTION SEQUENCES elements of schematic structure. 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 these elements of schematic structure. The comparisons are discussed for the Given Information and then for separate phases of the DEDUCTION SEQUENCES. Consolidated maps are then given, which allow comparisons among the primary texts and of each primary text with the secondary texts.

Types of reader access to the meanings in the primary texts were categorised as literal or inferential and then subcategorized as for 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.

5.2.4.1 Variation in the selection of ideational meanings

Some meanings in the Given Information in the secondary texts occurred only in the Explanation Summary in two of the primary texts. In fact PSEAS2 did not include a Given Information element. The semantic maps and primary text segments showing the inclusion of meanings from the Given Information element of the secondary texts are shown in Figure 5.31. Meanings in the primary texts which were also in the secondary texts are shown in thick black lines. Meanings from the secondary texts not included in the primary texts are shown in faint lines and additional meanings in the primary texts which did not occur in the secondary texts are shown in regular black lines.

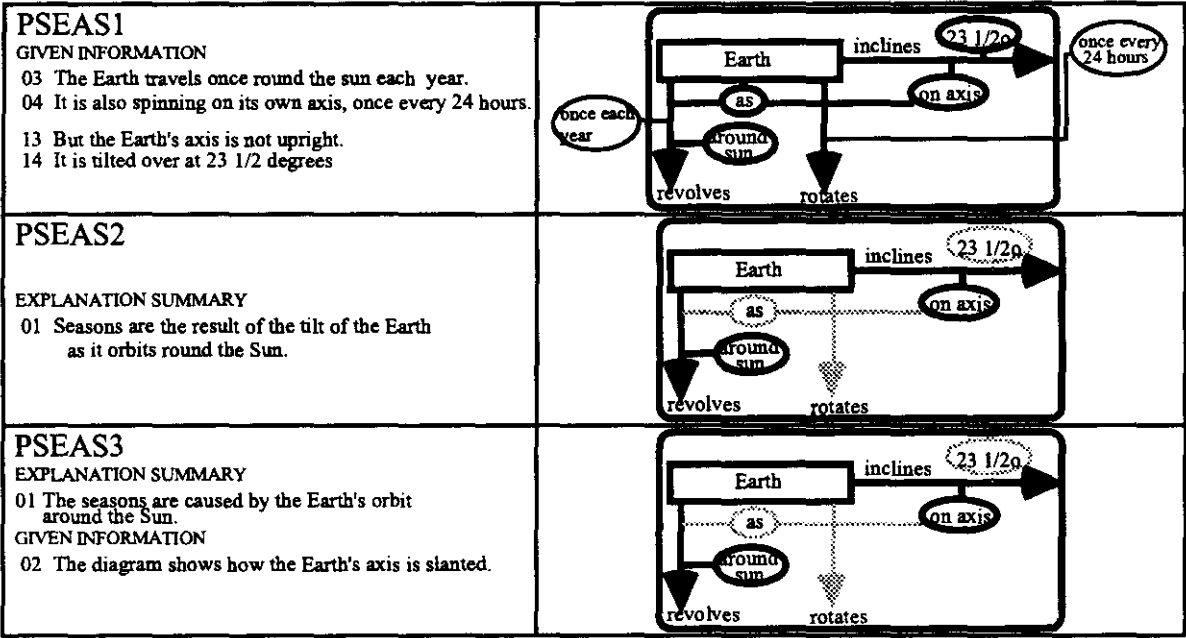


Figure 5.31 Semantic map for "Given Information" in primary seasons texts

PSEAS1 includes all of the meanings from the secondary texts and some additional meanings. The ideational meanings in PSEAS2 and PSEAS3 are similar and both omit the Earth's rotation and the numerical value of its inclination on its axis. One secondary text omitted the rotation of the Earth and another the numerical value of its inclination. Like the secondary texts, all meanings included were literal, apart from one text in which the meaning *on axis* was scriptally implicit. In terms of the meanings included as Given Information then, there is a great deal of similarity between the primary and the secondary texts.

In the first primary text the DEDUCTION SEQUENCES begin with elaborative meanings that do not occur in any other of the primary or secondary texts. The text segment and

semantic map showing these meanings and their relation to the meanings in the Given Information is shown in Figure 5.32.

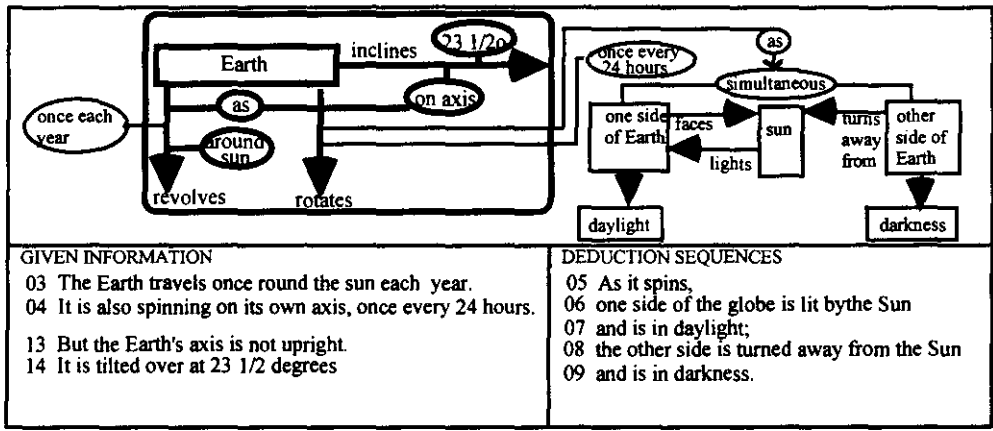


Figure 5.32 Initial elaborative meanings in DEDUCTION SEQUENCES in PSEAS1

In the secondary texts the DEDUCTION SEQUENCES progressed through phases dealing first with summer in the southern hemisphere, then winter in the northern hemisphere, followed by winter in the southern hemisphere and summer in the northern hemisphere. In all of the primary texts summer in the northern hemisphere was dealt with first (all were written and published in the United Kingdom). Two of the texts then addressed winter in the northern hemisphere, while one (PSEAS2) dealt with winter in the southern hemisphere as its second phase.

The pattern of meaning selection and the categories of reader access to these meanings was similar across the primary texts for the northern summer and northern winter phases. The semantic maps and primary text segments dealing with summer in the northern hemisphere are shown in Figure 5.33 (Corresponding semantic maps and text segments for the northern winter are included as Figures 5.14a and 5.15a in Appendix 5).

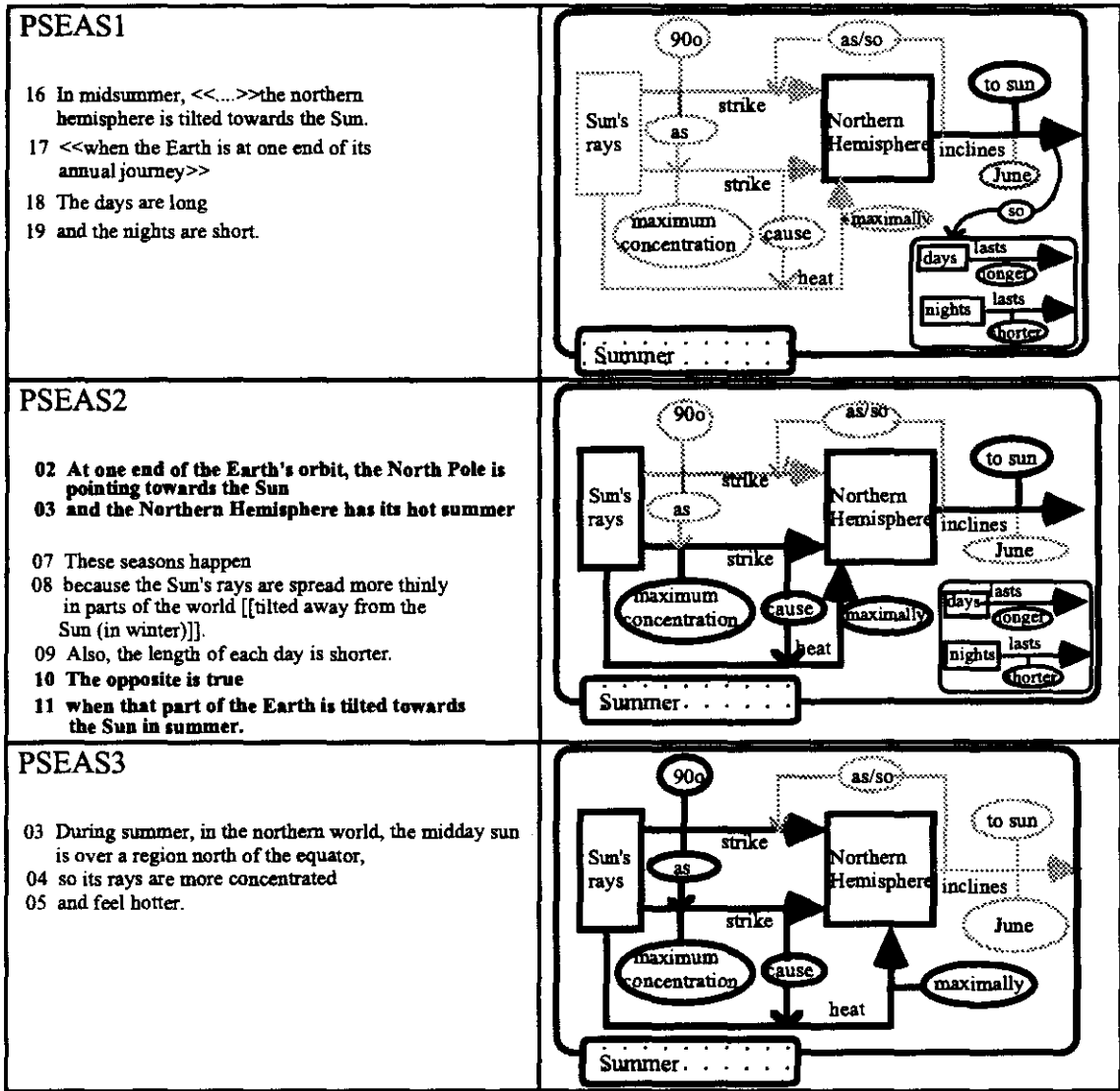


Figure 5.33 Semantic maps for "northern summer" phase of DEDUCTION SEQUENCES in primary seasons texts

Nuclear meanings are dealt with minimally in PSEAS1 and more extensively in PSEAS2 and PSEAS3. PSEAS2 includes the inclination of the northern hemisphere towards/away from the sun and the greater/lesser concentration of the sun's rays at the Earth's surface, but omits the meanings that are the link in the logical chain i.e. that more of the sun's rays strike the Earth perpendicularly/obliquely. However, in PSEAS3 the relationship between the angle of incidence and the concentration of the sun's rays is included, but the cause, i.e. the inclination of the northern hemisphere towards/away from the sun, is omitted. Elaborative meanings concerning night and day lengths occur in PSEAS1 and PSEAS2 but not PSEAS3.

The few nuclear meanings in PSEAS1 are literal. While PSEAS2 and PSEAS3 include a greater proportion, but different, nuclear meanings, both have about the same proportion of

literal meanings. PSEAS2 relies on inference through retrieval from the comparative reference "The opposite" to construct the meanings dealing with the maximum/minimum concentration of the sun's rays on the northern hemisphere in summer/winter. While these meanings are literal and explicit in PSEAS3, meanings concerning the angle of incidence of the sun's rays in summer/winter can only be inferred from "the midday sun is over a region north of the equator"/ "The sun is over a region south of the equator".

In the secondary texts the northern summer was not dealt with at all in SSEAS2; SSEAS1 relied on inference from the first DEDUCTION SEQUENCES element to provide a comprehensive account of the relevant nuclear meanings and SSEAS3 relied on inference from phase two to provide significantly fewer of these meanings (Appendix 5, Figure 5.7a). In fact SSEAS3 included fewer meanings than either PSEAS2 or PSEAS3, which can be seen by comparing Figure 5.34 with Figure 5.33.

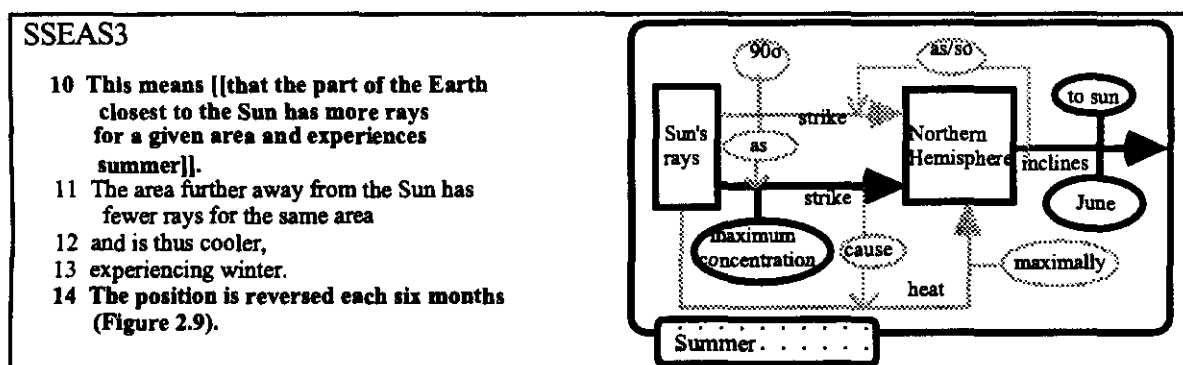


Figure 5.34 Text segment and semantic map for the northern summer in SSEAS3

The nuclear meanings for the northern winter phase were dealt with comprehensively in SSEAS1 and the meanings in SSEAS3 were similar to those in PSEAS2 (omitting the angle of incidence of the sun's rays). The very skeletal treatment in the primary text PSEAS1 was similar to that in SSEAS2 (see Appendix 5, Figure 5.5a).

Only one of the primary texts, PSEAS2, dealt with the southern winter and summer in its DEDUCTION SEQUENCES. Reader access to these meanings is predominantly literal in the case of the southern winter while those concerning the southern summer rely on inference through retrieval from the comparative reference "The opposite". The relevant text segments and semantic maps are shown in Figure 5.15a in Appendix 5.

The relative depth of treatment in the primary texts and the comparison with secondary texts in terms of the inclusion of nuclear meanings can be seen in Figure 5.35.

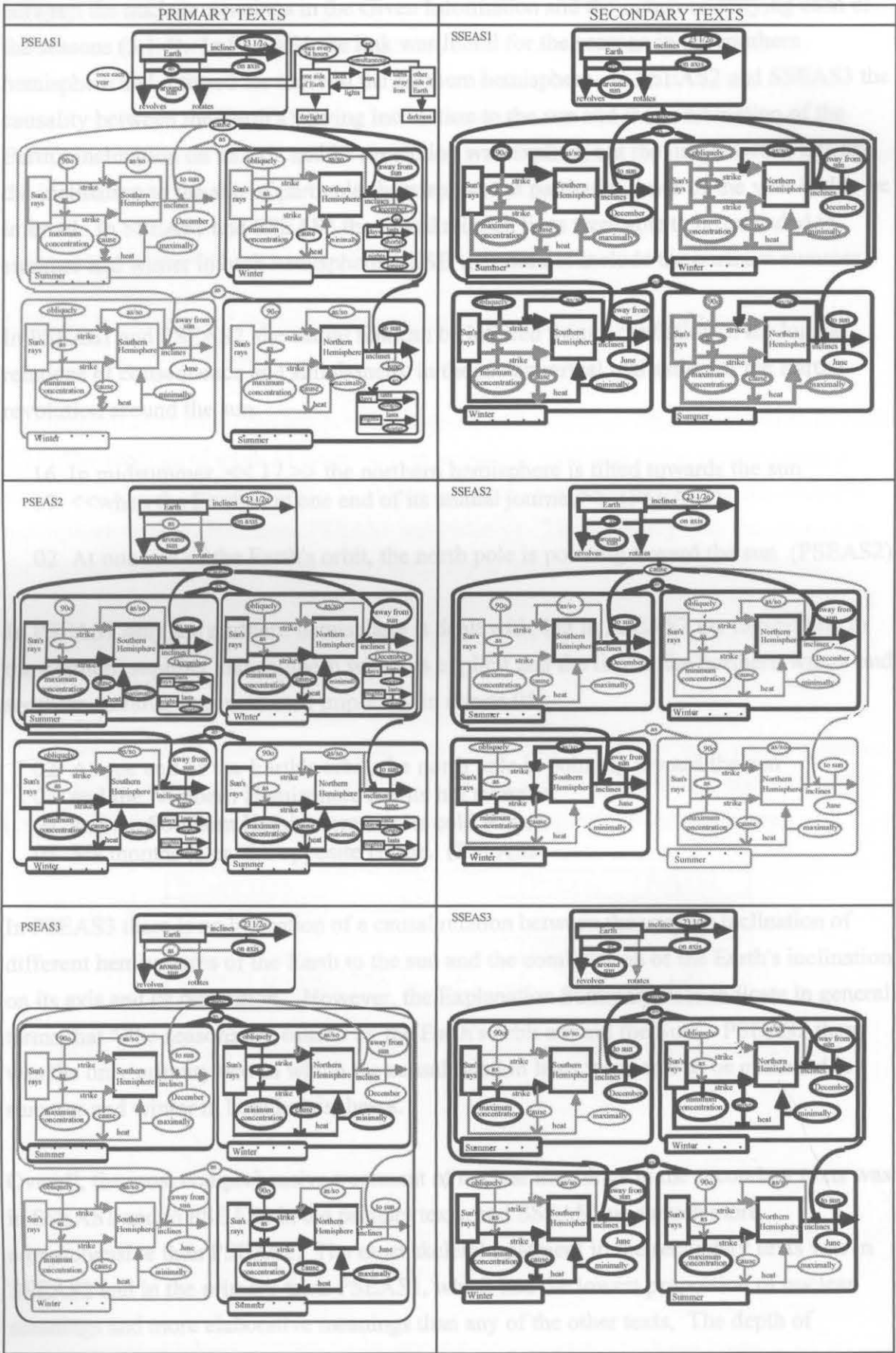


Figure 5.35 Semantic maps for primary and secondary seasons texts

In the secondary texts a good deal of inference was required to make the causal link between the nuclear meanings in the Given Information and the events underlying each of the seasons (5.1.4). In SSEAS1 the link was literal for the seasons in the southern hemisphere and inferred for those in the northern hemisphere. In SSEAS2 and SSEAS3 the causality between the Earth's varying inclination to the sun and the combination of the Earth's inclination on its axis and its revolution was explicit, but the link between this and the inclination to the sun of particular hemispheres at particular times of the year had to be inferred. In SSEAS1 and SSEAS3 the causal relation lines were able to be extended to summer and winter in both hemispheres. SSEAS2 did not include the northern summer.

In PSEAS1 and PSEAS2, the causal link can be inferred from a conflation of the logical relations of consequence and simultaneity in the metaphorical realisation of the Earth's revolution around the sun.

- 16 In midsummer, << 17 >> the northern hemisphere is tilted towards the sun
- 17 <<when the Earth is at one end of its annual journey>> (PSEAS1)

- 02 At one end of the Earth's orbit, the north pole is pointing toward the sun (PSEAS2)

In PSEAS1 only the northern hemisphere is dealt with, but in PSEAS2 the logical link to the northern summer and southern winter is explicit and the link to the northern winter and southern summer is constructed implicitly in clause 05:

- 02 At one end of the Earth's orbit, the north pole is pointing toward the sun
- 03 and the Northern Hemisphere has its hot summer
- 04 and the Southern Hemisphere has its cold winter.
- 05 Six months later, the opposite is true. (PSEAS2)

In PSEAS3 there is no indication of a causal relation between the varying inclination of different hemispheres of the Earth to the sun and the combination of the Earth's inclination on its axis and its revolution. However, the Explanation Summary does indicate in general terms that "The seasons are caused by the Earth's orbit around the Sun". PSEAS2 then, was the only primary text in which the causal relation lines were able to be extended to summer and winter in both hemispheres.

Overall, the most comprehensive treatment of nuclear meanings in the secondary texts was in SSEAS1 and in PSEAS2 in the primary texts, and SSEAS1 was much more comprehensive than PSEAS2. The most skeletal treatment in the secondary texts was in SSEAS2 and in the primary texts PSEAS1, which had the lowest proportion of nuclear meanings and more elaborative meanings than any of the other texts. The depth of

treatment of the topic in the secondary texts as indicated by the extent of inclusion of nuclear meanings in the Given Information and DEDUCTION SEQUENCES elements was reflected in the extent of meanings included in the Explanation Summaries (SSEAS1 > SSEAS3 > SSEAS2). This was also the case with the primary texts (PSEAS2 > PSEAS3 > PSEAS1). PSEAS1 had no Explanation Summary at all and PSEAS3 indicated that the seasons were caused "by the Earth's orbit around the Sun". But PSEAS2 included the most effective Explanation Summary of all primary and secondary texts:

01 Seasons are the result of the tilt of the Earth as it orbits around the Sun. (PSEAS2).

5.2.4.2 Types of reader access to ideational meanings in primary and secondary seasons texts

The proportion of literal meanings in the primary and secondary texts is compared in Table 5.21 (The analysis of types of reader access to nuclear meanings in the primary texts is shown in Table 5.5a in Appendix 5). Meanings dealing with the seasons in the southern hemisphere were omitted from PSEAS1 and PSEAS3. Those dealing with the seasons in the northern hemisphere were predominantly literal and little inference was involved. PSEAS2 was the only primary text to make substantial use of inference from the retrieval of reference items to construct nuclear meanings and this text included more nuclear meanings than the other primary texts.

This pattern is somewhat similar to that of the secondary texts. The most comprehensive treatment of nuclear meanings occurred in SSEAS1 and then SSEAS3 and both of these texts made substantial use of inference by retrieval from previous text segments.

Primary Texts	PSEAS1	PSEAS2	PSEAS3
% Nuclear Meanings Literal (Explicit + Implicit)	100	64	79
Secondary Texts	SSEAS1	SSEAS2	SSEAS3
% Nuclear Meanings Literal (Explicit + Implicit)	65	87	43

Table 5.21 Proportion of literal nuclear meanings in primary and secondary texts

5.2.5 Variation in grammatical realisation and construction of technicality

5.2.5.1 Transitivity

The transitivity analyses of the primary texts (Figures 5.16a - 5.18a in Appendix 5) revealed a pattern of selection of process types very similar to that of the secondary texts. This is shown in Table 5.22.

TEXT	CLAUSES	Material		Mental	Relational						Verbal	Behavioural
		Effective	Middle		Identifying			Attributive				
					int	circ	poss	int	circ	poss		
*PSEAS1	25	3	4	0	0	0	0	14	0	0	0	3
PSEAS2	12	0	3	0	1	0	0	7	1	0	0	3
PSEAS3	10	0	1	0	0	1	0	6	1	0	1	2
SSEAS1	41	13	3	1	1	2	0	10	7	0	1	7
SSEAS2	24	1	2	2	5	1	0	8	3	2	1	3
SSEAS3	17	1	2	1	5	2	0	8	2	2	0	2

* PSEAS1- 1 Existential Process

Table 5.22 Summary of process types in primary seasons texts

Relational Attributive Processes dominate and Material processes are much less prominent at both primary and secondary levels (the higher proportion of Material processes in SSEAS1 reflecting some additional meanings in the DEDUCTION SEQUENCES but more so in the Analogic Account, as discussed in 5.1.5.1). The primary texts contain fewer Relational: identifying and Relational: circumstantial: attributive processes.

The commonality in the selection and grammaticalization of nuclear meanings in the Given Information in the secondary texts also characterised the primary texts. The commonality across primary texts is shown in Figure 5.36. The thicker lines indicate meanings common to all texts and dotted lines indicate meanings that occurred in one text only.

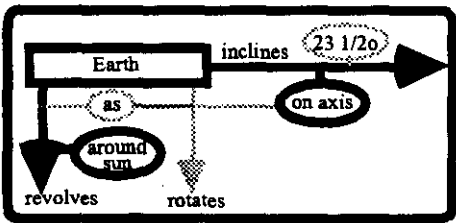


Figure 5.36 Commonality of nuclear meanings in Given Information in primary texts.

As noted in 5.2.4, there was no Given Information element in PSEAS2 and the meanings of the Earth's inclination on its axis and revolution around the sun occurred in the Explanation Summary. In PSEAS3 the Earth's revolution also occurred in the Explanation Summary. The realisation of these meanings in the primary texts is shown in Table 5.23.

	Rotation	Revolution
PSEAS1	04 It is also spinning on its own axis	03 The Earth travels once round the sun each year
PSEAS2		01[[as it orbits around the Sun]]
PSEAS3		01 ... the Earth's orbit around the Sun

Table 5.23 Realisation of the Earth's rotation and revolution in primary seasons texts

As in the secondary texts the grammatical selections were mainly centred on middle Material processes. The only primary level realisation of the Earth's rotation uses the commonsense item "spinning", while both secondary realisations use the more technical "rotates". However, two primary texts use the technical item "orbit" in realising the Earth's revolution, whereas all secondary texts introduced this meaning with the commonsense item "moves".

Again, as in the secondary texts, Relational: intensive: attributive clauses realised the Earth's inclination on its axis in PSEAS1 and PSEAS3.

14 It is tilted over at 23¹/₂ degrees. (PSEAS1)

02 The diagram shows [[how the Earth's axis is slanted]]. (PSEAS3)

In PSEAS2, however, this meaning was realised by the nominal group "the tilt of the Earth..." embedded in the Value of the Relational: identifying clause functioning as the Explanation Summary:

01 Seasons are the result of the tilt of the Earth as it orbits around the sun. (PSEAS2)

The predominance of Relational:attributive processes in the DEDUCTION SEQUENCES of the primary texts is shown in Table 5.24.

TEXT	CLAUSES	Material		Mental	Relational						Behavioural
		Effective	Middle		Identifying			Attributive			
					int	circ	poss	int	circ	poss	
PSEAS1	17	1	2					12			*
PSEAS2	10		2					6	1		2
PSEAS3	6	1	0					5	1		

* PSEAS1- 1 Existential Process

Table 5.24 Process types in DEDUCTION SEQUENCES in primary seasons texts

In the secondary texts there were no middle Material processes in the DEDUCTION SEQUENCES and effective Material processes in SSEAS1 only, whereas in the primary texts middle Material processes occurred in PSEAS1 and PSEAS2 and one effective

Material process in each of PSEAS1 and PSEAS3. Behavioural processes occurred in the DEDUCTION SEQUENCES of all secondary texts but in only one of the primary texts.

In the secondary texts the DEDUCTION SEQUENCES involved four phases dealing with winter and summer in the northern and southern hemispheres and each of these phases progressed through a number of steps, which were described in Table 5.11. Not all phases, nor all steps in phases, were included in all texts. Furthermore, some of the steps were realised explicitly and some needed to be inferred, and the pattern of explicit and inferential realisation also varied across texts. However each of the steps were characterised by particular distributions of process types and within the steps there was little variation in the grammatical realisation. This patterning of process selection is compared with that of the primary texts in Table 5.25. In the "PROCESS SELECTIONS" column, the categories which occurred in the primary texts only are shown in *italics*.

STEPS	MEANINGS	PROCESS SELECTIONS	REALIZATIONS
Contextual STATE	Inclination of particular hemispheres to the sun	Relational: Intensive: Attributive Relational: Circumstantial: Attributive	16 In midsummer <<17>> the northern hemisphere is tilted toward the Sun. (PSEAS1) 11 when that part of the Earth is tilted towards the Sun in summer. (PSEAS2) 02 At one end of the Earth's orbit the North Pole is pointing towards the sun. (PSEAS2)
Simultaneous EVENT	Sun's rays strike the Earth's surface at an oblique or perpendicular angle	Material: effective	
Consequential STATE	Sun's rays are concentrated or spread out at the Earth's surface	Relational: Intensive: Attributive <i>Relational: Circumstantial: Attributive</i> Relational: Possessive: Attributive	08 because the Sun's rays are spread more thinly... (PSEAS2) 04 so its rays are more concentrated (PSEAS3) 07 and the rays[[reaching the north]] spread out over a larger area. (PSEAS3)
Consequential EVENT	Ray's heating effect is relatively high or low (Relatively more or fewer light rays from the sun are absorbed by the Earth and converted to heat energy)	Relational: Intensive: Attributive	05 and feel hotter. (PSEAS3)
Consequential Behavioural EVENT	Particular hemispheres experience summer or winter	Behavioural <i>Circumstance of temporal location</i>	03 and the Northern Hemisphere has its hot summer (PSEAS2) 16 In midsummer <<17>> the northern hemisphere is tilted towards the sun. (PSEAS1)

Table 5.25 Realisation of meanings in steps within phases of DEDUCTION SEQUENCES in primary seasons texts

The process types selected within each step in the primary and secondary texts were similar in all but two cases and only two steps each included one process type selection peculiar to the primary texts. So where there was commonality in ideational meanings and explicit realisation, there was substantial commonality in grammatical realisation.

The realisational variation that did occur across the primary texts and between these and the secondary texts can be appreciated by considering each of the steps in Table 5.25.

Firstly, Table 5.24 showed that the primary texts contained fewer Relational: circumstantial: attributive clauses. Instead of processes like "tilts" and "faces", the primary texts tended to select Relational: intensive processes and attributes like "...is tilted...". But no examples of either of these selections from PSEAS3 are shown in Table 5.25. In this text the relevant meanings needed to be inferred from clauses like:

06 During winter the Sun is over a region south of the equator, (PSEAS3)

The process type is still Relational:intensive:attributive, so the pattern of grammatical selection is not affected.

The only effective Material process in the primary texts realising the sun's rays striking the Earth, was embedded in the Qualifier of "rays" in PSEAS3 (07 and the rays reaching the north spread out over a larger area). In SSEAS3 the realisation of this event involved four effective material processes.

The middle Material processes in PSEAS1 and PSEAS2 are either recapitulations of meanings in the "Given Information" element, or elaborative or generalised meanings not relevant to any of the steps listed:

05 As it spins (PSEAS1)

20 North of the Arctic Circle the Sun never sets. (PSEAS1)

06 In between, the weather changes during spring and autumn.

07 These seasons happen.... (PSEAS2)

Only one text at each level (SSEAS1 and PSEAS3) realised meanings from step four using Relational:intensive: attributive clauses with a realisation of the Sun's rays as Carrier:

32 and their heating effect is less (SSEAS1)

05 and feel hotter. (PSEAS3)

An additional and significant resource used in PSEAS2 and in the secondary texts SSEAS2 and SSEAS3 was the Relational:intensive: attributive clause with the comparative reference item "the opposite" as Carrier:

05 Six months later, the opposite is true.

...

10 The opposite is true.... (PSEAS2)

20 In winter the reverse is true (SSEAS2)

14 The position is reversed each six months.... (SSEAS3)

The primary text PSEAS1 does not explain the seasons in terms of the effect of the tilt of the Earth as it revolves around the Sun on the relative heating effect of the Sun's rays in different hemispheres when those hemispheres are inclined toward or away from the Sun. Rather this text is concerned with the effect of the tilt of the Earth as it revolves around the Sun on the relative lengths of night and day in different hemispheres when those hemispheres are inclined toward or away from the Sun. In fact, as noted above, the only reference to heat is that in winter "... the days are short and cool", and this is not related to the heating effect of the Sun's rays explicitly or implicitly. Consequently, of the twelve Relational:intensive: attributive processes in the DEDUCTION SEQUENCES, very few realise meanings in the steps listed in Table 5.25. The majority are concerned with the occurrence and relative lengths of day and night in the different seasons:

07 and is in daylight

09 and is in darkness

11 day and night would be the same length all over the world,

18 The days are long

19 and the nights are short.

22 Nights are long,

23 and the days are short and cool. (PSEAS1)

What was common about the process selections in the Explanation Summary of the primary and secondary texts was that they are all involved in the metaphorical realisation of causal conjunction. In both primary and secondary texts Relational:intensive: identifying clauses were used with a nominalisation of cause (SSEAS3 - "the cause of the seasons"; PSEAS2 - "the result of the tilt of the Earth...") as Value. Both primary and secondary texts used Relational:circumstantial:identifying clauses (SSEAS1 - "...gives rise

to.."; SSEAS3 - "..caused by.."; PSEAS3 - "...are caused by.."). In addition the secondary texts used a Relational: intensive: attributive clause:

09 They are due to the rays of light from the Sun..... (SSEAS3)

and a Material process embedded in the Value of a Relational:intensive: identifying clause, as metaphorical realisations of cause:

12 It is the Earth's revolution around the Sun [[that gives us our seasons....]]

Other Material processes in the Explanation Summary of both primary and secondary texts were embedded within the Value of Relational:identifying clauses:

01 Seasons are the result [of the tilt [of the Earth]
[[as it orbits around the Sun]]] (PSEAS2)

05 Day lengths and temperatures depend on [[how long the sun shines and the angle
[[at which the sun's rays strike the Earth]]]] (SSEAS1)

Overall, there is little variation in the transitivity selections realising meanings that are common across primary and secondary texts. Secondary texts tended to use Relational: circumstantial: attributive processes to realise the inclination of the Earth to the Sun ("tilts"; "faces"), whereas primary texts used this form only once, favouring Relational:intensive:attributive clauses for this purpose. Variation in the use of different process types is largely due to differences in the meanings included across texts.

5.2.5.1.1 *Naming and defining technical terms in primary and secondary seasons texts*

The primary texts were analysed for the occurrence of resources for naming and defining technical terms in the same way as the secondary texts as detailed in chapter two (2.2.4.3). None of these resources were deployed in the primary texts. This is not very surprising since it was found that few such resources were used in the secondary texts and the technical terms that were named or defined were not central to the explanation of the occurrence of the seasons. The undefined technical terms in the primary and secondary texts are set out in Table 5.26. Terms which occurred in both primary and secondary texts are shown in bold. Those that occurred in the secondary texts only are shown in italics and those occurring in the primary texts only are shown in normal type.

PRIMARY TEXTS			SECONDARY TEXTS		
PSEAS1	PSEAS2	PSEAS3	SSEAS1	SSEAS2	SSEAS3
orbit axis globe hemisphere Arctic Circle tropical regions Equator	orbits hemisphere North Pole	orbit axis Equator	axis <i>rotates</i> hemisphere <i>perpendicularly</i> <i>obliquely</i>	axis <i>rotates</i> hemisphere North Pole South Pole	orbit axis Southern Cross Achemar

Table 5.26 Undefined technical terms in primary and secondary seasons texts

Although PSEAS1 does seem to have more undefined terms than the other primary texts, there does not seem to be very much difference in the extent of these undefined terms across texts both within and across school levels. A core of common technical terms (orbit, axis, hemisphere) is assumed at both levels.

5.2.5.2 Grammatical metaphor in primary and secondary seasons texts

The analyses of grammatical metaphor in the primary texts are shown in Tables 5.6a - 5.8a in Appendix 5. (The analyses are again based on the categories of grammatical metaphor summarised in Tables 2.12 and 2.13 in Chapter two). Table 5.27 compares the occurrence of categories of metaphor in the primary and secondary texts. The final column indicates the overall density of metaphor per clause in each text.

Text	Clauses	Type of Metaphor												
		1a	1c	2b	5a	5d	5h	6a	12a	12b	12c	12d	Total	
SSEAS1	41	0	1	5	4	1	0	1	5	2	0	4	23	0.56
SSEAS2	23	4	0	2	0	0	2	0	1	1	0	0	10	0.44
SSEAS3	17	0	0	1	0	0	0	0	1	4	1	0	7	0.41
PSEAS1	25	1		3				1	1				6	0.24
PSEAS2	12			2					4				6	0.50
PSEAS3	10									1			1	0.10

Table 5.27 Frequency of occurrence of types of grammatical and logical metaphor in *primary and* secondary seasons texts

Although little use is made of grammatical metaphor in two of the three primary texts, the deployment has some similarity with that in the secondary texts, which was also quite low. As with the secondary texts logical metaphors occur in the Explanation Summary and PSEAS2, like SSEAS1 and SSEAS3, also uses metaphorical realisations of external

contrast:opposition ("the opposite") in the DEDUCTION SEQUENCES. Seven of the eight instances of category 2b (Quality of Thing→Thing) in the secondary texts were accounted for by the nominalisation "tilt" and "length" and three of the five instances of this category in the primary texts were accounted for by the same nominalizations (the other two instances in the primary texts were "daylight" and "darkness"). In section 5.1.5.2 it was argued that the use of metaphor was not central to the realisation of meanings constructing the secondary textbook explanations of the occurrence of the seasons and this is also clearly the case with the primary texts.

5.2.6 Causal conjunction, "depth" of explanation and relative technicality of primary and secondary seasons texts

All secondary texts made more use of external temporal conjunction than external consequence in the Given Information and DEDUCTION SEQUENCES elements, but the greatest proportion of external temporal and consequential relations as well as internal consequence occurred in SSEAS1 (5.1.6). This text was the most comprehensive in terms of the inclusion of nuclear meanings as shown by the semantic map analyses, indicating that greater depth of treatment of this topic is not incompatible with a more temporally oriented explanation.

The relative depth of treatment of the topic in the primary texts, as indicated in the semantic map analyses, was PSEAS2 > PSEAS3 > PSEAS1. But the relationship between depth of treatment and the relative use of temporal and consequential conjunction is not clear. This can be seen in Table 5.28, which indicates the frequency of external temporal and consequential relations (including metaphorical realisations) and internal conjunction.

TEXTS	External conjunction per Conjunctively related unit		Internal consequence per Conjunctively related unit
	Temporal	Consequential	
PSEAS1	.10	.24	.14
PSEAS2	.10	.20	.10
PSEAS3	0	.14	.29

Table 5.28 Conjunction in Given Information and DEDUCTION SEQUENCES in primary seasons texts

The proportions of conjunctive relations in each of the categories in PSEAS2, which evidenced the greatest depth of treatment, do not differ significantly from those in PSEAS1, which evidenced the least depth of treatment. However, PSEAS1 was concerned with the causes of day and night and the relationship of their varying lengths at different times of the year to the seasons, while PSEAS2 was concerned with the cause of the different heating effect of the sun's rays at different times of the year in different

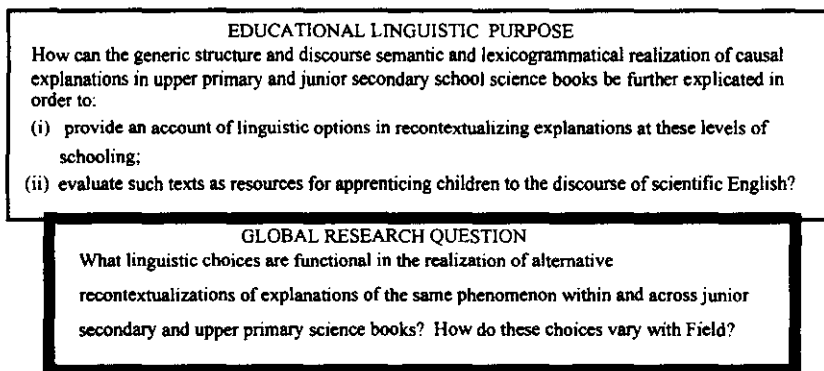
hemispheres as the cause of the seasons. The comparison of PSEAS2 with PSEAS3 suggests that increased use of external temporal and consequential relations is related to increased depth of treatment, as was the case with the secondary texts. However PSEAS3 has more internal consequential conjunction than PSEAS2, which is not consistent with the finding from the secondary texts that greater use of internal consequence was associated with greater depth of treatment.

In section 5.2.5 it was shown that in both primary and secondary texts there was little construction of technicality and quite low densities of grammatical metaphor and that neither technicality nor grammatical metaphor were central resources in the explanations of the occurrence of the seasons.

On the basis of the relative depth of treatment as indicated by the semantic maps then, and its relation to the deployment of conjunction, it seems that while there is no clear correlation in the primary texts, in the secondary texts greater use of external temporal and consequential relations and of internal consequence are all associated with greater depth of treatment. But the greater use of external temporal relations in SSEAS1, indicates that greater depth of treatment is not incompatible with a more temporally oriented explanation.

5.3 Educational implications

This section summarises the variation in the linguistic dimensions of recontextualization across the primary and secondary texts and relates these findings to the global research question and the educational linguistic purpose of the study.



Genre

The elements of schematic structure included in SSEAS1 and not in the other secondary texts were the Analogic Account and the iteration of the DEDUCTION SEQUENCES and CLOSURE. SSEAS3 did not include the Conclusion and SSEAS2 did not include the Conclusion or Extension components in the CLOSURE. The omission of the Conclusion

means there is no summary resulting from the reasoning of the DEDUCTION SEQUENCES and the omission of the Extension means there is no mention of Autumn and Spring in SSEAS2. These could be seen as non-essential elements of structure and hence the absence of the Conclusion in PSEAS1 and PSEAS2 and the Extension in PSEAS3 as not limiting the primary explanations. The Analogic Account is not essential and the ideational meanings in the two DEDUCTION SEQUENCES elements in SSEAS1 could be accommodated by expanding the second element, since it includes a good deal of re-iteration. For example in the following segment from the second DEDUCTION SEQUENCES element, the interpolation of clause 19 from the first element between 31 and 32 is all that is required to provide a repetition of clauses 18-20 from this first element:

30 When the southern hemisphere tilts away from the sun
 31 most of the sun's rays strike the Earth obliquely
 (19 *they are spread over a larger area*)
 32 and their heating effect is less. (SSEAS1)

The iteration of the DEDUCTION SEQUENCES and CLOSURE is therefore also not an essential aspect of the schematic structure. The obligatory elements then would be: Phenomenon Identification ^ Given Information · Explanation Summary ^ DEDUCTION SEQUENCES. The variations in schematic structure peculiar to the primary texts were the omission of an Explanation Summary in PSEAS1 and of a Given Information element in PSEAS2. Although it was suggested that the Explanation Summary in PSEAS1 is conflated with the Link element, this did not occur in any of the other primary or secondary texts, and it seems more appropriate for the primary texts to include an explicit Explanation Summary. The omission of the Given Information in PSEAS2 is dysfunctional since it assumes the reader's knowledge of the Earth's orbit and its inclination on its axis. None of the secondary texts made this assumption and furthermore, this information was not provided in previous sections of the primary book. In terms of schematic structure then, recontextualizations of explanations of the occurrence of the seasons at the primary level should include the obligatory elements as noted above.

Texturing: Patterns of Theme and Information Focus

The clearest patterning of Thematic choice in relation to schematic structure was in SSEAS1. The first clause in the Explanation Summary functioned as a Macro-Theme, predicting Hyper-Themes, which were predictive of Theme selections in the DEDUCTION SEQUENCES. Marked Themes tended to scaffold the introduction of each phase in the second DEDUCTION SEQUENCES element. New information introduced Rhematically in the DEDUCTION SEQUENCES formed sets of contrasts which were accumulated and summarised in the Conclusion element as a Hyper-New. The Thematic

organisation in SSEAS2 was similar except that the seasons were selected as marked Themes rather than the changes in the orientation to the sun of the Earth's hemispheres during the Earth's orbit, as was the case in SSEAS1. The method of development in SSEAS2 was also influenced by the selection of reference to illustrations as Theme, which were not predicted by the Hyper-Theme. In this text also there is no Conclusion element and no accumulation of new information in a Hyper-New. No consistent pattern of Theme selection was found in SSEAS3.

The Thematic organisation in the primary texts approximated that of SSEAS1 with the Explanation Summary element as Hyper-Theme predicting Theme selection in the DEDUCTION SEQUENCES, and the use of marked Themes to introduce new phases. The clearest and most consistent pattern of this type occurred in PSEAS3. In this text the seasons were selected as Theme as in SSEAS2. The only Conclusion element in the primary texts was in PSEAS3 and this did not accumulate new information from previous clauses, so there were no Hyper-News in the primary texts. The primary texts did not utilise Thematic organisation which was distinctively different from that of the secondary texts (although a number of Topical Themes in PSEAS1 were concerned with day and night since this text explained differences in the seasons in terms of the relative length of day and night at different times of the year). The distinctive Thematic features of SSEAS1 i.e. the orientation to the sun of the Earth's hemispheres during the Earth's orbit as points of departure in the DEDUCTION SEQUENCES, and the accumulation of new information in the Conclusion element as a Hyper-New, could be accommodated in texts at the primary level.

Reasoning: Patterns of conjunctive relations

The use of internal conjunctive relations of reformulation and consequence and external relations of simultaneity, consequence and contrast was common to all texts at both levels. But the pattern of conjunctive relations constructing the reasoning in the DEDUCTION SEQUENCES was more elaborated and clearer in SSEAS1. This was partly due to the greater depth of treatment of the topic in this text and hence the inclusion of meanings that did not occur in the other texts. However, there were two other important influences. The first was that the occurrence of winter and summer in both hemispheres was dealt with explicitly, whereas in the other texts metaphorical realisations of external contrast and text reference (e.g. "In winter the reverse is true.") obviated many of the explicit realisations of external simultaneity and internal consequence that occurred in SSEAS1. In this text, the metaphorical form of external contrast did not occur until the Conclusion element. The second influence on the reasoning in SSEAS1 was that this text set up the causal chain of the variation in the heating effect of the sun on different hemispheres at the same time of the year as the rhetorical means for concluding that these uncommonsense events

corresponded with the more commonsense experience of variation in the seasons. This aspect of internal reasoning did not occur in the other texts, which realised the summer and winter as locations in time during which these uncommonsense events took place.

The latter orientation was common to the primary texts and this might be considered an appropriate means of using commonsense as the point of departure for younger readers. However, none of the primary texts dealt explicitly with summer and winter in both hemispheres in the DEDUCTION SEQUENCES as did SSEAS1. PSEAS1 did not deal with the southern hemisphere at all and PSEAS2 used the metaphorical realisation of external contrast and text reference as in SSEAS2 and SSEAS3. Dealing explicitly in the DEDUCTION SEQUENCES with summer and winter in both hemispheres and avoiding the logical metaphor in realising external contrast, as in SSEAS1, are characteristics of this secondary text which seem most appropriate to texts for younger readers at primary level.

Ideational Semantics: The selection of nuclear, elaborative and peripheral meanings

The explanations of the seasons in these texts were focussed on the causes of winter and summer in the northern and southern hemispheres. In the secondary texts Autumn and Spring were not mentioned in SSEAS2 at all and in SSEAS1 and SSEAS3 they were included as an Extension in the CLOSURE element. In the primary texts Autumn and Spring occurred in only one clause in the DEDUCTION SEQUENCES of one text:

06 In between the weather changes during spring and autumn. (PSEAS2).

The lack of seasonal variation in these terms in the tropics is addressed in only one text - as the Extension element in the primary text PSEAS1.

The comparison of ideational meanings selected in the explanations of the occurrence of winter and summer was achieved by projecting semantic maps of the meanings in the Given Information and DEDUCTION SEQUENCES elements in each text onto a semantic map of the aggregated meanings occurring in these elements of structure in all three secondary texts. Again SSEAS1 included the most comprehensive selection of nuclear meanings. It was the only text to include the relationship of the Earth's inclination to the sun to the angle of incidence of the sun's rays on the Earth's surface and the consequent density of the sun's rays on that surface area. SSEAS2 indicated that the lower concentration of the sun's rays in the southern winter was due to the southern hemisphere tilting away from the sun, but did not mention anything about the angle of incidence of the sun's rays. However this text did not indicate that this lower concentration of the sun's rays decreased their heating effect. More commonly (in SSEAS3, PSEAS2 and PSEAS3) the causal link between the concentration of the sun's rays and their heating effect was made, but in SSEAS3 and

PSEAS2 this was not linked to the inclination of the Earth to sun, nor to the angle of incidence of the sun's rays and in PSEAS3 it was linked the angle of incidence but not back to the Earth's inclination to the sun. Apart from SSEAS1 then, there seems to be an avoidance of explaining the relationship between the Earth's inclination to the sun, the angle of incidence of the sun's rays and their consequent concentration at different locations on the Earth's surface. These links should be made to avoid the logical gaps in the explanation. Primary texts could well include the kind of Analogic Account in SSEAS1 to assist in making these meanings accessible to younger readers.

PSEAS1 dealt most skeletally with the meanings in the semantic map because this text does not explain the occurrence of the seasons in terms of the effect of the tilt of the Earth as it revolves around the Sun on the relative heating effect of the Sun's rays in different hemispheres when those hemispheres are inclined toward or away from the Sun. Rather this text is concerned with the effect of the tilt of the Earth and its revolution on the relative lengths of night and day in different hemispheres when those hemispheres are inclined toward or away from the Sun and the correspondence of this variation with seasonal change. These relationships are not explained in any of the other texts. They are mentioned in the Explanation Summary in SSEAS1, but are actually dealt with in a separate, subsequent text segment with its own sub-heading.

Apart from this different perspective in PSEAS1, extensive peripheral meanings occurred in the secondary texts PSEAS2 and PSEAS3 only. Text renovation from the perspective of the selection of ideational meanings then, would involve ensuring the inclusion of all nuclear meanings relevant to the explanation of the cause of summer and winter in both hemispheres in terms of the different heating effects of the sun's rays brought about by the variation in the inclination of each hemisphere to the sun as the Earth makes its orbit.

Lexicogrammatical realisation and the construction of technicality

There was little variation in the transitivity selections realising meanings that were common across primary and secondary texts. Relational: attributive processes dominated all texts at both levels. Material processes were much less prominent at both levels, but the proportion was higher in SSEAS1. More effective Material processes occurred in the DEDUCTION SEQUENCES of SSEAS1 because this was the only text to include meanings concerning the sun's rays striking the Earth perpendicularly or obliquely. There was a tendency for secondary texts to use Relational: circumstantial: attributive processes to realise the inclination of the Earth to the Sun, whereas this form occurred only once in the primary texts, which favoured the use of Relational:intensive:attributive clauses. The proportion of Relational: identifying processes was also lower in the primary texts. This was partly due to the absence of definitions of technical terms which occurred in the Given

Information in SSEAS2 and SSEAS3. These technical terms however, were not central to the explanation, not occurring in the DEDUCTION SEQUENCES in either text. There was little difference in the extent of undefined technical terms across texts both within and across school levels. A core of common technical terms was assumed at both levels.

The main types of grammatical metaphor in both primary and secondary texts were logical metaphors and the realisation of the quality of a Thing as a Thing (category 2b). Two of the primary texts used significantly less metaphor than the secondary texts. However, the metaphors that were used were very similar across both levels. Logical metaphors of consequence occurred in the Explanation Summaries and PSEAS2, like SSEAS1 and SSEAS3, also used metaphorical realisations of external contrast:opposition in the DEDUCTION SEQUENCES element. Seven of the eight instances of category 2b in the secondary texts were accounted for by the nominalisation "tilt" and "length" and three of the five instances of this category in the primary texts were accounted for by the same nominalizations. SSEAS1 included more logical metaphors of simultaneity in dealing explicitly with the occurrence of summer and winter in both hemispheres. It also included more logical metaphors of consequential relations because it realised the fact that the sun's rays feel hotter or cooler depending on their concentration using the metaphorical form "the heating effect", whereas the primary texts used congruent forms such as "(the sun's) rays are more concentrated and feel hotter" (PSEAS3). The variation in lexicogrammatical choices, deployment of grammatical metaphor and the construction of technicality were not very significant factors in distinguishing the primary and secondary explanations on this topic.

Summary

At the level of genre it is necessary to ensure that primary texts include an Explanation Summary and a Given Information element. Texts at both levels would benefit from a pattern of Theme selection and information focus similar to that of SSEAS1. Similarly, explicit accounts of the cause of summer and winter in both hemispheres in the DEDUCTION SEQUENCES, avoiding logical metaphor in realising external contrast, as in SSEAS1, would achieve more explicit explanations at both primary and secondary levels. The selection of ideational meanings in texts at both levels should ensure the inclusion of all nuclear meanings relevant to the explanation of the cause of summer and winter in both hemispheres in terms of the different heating effects of the sun's rays brought about by the variation in the inclination of each hemisphere to the sun as the Earth makes its orbit. The variation in lexicogrammatical choice and construction of technicality does not seem to be problematic in these texts.

Chapter 6

Functional variety in school science explanations: Educational Implications

This chapter consolidates the findings of the previous three chapters in working toward an account of the linguistic choices which are functional in recontextualizing explanations of the same phenomenon within and across primary and secondary school levels, and of the variation in these functional choices across different Fields. The first section presents a comparison of the results from the previous three chapters. Each of the dimensions of recontextualization investigated in research questions one through six and compared across school levels in research question seven will now be compared across Fields at both the primary and secondary school levels, as indicated in Figure 6.1.

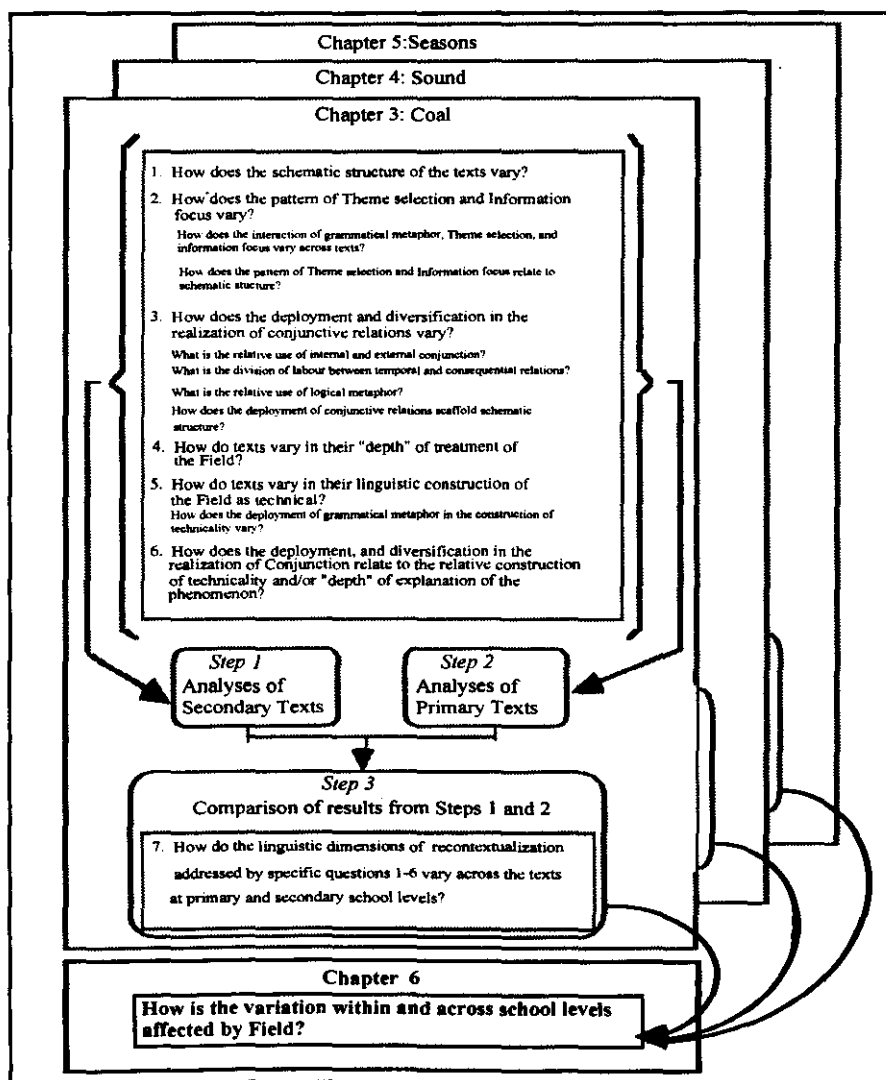


Figure 6.1 Organisation of the first section in chapter six

The second section summarises the salient aspects of the emerging educational linguistic account of explanations in school science books and indicates further aspects in need of research. The final section contextualizes this work on the semiosis of explanation in school science books within the transdisciplinary nature of educational linguistics in which theoretical analysis and social action tend to coalesce.

6.1 The effect of Field on variation in explanatory texts within and across primary and secondary school levels

6.1.1 Schematic structure

The application of the concept of rank, producing an analysis of schematic structure in terms of layers of staging (Martin, 1994; 1995:24) has provided a means of clarifying earlier apparently discrepant descriptions - for example, the apparent subsumption of the Phenomenon Identification in Shea's (1988) Link stage and the absence of any mention of the Link in the account by Veel (in press, a), while the Phenomenon Identification in this account (in press, a:120) seemed to subsume the Explanation Summary and Given Information elements identified in the present study. The layered account of schematic structure also allowed differential functional labelling of the elements of the Implication/Explanation Sequences stage, which had previously only occurred in the research by Cross (1992), dealing with "cycle" texts. The more delicate descriptions of schematic structure enabled the accounts in preceding chapters of variation on this dimension within and across school levels in each of the three Fields investigated. The next step is to compare across Fields the descriptions of schematic structure and the variation within and across school levels. The results are related to the work of Cross (1992) dealing with variation in schematic structure across water, nitrogen and nutrient cycle texts and across the intended readership levels of a number of texts on each of these topics. As well as a more elaborated account of layering of schematic structure in explanations in combination with the concept of "hyper-elements" of structure proposed by Cross (1992), the comparison of schematic structure across Fields also uses Martin's (1995; in press) modelling of particulate structures at the level of genre. A tentative proposal for the development of a complementary typological/topological approach to the generic description of different types of explanations in school science is briefly outlined.

The possible schematic structures for explanations in the three Fields investigated, as evidenced by the actual schematic structures of the three secondary texts analysed in each Field, are shown in Figure 6.2. Two layers of staging are indicated. The first layer is in upper case and the second in lower case with initial capitalisation. Iterative elements are

indicated by the superscript ⁿ. Elements of structure which occurred in explanations across two or more Fields are in bold.

COAL	SOUND	SEASONS
ORIENTATION	ORIENTATION	ORIENTATION
Phenomenon Identification	Phenomenon Identification	Phenomenon Identification
^ (Link)	^ (Link)	^ (Link)
		^ Given Information
^ (Phenomenon Contextualization)		
^ (Explanation Summary)		· Explanation Summary
	^ (Analogic Account)	^ (Analogic Account)
	^ PHENOMENON EXEMPLIFICATION	
^ IMPLICATION SEQUENCES	^ IMPLICATION SEQUENCES	^ DEDUCTION SEQUENCES
Conditions		
^ Trigger		
^ Transformation		
^ Transformationⁿ		
^ (CLOSURE)	^ CLOSURE	^ (CLOSURE)
(Conclusion)	Conclusion	(Conclusion)
	^ [(Extension)	^ (Extension)
	· (Generalisation/ Application)	
	· (Clarification)]	
^ (Comment)		

Figure 6.2 Comparison of schematic structures across Fields for secondary texts

At the first layer of staging the differences are that the PHENOMENON EXEMPLIFICATION occurs in the Sound texts only and that the CLOSURE appears to be obligatory in the sound texts and optional in the other Fields. At the next level of delicacy in the ORIENTATION only two elements are peculiar to particular Fields - the Phenomenon Contextualization occurs only in the coal texts and the Given Information element only in the seasons texts. Links and Analogic Accounts occur in both sound and seasons texts but only one coal text included a Link. The Explanation Summary occurs obligatorily in seasons and optionally in coal but not at all in the sound texts. This seems to correspond with the PHENOMENON EXEMPLIFICATION element being peculiar to the sound texts. In fact, the latter element as well as being a particular instance of the production of sound waves, which the subsequent text explains, is also a metaphorical realisation of the event sequences to be "unpacked" in the IMPLICATION SEQUENCES and hence does supply a kind of abstract summary of the explanation. This can be seen in the PHENOMENON EXEMPLIFICATION elements of the first two secondary texts, but is not as clear in the third text:

- 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)

While there is a fairly high degree of commonality in the range of orienting strategies used, the deployment of the Analogic Account is clearly influenced by Field and the Phenomenon Contextualization and Given Information are Field specific. In the cycle texts Cross (1992) identified in the ORIENTATION, the summarise and contextualize strategies only, which correspond here to the Explanation Summary and Phenomenon Contextualization. Cross incorporated the sub-heading/title as part of the summarise strategy, whereas here it has been found to function distinctively as the Phenomenon Identification. At the least level of delicacy then, all texts have an ORIENTATION, but at the more delicate level the only orienting element shared by all texts is the Phenomenon Identification. An intermediate level of delicacy, as indicated in Figure 6.3, would capture the similarities across Fields, while specifying the range of orienting strategies. This would have pedagogical advantages as a means of children gradually learning the more differentiated elements of the ORIENTATION stage as they build up familiarity with explanations in different Fields.

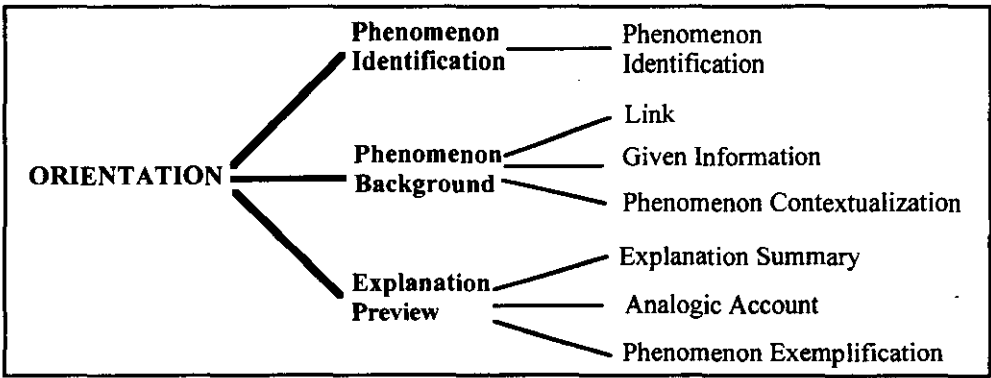


Figure 6.3 Layers of staging in the ORIENTATION

In the CLOSURE there was less variability in the range of elements included in the more delicate description, as shown in Figure 6.2. The Conclusion occurs in all Fields but is obligatory only in Sound. Extension elements occur in Sound and Seasons, while the Generalisation/Application and Clarification are peculiar to Sound and the Comment element is peculiar to the Coal texts. An intermediate level of delicacy here might include the Conclusion, Extension and an Elaboration element subsuming the

Generalisation/Application, Clarification and Comment elements at the more delicate level, as indicated in Figure 6.4.

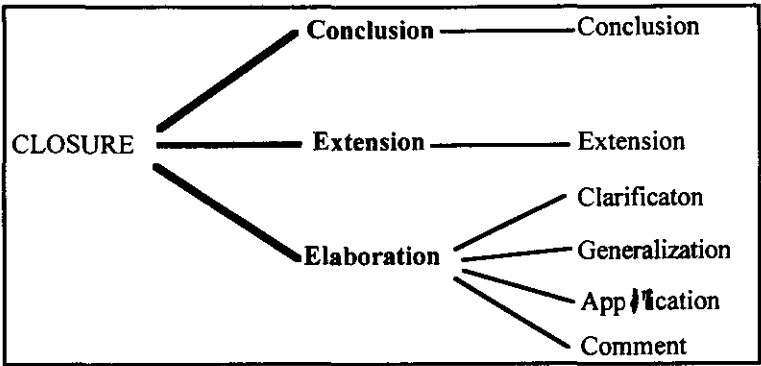


Figure 6.4 Layers of staging in the CLOSURE

In the IMPLICATION SEQUENCES a second layer of staging is shown for the coal texts but not for the sound texts nor for the DEDUCTION SEQUENCES in the seasons texts. A more delicate analysis of these stages is illustrated in Table 6.1. At this greater level of delicacy the staging is quite Field specific. This is similar to the Field-specific elements for each of the water, nitrogen and nutrient cycle texts which, in the generalised Generic Structure Potential, were subsumed under the iterative TRANSFORM hyper-element in the work of Cross (1992), described in chapter one (1.5.2.4).

SOUND	SSND1	SEASONS	SSEAS1
IMPLICATION SEQUENCES		DEDUCTION SEQUENCES	
Compression	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 and compress them. 20 As each air particle pushes on the next one to its right 21 the compression travels through the air.	Orientations Summary	23 As a result of the tilt of the Earth's axis the southern hemisphere is inclined towards the sun in December and away from the sun in June 24 (see figure 7.24)
Rarefaction	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	Southern Summer	25 When the southern hemisphere tilts towards the sun, 26 it receives more of the sun's rays at an angle closer to 90° 27 and it experiences summer.
Seriation	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.	Northern Winter	28 During this time the northern hemisphere points away from the sun 29 and is experiencing winter.
		Southern Winter	30 When the southern hemisphere tilts away from the sun, 31 most of the sun's rays strike the Earth obliquely 32 and their heating effect is less 33 During this time the southern hemisphere has its winter.
		Northern Summer	34 The northern hemisphere at the same time points toward the sun 35 and has its summer.

Table 6.1 Second layer of staging for IMPLICATION SEQUENCES in secondary Sound texts and DEDUCTION SEQUENCES in secondary seasons texts.

Again, at the least level of delicacy all of these explanations have the IMPLICATION SEQUENCES stage, commonly referred to even more generally as the "EXPLANATION SEQUENCE" (Derewianka, 1990:62; Christie et al, 1992:73; Butt et al, 1995:20; Veel, in press a:119). On the other hand at the more delicate level all of the elements are quite Field specific. But determining an intermediate level of delicacy here is quite problematic. One approach from the work of Cross (1992) is the iterative TRANSFORM hyper-element for all cycle texts, which is "customised" in the form of the Field-specific elements corresponding to more delicate Field specification in the contextual configuration (Cross, 1992:131). But while this hyper-element is relevant to the broad Field category of cycles, it is not applicable to the different Field categories that would include the sound and seasons texts. The specification of IMPLICATION SEQUENCES at this intermediate level of delicacy then, seems to rely on first specifying the type of explanation in terms of such broad Field categories. Clearly more research is needed to explore this, but some speculation is possible on the basis of currently available data. The coal texts could be part of a broader category of natural formations, including other sedimentary rocks and geologic formations or even the formation of stars. The elements of the IMPLICATION SEQUENCES stage described for the coal texts, could in fact function as hyper-elements, which, following Cross (1992), would be customised to correspond to more delicate Field choices, as shown in Figure 6.5.

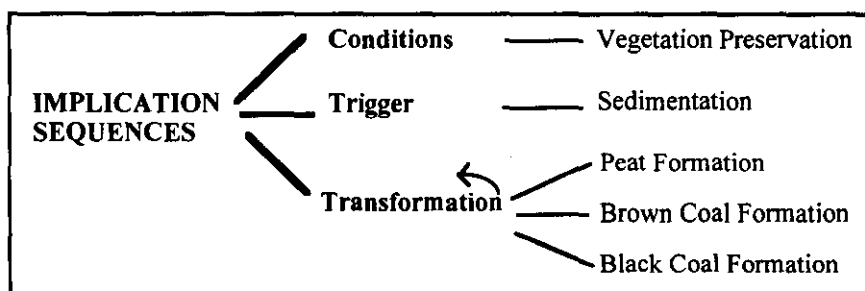


Figure 6.5 Layers of staging for IMPLICATION SEQUENCES in the explanation of coal formation

The seasons texts could be part of a category of natural phases including phenomena such as the tides and phases of the moon. The progression in delicacy for the description of the IMPLICATION/DEDUCTION SEQUENCES could be as shown in Figure 6.6.

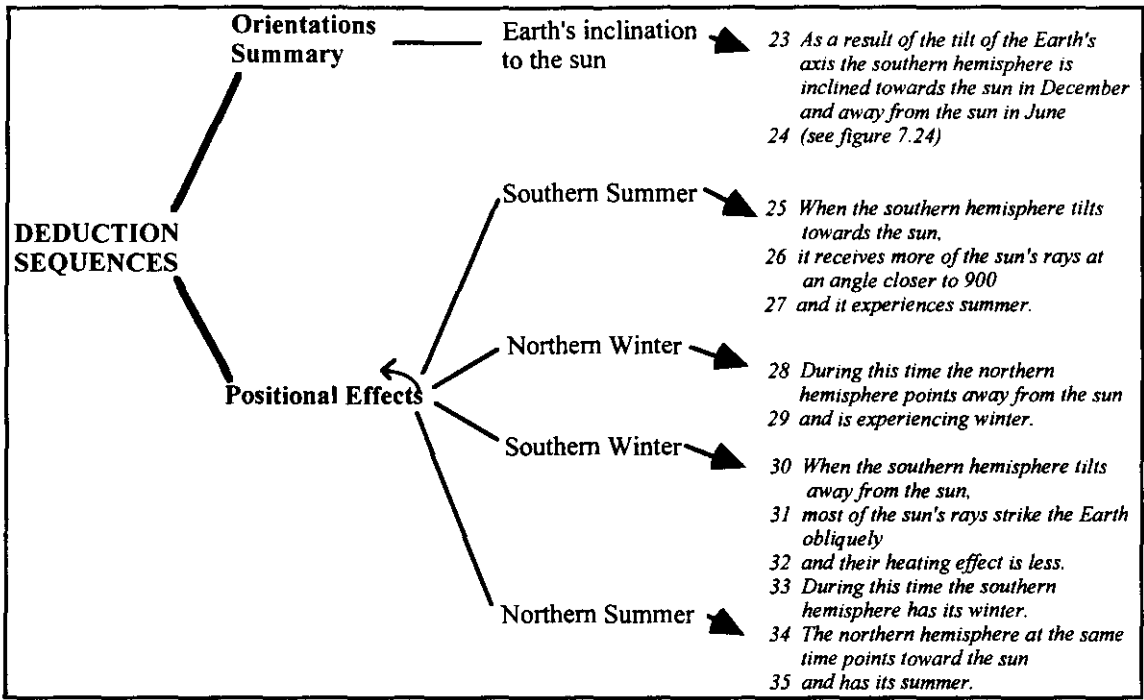


Figure 6.6 Layers of staging for DEDUCTION SEQUENCES in the explanation of the seasons

Similarly the sound texts could be part of a broader of category of waves explanations incorporating light waves and other forms of energy transferred in this manner. The hyper-elements would be specific to this broad Field category and again customised for specific categories such as sound.

This classification of explanation types based on broad Field categories could also be described using more genre oriented categories reflective of the structural characteristics of the IMPLICATION/EXPLANATION SEQUENCES in each type. As an alternative to the constituency bias of current descriptions of schematic structure Martin (1995; in press) showed how descriptions of the particulate, prosodic and periodic structuring of the clause corresponding to the metafunctional diversification in its realisation, could be applied at the level of genre. Martin's application of particulate structure draws first on Halliday's (1985; 1994a) ergative account of the realisation of experiential meaning in which the Process and Medium form the nucleus of the clause and the Agent and Circumstance(s) form satellites, as indicated in Figure 6.7.

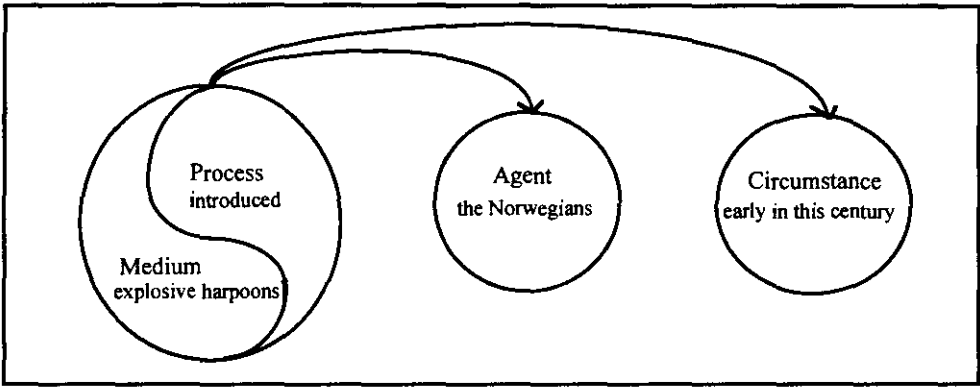


Figure 6.7 Clause rank experiential meaning as nucleus and satellites (from Martin, in press)

He then shows how the structure of a news story can be construed in this way constructing an orbital (mono-nuclear) structure (Figure 6.8). Here it is only possible to show Martin's diagram skeletally listing the participants and events in each Lead Development from the Headline. But the crucial point made by Martin (in press) is that Lead Developments 1, 2 and 3 each function as satellites elaborating the nucleus - Lead Developments 2 and 3 relate to the Lead/Headline in the same way that Lead Development 1 does. Lead development 2 does not follow on from 1, nor does 3 follow on from 2.

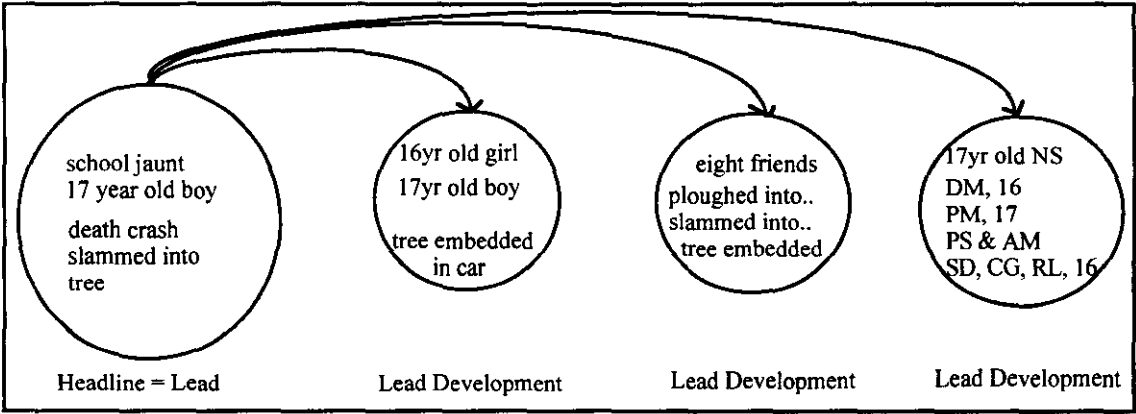


Figure 6.8 Orbital (mono-nuclear) structure in a news story from Martin (in press)

The application of Martin's modelling to the further study of news stories (Iedema et al, in press) identified some texts which evidenced this kind of orbital structure but were not mono-nuclear in that they incorporated "sub-Satellites", which were in fact satellites to another satellite acting as their nucleus, as shown in Figure 6.9.

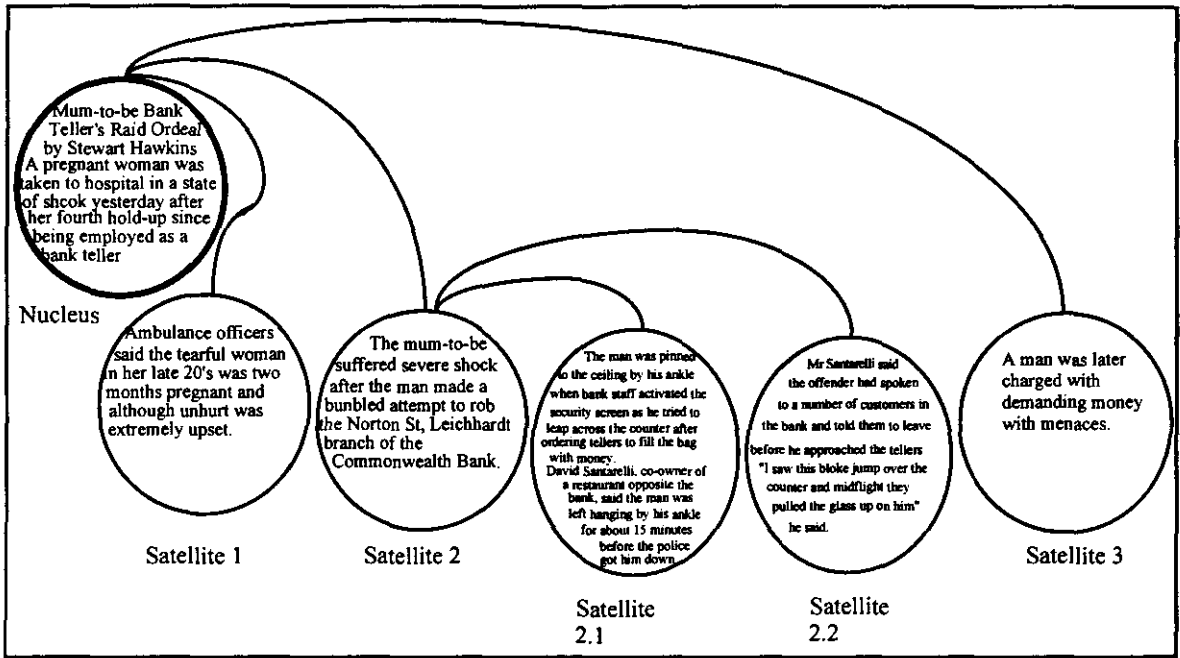


Figure 6.9 Orbital structure with "sub-Satellites" in a news story

In the DEDUCTION SEQUENCES of the seasons texts illustrated above, the Orientations Summary element and the recursive Positional Effects element seem to have something of this nucleus/satellite structure, as indicated in Figure 6.10:

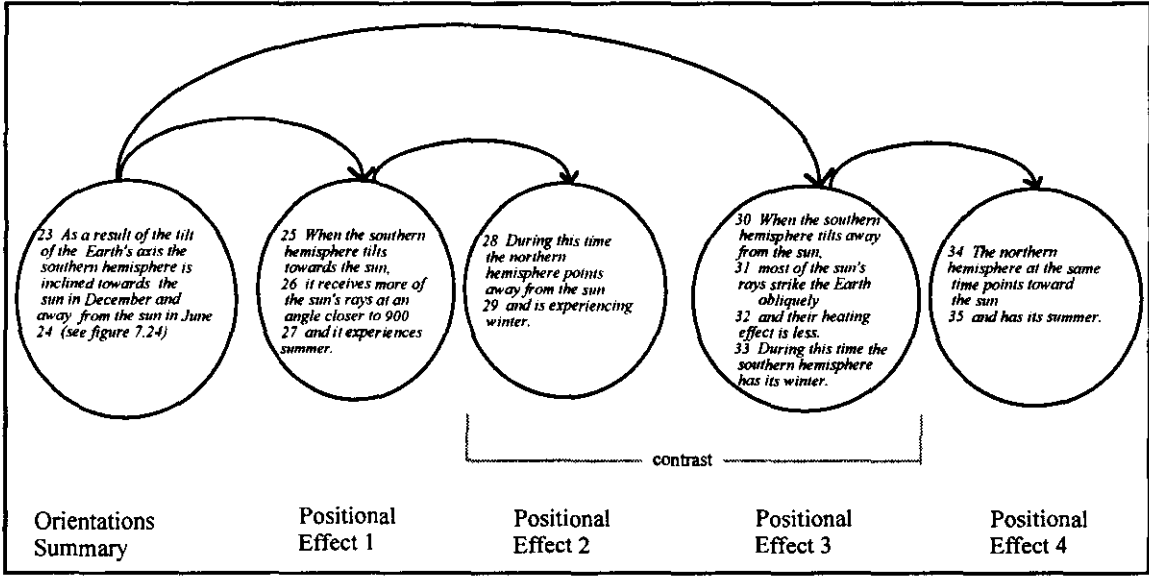


Figure 6.10 Orbital structures in the DEDUCTIONS SEQUENCES element of a secondary seasons text

Here Positional Effect 2 must follow on from Positional Effect 1 and similarly Positional Effect 4 must follow on from Positional Effect 3, but Positional Effects 3 and 4 do not necessarily follow on from Positional Effects 1 and 2 and could occur before them. The

combination of 1 and 2 is linked by contrast with the combination of 3 and 4, but this does not affect the structural ordering of these combinations. Hence we have an orbital structure with the Orientations Summary element as nucleus. But the structure is not mono-nuclear because Positional Effects 1 and 3, as well as being satellites to the Orientations Summary element, are also nuclear to Positional Effects 2 and 4 respectively.

Martin (1995; in press) contrasted orbital structures with serial structures, which reflected the particulate realisation of logical meanings as univariate structures such as those of projection and expansion relating clauses in clause complexes. In structures of this kind, one segment gives rise to another, in an open ended interdependency series - they are multi-nuclear in that each satellite is itself a nucleus . In the coal texts, the elements in the IMPLICATION SEQUENCES form this kind of serial structure, as shown in Figure 6.11.

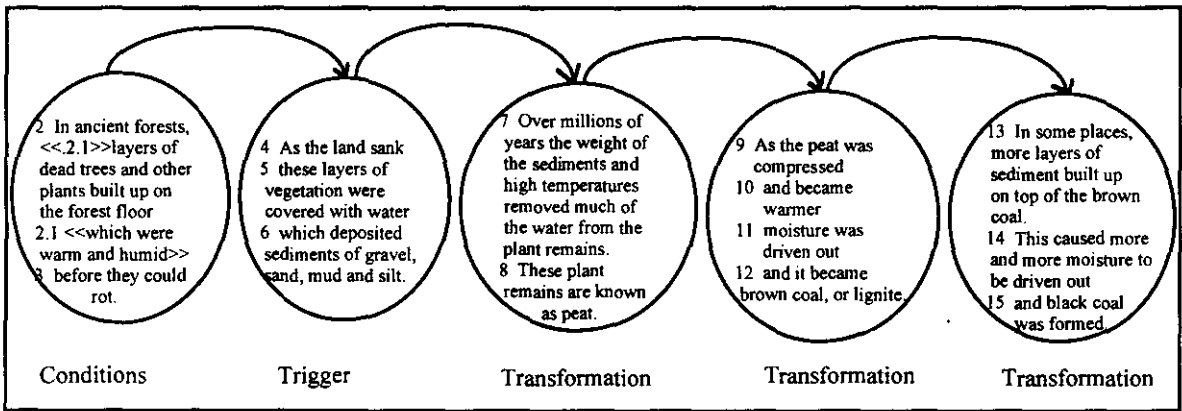


Figure 6.11 Serial structure in IMPLICATION SEQUENCES in a secondary coal text

A form of serial structure can also be seen in the IMPLICATION SEQUENCES of the sound texts, but here there is a "nesting" effect so that a nucleus - satellite structure becomes the nucleus for a further satellite, as indicated in Figure 6.12.

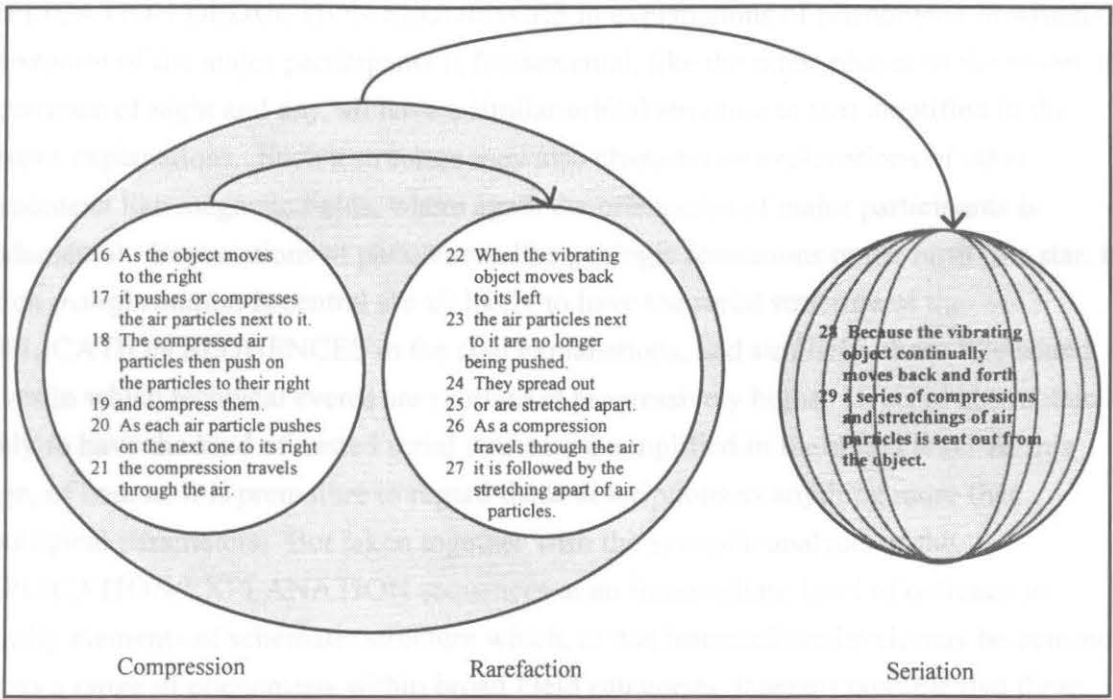


Figure 6.12 "Nested" serial structure in the IMPLICATION SEQUENCES in a secondary sound text

Here the Compression and Rarefaction elements are related by enhancement (external succession), but the Seriation element is not related directly to either one of these elements separately. However the Compression and Rarefaction together are the rhetorical means for the Seriation element, so it is related to the combination of these two elements by enhancement (internal consequence). Thus we have a serial structure in which a nesting of two elements gives rise to a further element. But this Seriation element is also a more abstract reconstrual of the combination of the nested Compression and Rarefaction elements). As discussed in Chapter four (4.1.5.2) and summarised in Figure 4.23, the Compression and Rarefaction elements both reconstrue congruently realised technical events as Things ("compression" and "the stretching apart of air particles"), which then participate in macro technical events at a higher level of abstraction. Then the Seriation element involves further abstract reconstrual because it is the recursive macro event complex constructed in the Compression and Rarefaction elements that is reconstrued as a Thing so that it can participate in a technical meta event - i.e. the sound wave ("a series of compressions and stretchings of air particles") sent out from the vibrating object.

It seems then, that the IMPLICATION SEQUENCES in each of the Fields have quite characteristic particulate structuring. Further research is needed to determine whether explanations of other phenomena in each of the broad Field categories (natural formations, natural phases, and waves) have similar structures. It may be, for example that the

IMPLICATION/DEDUCTION SEQUENCES in explanations of phenomena in which the *orientation* of the major participants is fundamental, like the tides, phases of the moon, the occurrence of night and day, all have a similar orbital structure to that identified in the seasons explanations. Such a structure may also characterise explanations of other phenomena like magnetic fields, where again the orientation of major participants is fundamental. Explanations of phenomena like geologic formations or the birth of a star, in which *transformation* is central are all likely to have the serial structure of the IMPLICATION SEQUENCES in the coal explanations, and similarly, those like sound waves in which technical events are *realised* at progressively higher levels of abstraction are likely to have the kind of nested serial structure exemplified in the sound text. At this stage, of course, it is premature to regard these descriptions as anything more than topological parameters. But taken together with the synoptic analysis of the IMPLICATION/EXPLANATION sequences at an intermediate level of delicacy to identify elements of schematic structure which, at that intermediate level, may be common across a range of phenomena within broad Field categories, it seems possible that these descriptions might support a more Genre oriented than Field oriented classification of explanation types including *Transformational*, *Realisational* and *Orientational* explanations, as indicated in Figure 6.13.

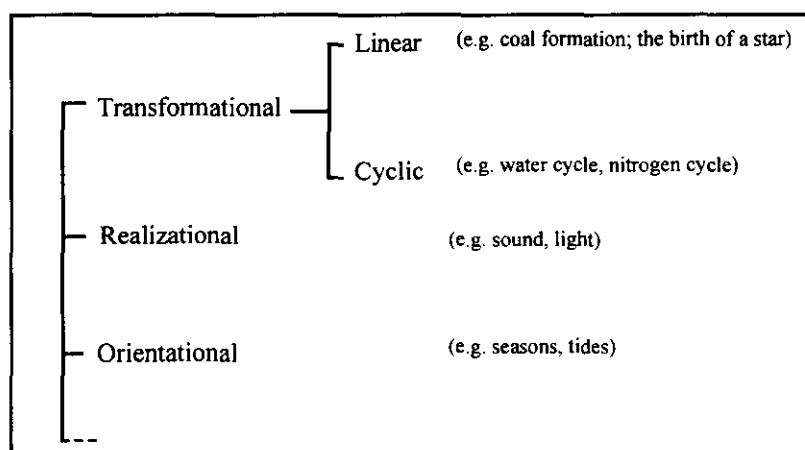
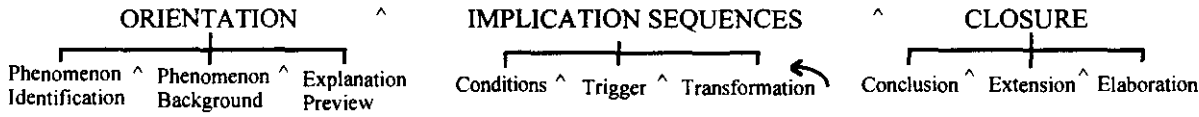


Figure 6.13 Partial network of Explanation Genres

This may provide the kind of typological/topological complementarity that would inform a review of the explanation types proposed by Veel (in press, a; in press b) - problematic aspects of which were outlined in Chapter one (1.5.4.2) and further discussed in Chapter two (2.2.3.2.3). Such a refining may better account for the diversity in school science explanation at the level of genre and still provide a manageable description for educational intervention.

On the basis of the data from this study it is clear that there is sufficient commonality in the structure of the ORIENTATION and CLOSURE that their further description at an intermediate level of delicacy can be applied across the Fields investigated, although this would not permit the distinction between obligatory and optional elements such as the obligatory Conclusion in the sound texts. Nevertheless, it would provide a more comprehensive, yet pedagogically manageable, description than those currently in use. The sensitivity of the staging of the IMPLICATION/EXPLANATION SEQUENCES to Field, means that even an intermediate level of delicacy in their description necessitates a prior differentiation of Explanation types. On the basis of these proposals the coal explanations would be categorised as *Linear Transformational Explanations* and their schematic structure for pedagogical purposes would be represented as follows:



For other types of explanations the second layer of staging for the IMPLICATION SEQUENCES only would change.

The variation of schematic structure with Field in the primary texts was similar to that of the secondary texts, except for the fact that some elements of structure did not occur in the primary texts. The elements common to the primary and secondary texts are shaded in Figure 6.14.

COAL	SOUND	SEASONS
ORIENTATION	ORIENTATION	ORIENTATION
Phenomenon Identification	Phenomenon Identification	Phenomenon Identification
^ (Link)	^ (Link)	^ (Link)
		^ Given Information
^ (Phenomenon Contextualization)		
^ (Explanation Summary)		· Explanation Summary
	^ (Analogic Account)	^ (Analogic Account)
	^ PHENOMENON EXEMPLIFICATION	
^ IMPLICATION SEQUENCES	^ IMPLICATION SEQUENCES	^ DEDUCTION SEQUENCES
Conditions		
^ Trigger		
^ Transformation		
^ Transformation ⁿ		
^ (CLOSURE)	^ CLOSURE	^ (CLOSURE)
(Conclusion)	Conclusion	(Conclusion)
	^ [(Extension)]	^ (Extension)
	· (Generalisation/ Application)	
	· (Clarification)]	
^ (Comment)		

Figure 6.14 Variation in schematic structures between primary and secondary texts in different Fields

The most significant variation across levels is in the sound texts. Here the obligatory PHENOMENON EXEMPLIFICATION element in the secondary texts does not occur in any of the primary texts. It was argued in Chapter four that this was significant in accounting for the limitations of the primary explanations in this Field. In the primary coal texts there was less iteration of the Transform element in the IMPLICATION SEQUENCES and the primary seasons texts tended to deal with the summer and winter in one hemisphere only. This is consistent with the findings of Cross (1992:155) that nitrogen cycle texts for older readers included more optional elements in the PROCESS stage. The similarities in schematic structure across levels and the fact that the renovation of the primary sound texts should involve the inclusion of a Phenomenon Exemplification, indicates that the same approach proposed for the description of the schematic structure of the secondary texts can be applied at the primary level.

The variation of schematic structure with Field within the secondary texts is indicated in Table 6.1a in Appendix 6. Although it is difficult to estimate the relative variation with Field of schematic structure across texts, it is clear that the first text in each Field makes quite exhaustive use of the schematic structure potential, while at least one text in each Field omits essential elements in the IMPLICATION/DEDUCTION SEQUENCES. In the coal texts 3a and 3b this was the Trigger element, and in sound texts 2 and 3, it was the Seriation element, while the seasons text 2 omitted the Northern Summer and seasons text 3 omitted the Orientations Summary. No principled basis could be found for these omissions. The proposed schematic structure potential for these explanation types then, provides one starting point for teachers' evaluation of such texts and for the development of students' critical reading of them.

In the case of the primary texts a different picture emerges of the variation of schematic structure with Field. This variation is indicated in Table 6.2a in Appendix 6. At the primary level, coal texts 2 and 3 include the essential elements in the IMPLICATION SEQUENCES approximating the schematic structure of the first secondary coal text, except that the primary texts do not have the CLOSURE element. The primary coal text 1 does not include the essential Conditions and Trigger elements. On the other hand it is more difficult to distinguish among the Sound texts, all of which omit the PHENOMENON EXEMPLIFICATION and essential elements in the IMPLICATION SEQUENCES (Text 1 omits the Seriation element and texts 2 and 3 omit the Rarefaction element). The failure of the primary texts to deal with the Rarefaction element, which occurred in all secondary texts, meant that the Seriation element, essential to the wave concept, could not be developed in these primary level explanations, as indicated in Figure 6.15.

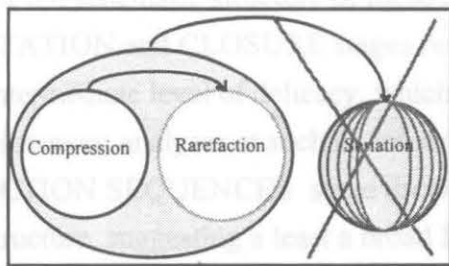


Figure 6.15 Effect of omission of Rarefaction element in primary sound explanations

In the seasons texts there does seem to be a more consistent basis for the variation from the secondary texts in the structure of the DEDUCTION SEQUENCES. None of the primary texts include the Orientations Summary and, although primary text 2 deals with Summer and Winter in both hemispheres, the other two texts deal with the seasons in the Northern hemisphere only (Text 3 refers to the Southern hemisphere in the Conclusion element).

Modifications of this kind can be accommodated within the structure of the DEDUCTION SEQUENCES, as indicated in Figure 6.16.

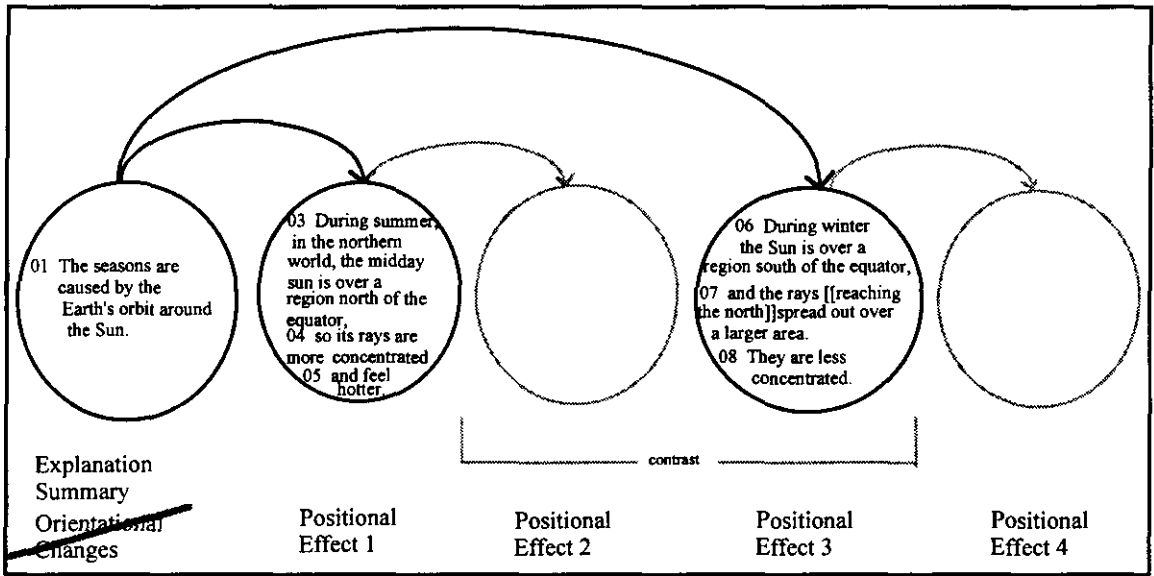


Figure 6.16 DEDUCTION SEQUENCES in PSEAS3 dealing with the seasons in the Northern Hemisphere only

The most appropriate recontextualizations at primary level are likely to occur in explanations of coal formation. This may also be the case for explanations of the seasons, although partial explanation based on one hemisphere is also likely. But the primary sound texts seem least likely to provide an appropriate apprenticeship to effective explanation at the secondary level.

In developing this account of the schematic structure of these explanatory texts, the investigation of the ORIENTATION and CLOSURE stages resulted in the identification of elements of structure at an intermediate level of delicacy, which highlighted commonalities across Fields at this level. However, analyses at such an intermediate level of delicacy of the IMPLICATION/DEDUCTION SEQUENCES stage drew attention to Field related differences at this level of structure, suggesting a least a broad Field-based classification of explanation types. Further work on the particulate realisation of the IMPLICATION/DEDUCTION SEQUENCES stage, following Martin's (1995; in press) modelling of orbital and serial structures may determine whether a more generalised genre-oriented classification of these explanation types is viable. The description of schematic structure at the intermediate level of delicacy proposed here distinguished among the Fields investigated in the IMPLICATION/DEDUCTION SEQUENCES stage and enabled critical comparison across texts within each Field. Investigation of additional Fields within the broad categories indicated would be necessary to establish the extent of generalisability of

the structural elements at this intermediate level. Evidence from the primary texts suggests that the descriptions of schematic structure potential for the Fields of coal formation and the cause of the seasons are applicable across school levels, again enabling critical comparison across texts within Fields. Disparities between the schematic structure of the primary and secondary sound texts indicated omissions in the primary texts that precluded an adequate recontextualization of the Field at this level.

6.1.2 Theme and information focus

Across Fields in the secondary explanations there was a common hierarchy of periodicity in a number of the texts. As well as this pattern of Macro-Theme predicting Hyper-Theme(s) predicting Themes at the clause rank, there was a similarity in the deployment of marked Themes to introduce each element in the IMPLICATION/DEDUCTION SEQUENCES stage of schematic structure. These similarities across fields can be seen by comparing Figures 6.17 - 6.19 on the following pages (Themes are in the right hand column and marked Themes are in *italics*).

The coal texts did not include effective Macro-Themes as did the sound and seasons texts. This is illustrated in Figure 6.17. The sub-heading "COAL" is not an effective Macro-Theme as would have been something like "The formation of coal". Marked Themes introduce each element in the IMPLICATION SEQUENCES.

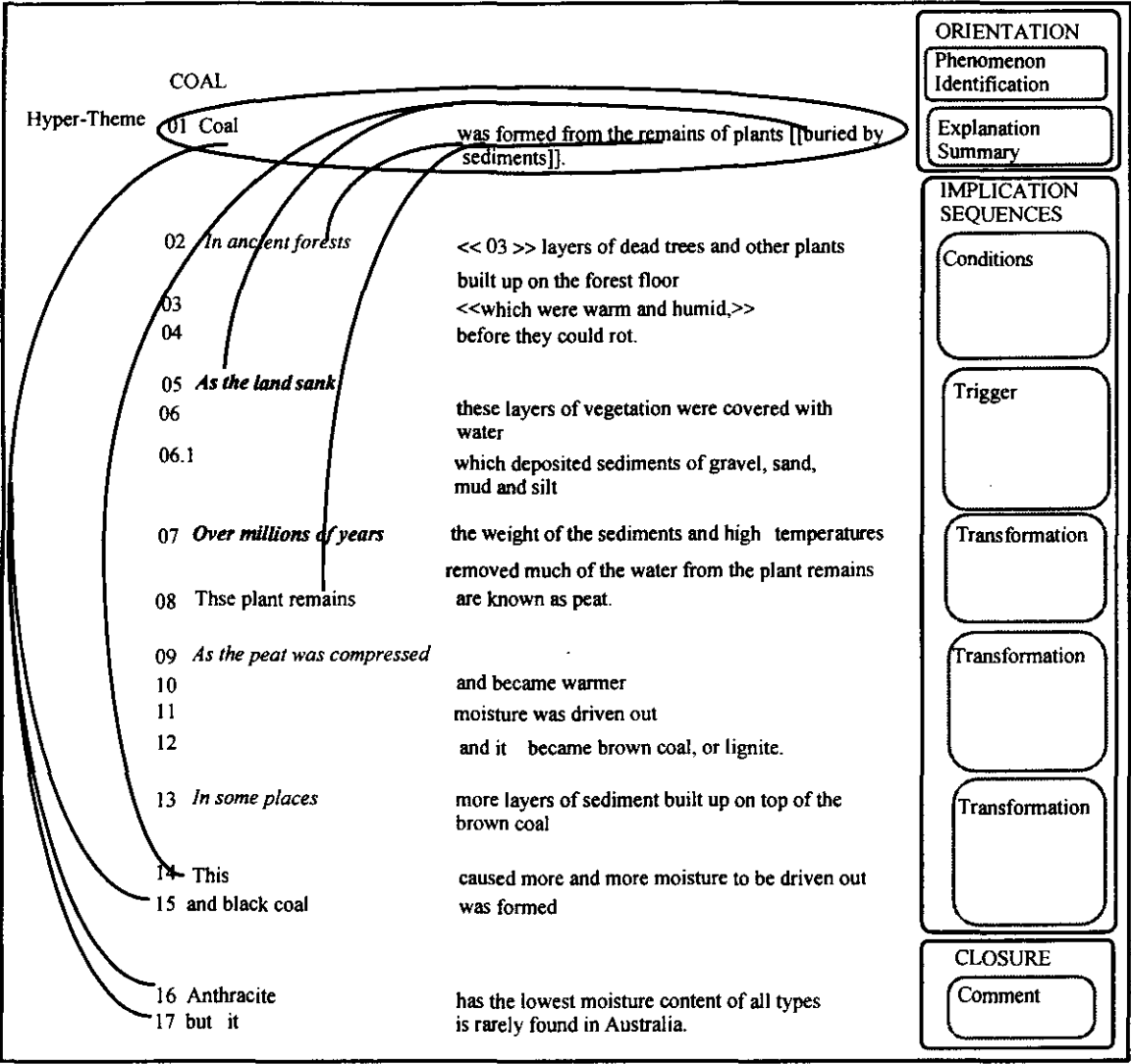


Figure 6.17 Theme in SCOAL2

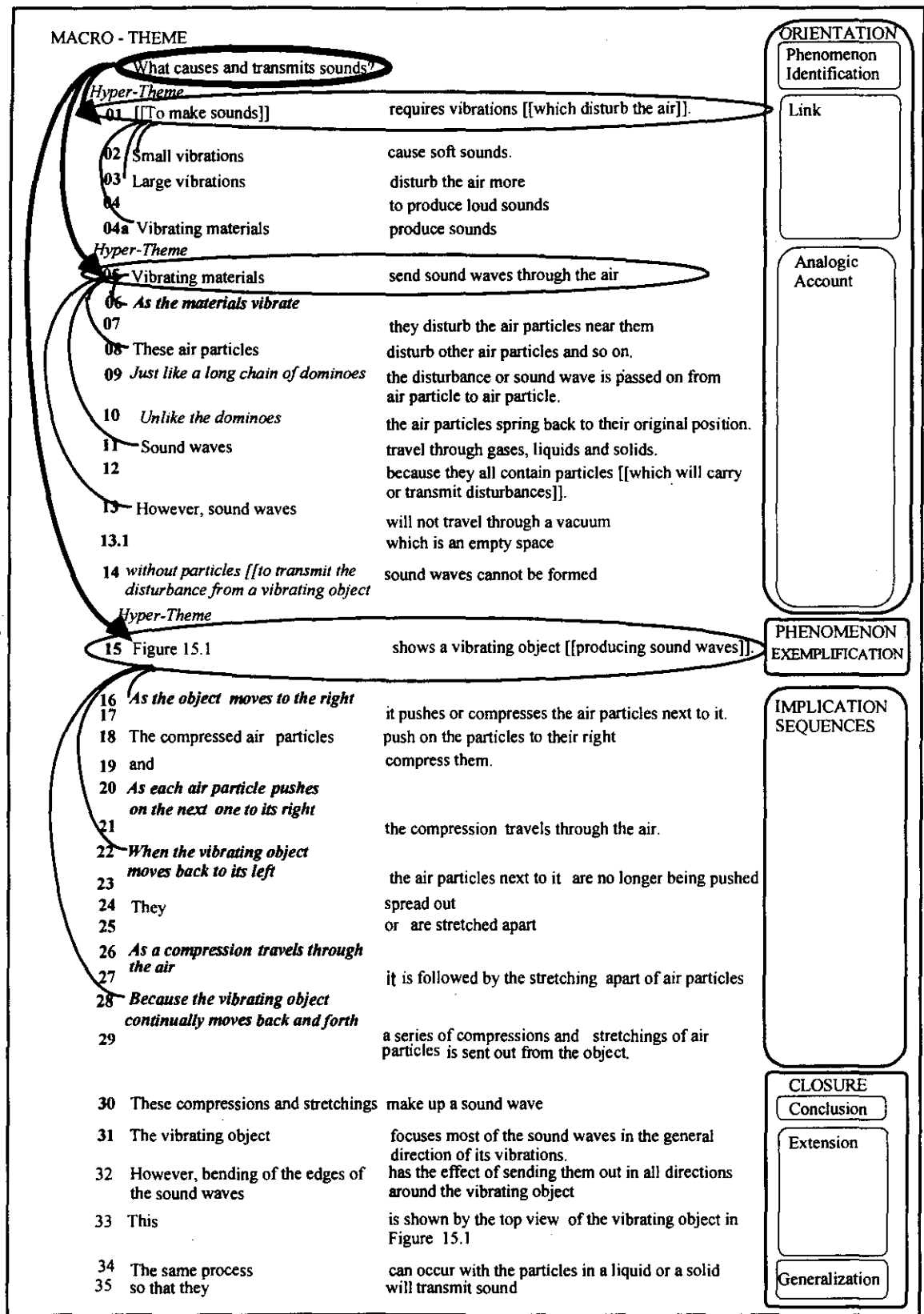


Figure 6.18 Theme in SSND1

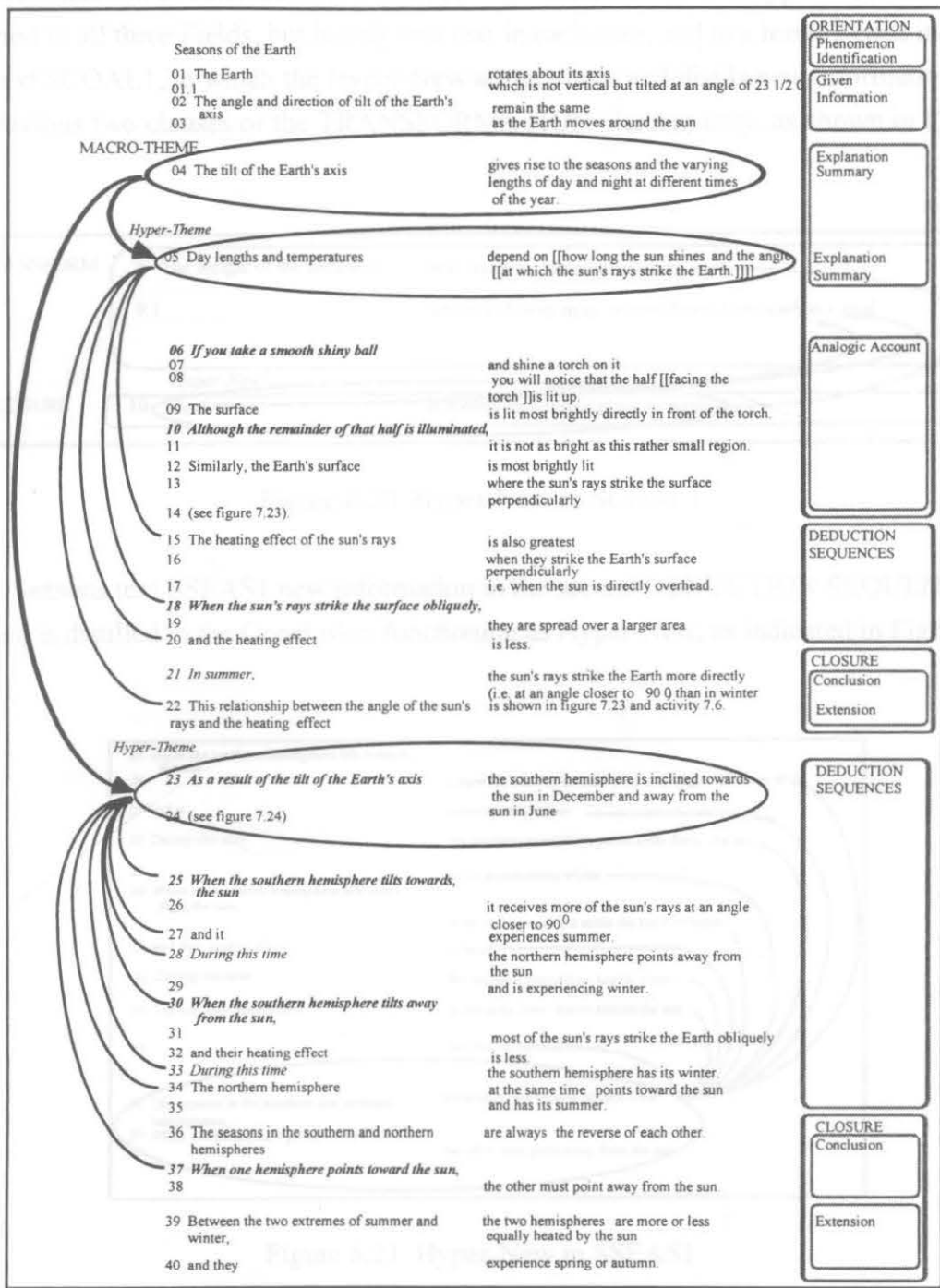


Figure 6.19 Theme in SSEAS1

These patterns of Thematic organisation were fairly consistent across texts within each of the Fields at the secondary level. In the Coal texts SCOAL3a and SCOAL3b, and in the Seasons texts SSEAS3, did not show this organisation. Although the first sound text made more extensive use of Hyper-Themes and marked Themes, similar patterns were evident in both of the other sound texts.

The accumulation of Rhematically introduced new information as a Hyper-New also occurred in all three Fields, but in only one text in each case, and to a lesser extent in the coal text SCOAL1, in which the Hyper-New accumulates and distills new information from the previous two clauses of the TRANSFORMATION element only, as shown in Figure 6.20.

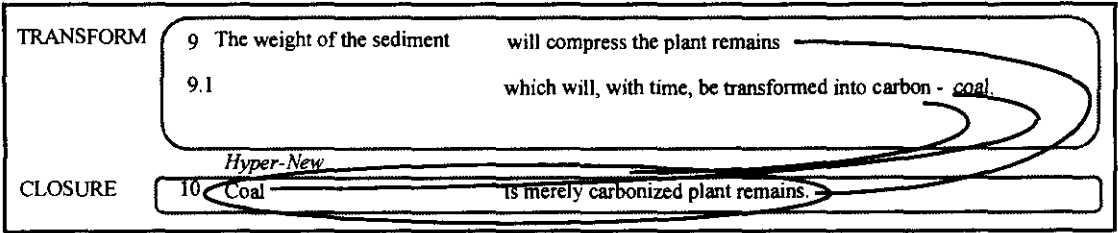


Figure 6.20 Hyper-New in SCOAL1

In the Seasons text SSEAS1 new information in the second DEDUCTION SEQUENCES element is distilled in the Conclusion functioning as Hyper-New, as indicated in Figure 6.21.

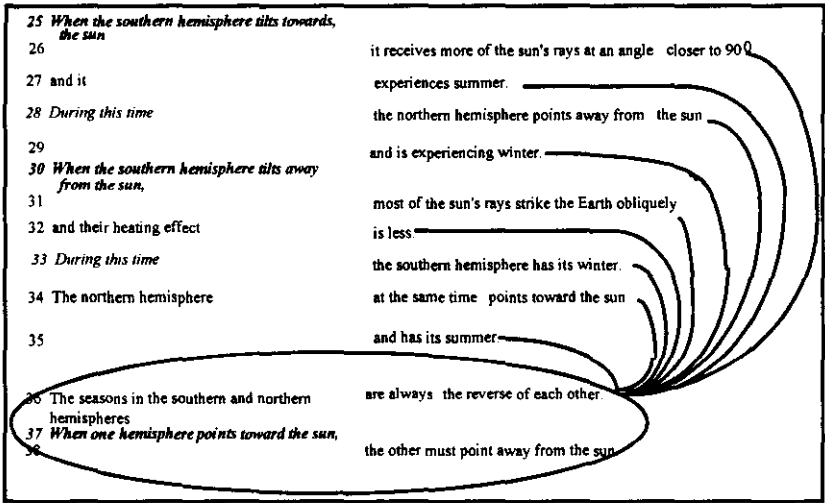


Figure 6.21 Hyper-New in SSEAS1

In the sound texts an effective Hyper-new occurred in SSND1 only. In this text the accumulation and distillation of new information occurred in stages, as discussed in Chapter four (4.1.2) and illustrated again in Figure 6.22.

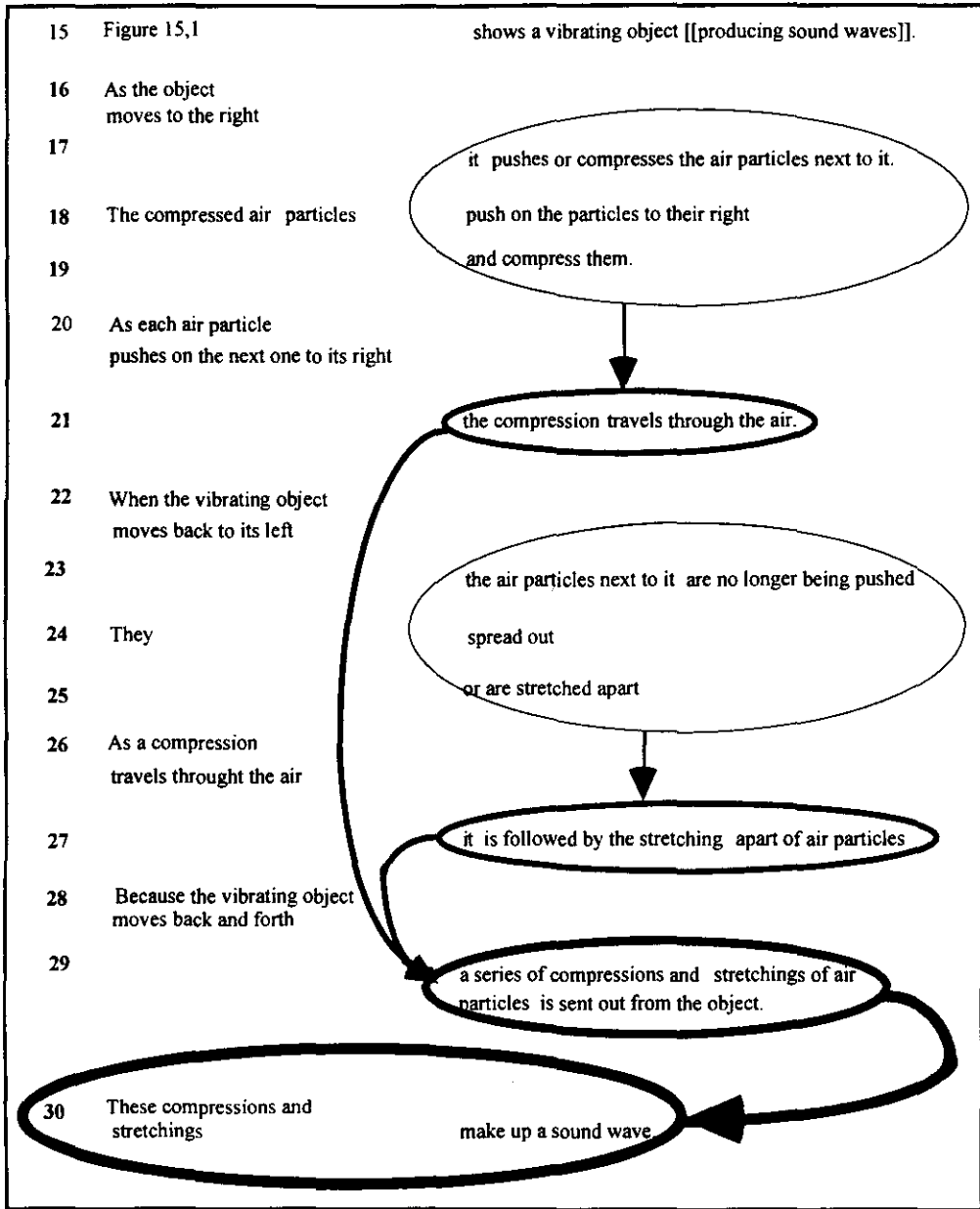


Figure 6.22 Hyper-New in SSND1

What is distinctive about the sound text is that the more extensive use of grammatical metaphor involving "shift to Thing" is consistently constructed in the Rhemes. The technical nominalisations therefore never occur Thematically before they have been introduced Rhematically. These Rhematically introduced nominalisations are integral to the progressive accumulation of the new information from "the compression" and "the stretching apart of air particles" to "a series of stretchings of air particles" and finally "These compressions and stretchings". This contrasts with the absence of grammatical metaphor in the Rhemes of the DEDUCTION SEQUENCES in the seasons text as shown in Figure 6.19 (and there is only one metaphorical shift to Thing in the Themes). The

Hyper-New contains the metaphorical realisation of the logical relation of contrast ("the reverse"). There is also comparatively little use of grammatical metaphor in the construction of the Hyper-New in the coal text SCOAL1, as shown in Figure 6.18.

At the secondary level there was a high degree of commonality across Fields in Thematic organisation and fairly consistent use of this patterning across texts, although two coal texts and one seasons text showed significant departures. The effective accumulation and distillation of new information as a Hyper-New also occurred across Fields, but in only one text in each Field.

At the primary level there was a good deal of similarity with the secondary texts and commonality across Fields in Thematic organisation in the Coal and Seasons texts. Hyper-Themes predicted Theme selection at clause rank and marked Themes introduced new phases in the IMPLICATION/DEDUCTION SEQUENCES. The similarity of Thematic patterning across the two Fields in the primary texts can be seen in Figures 6.23 and 6.24. Within these two Fields the Thematic patterning was consistent across the three texts in each case.

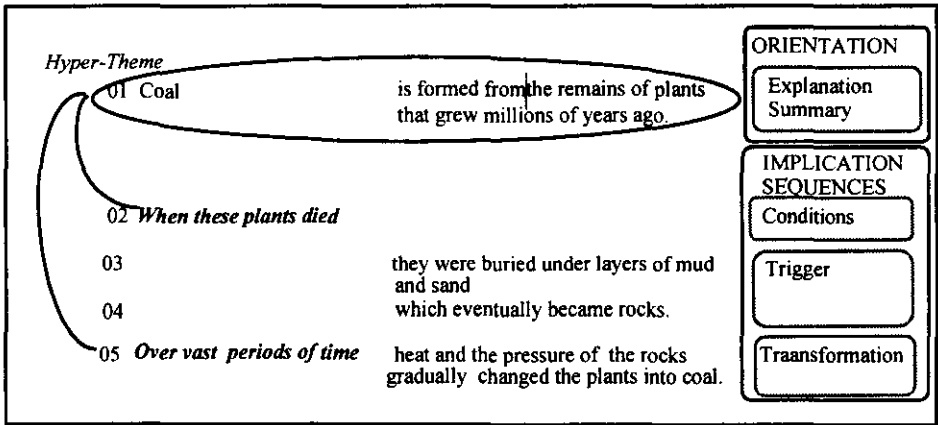


Figure 6.23 Theme in PCOAL2

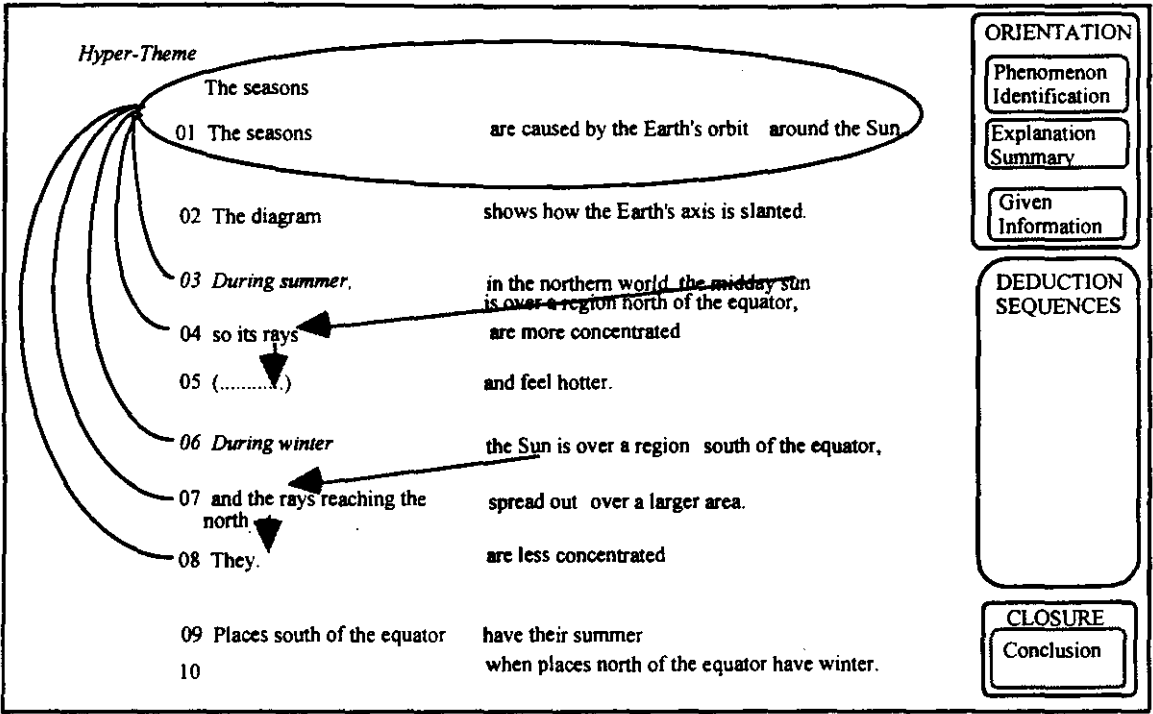


Figure 6.24 Theme in PSEAS3

In the primary Coal and Seasons texts there was no accumulation of News as Hyper-New.

In the case of the Sound texts, the hierarchy of periodicity evident in all of the secondary texts, did not occur in the primary texts at all. However, there were some consistent aspects of Thematic choice across the primary texts. Thematic β clauses realised commonsense events, personal reference was frequently selected as Topical Theme and the method of development relied on Rheme→Theme progression. The progressive accumulation and distillation of technical implication sequences, which occurred Rhematically in the secondary texts, occurred only minimally in one primary text (PSND2). The patterns of Theme and information focus for this text are shown in Figure 6.25.

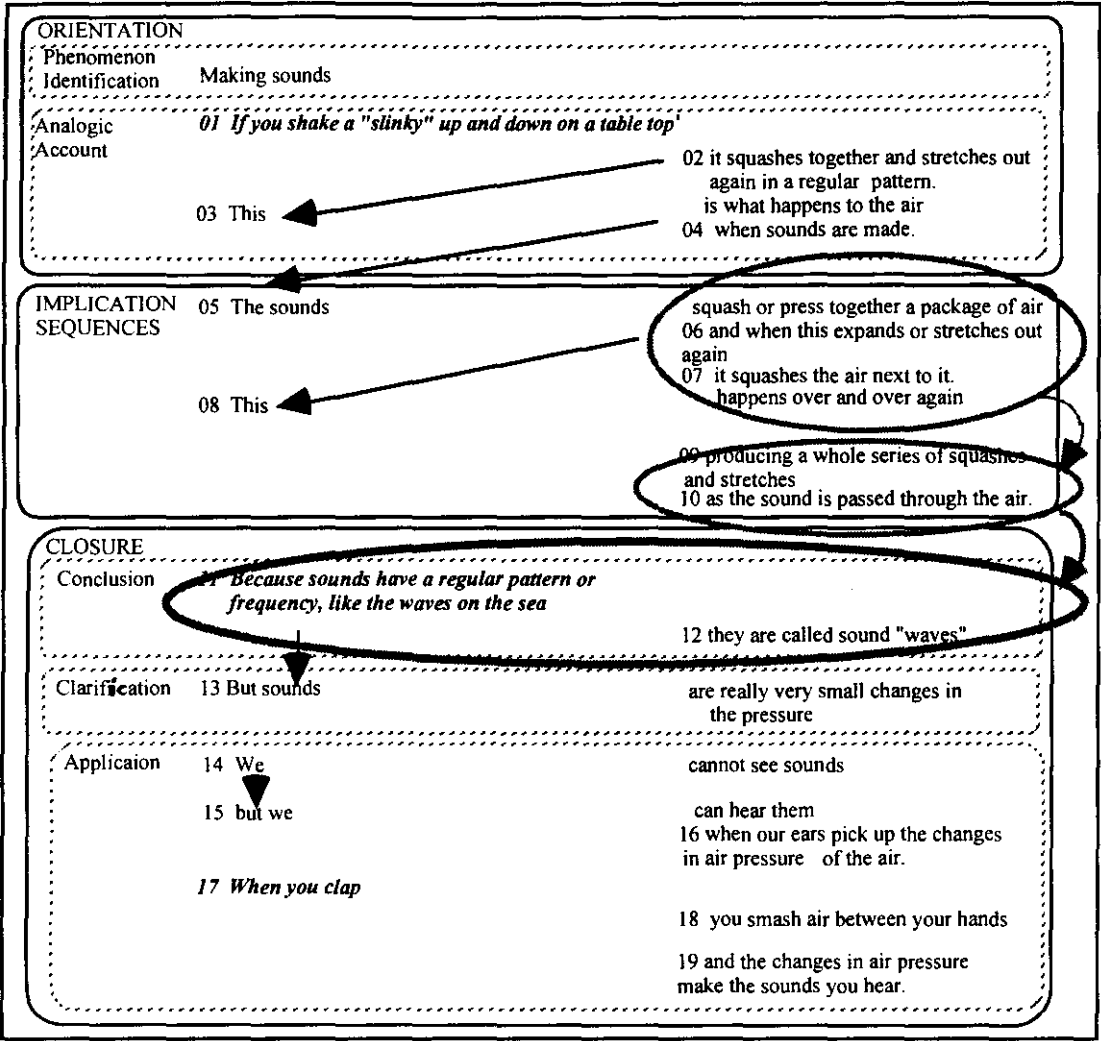


Figure 6.25 Theme and information focus in PSND2

The schematic structure of the secondary and primary texts across Fields is clearly interrelated with the effectiveness of the texturing of the explanations through the pivotal role of the Explanation Preview elements of structure as Hyper-Themes. In the secondary texts across Fields there was a consistent predictive patterning through the selection of Macro-Themes, predicting Hyper-Themes, predicting Themes at the clause level. Texts in which this hierarchy of periodicity is not developed are those like SCOAL3a and SCOAL3b in which the Explanation Summary is omitted, and the primary sound texts in which the Phenomenon Exemplification is omitted.

Texts in which new information is accumulated and distilled are those which include a Conclusion element of structure functioning textually as a Hyper-New. The accumulation of new information as Hyper-New also occurred across Fields in the secondary texts but was more variable within Fields. In the coal texts this was related to the Phenomenon Contextualization, which in SCOAL1 concerned the *biochemical*, sedimentary nature of

coal. The Hyper-New accumulated the new information to support this perspective on coal formation in the Conclusion element. In the other secondary texts and the primary texts the Phenomenon Contextualization was either absent or concerned supply of coal as an industrial resource, so there was no accumulation of new information relevant to the Phenomenon Contextualization to be built up from the nature of coal formation. In the sound texts the absence of the Seriation element in the IMPLICATION SEQUENCES stage in some texts at both school levels precluded the accumulation of new information necessary to the Conclusion element and hence there was no Hyper-New. There seemed to be no principled basis for the inclusion or exclusion of the Conclusion element, and hence the presence or absence of the Hyper-New, in the seasons texts. For example, this element did occur in SSEAS1, but in SSEAS3 and PSEAS2, which also dealt with summer and winter in both hemispheres, it did not occur.

From the combination of analyses of schematic structure, Theme and New, it has been possible to distinguish, from these perspectives, the more effective explanations at secondary level in each Field, and to identify commonalities in the structuring and texturing of these explanations across Fields. From the perspective of texturing as well as schematic structure, explanations at the primary level are more likely to be effective for coal formation and the seasons, but quite problematic in the case of sound texts.

6.1.3 Conjunction

The deployment of conjunction reflects very clear differences across Fields in the secondary explanations, despite some variation across texts within Fields. The differences across Fields are in the relative use of internal conjunction; the types of conjunction linking elements of schematic structure within the IMPLICATION SEQUENCES stage; the types of conjunction within elements in the IMPLICATION SEQUENCES; and the extent and type of metaphorical realisation of conjunction. At the primary level the coal texts evidenced the most consistent approximation to the deployment of conjunctive relations in the secondary texts. This was the case with one of the seasons texts and not at all with the primary sound texts.

Internal conjunction in the coal texts is minimal, with internal reformulation relating the IMPLICATION SEQUENCES to the Explanation Summary (In SCOAL1 the IMPLICATION SEQUENCES are simultaneously the reformulation of the Explanation Summary and the rhetorical means for the Conclusion to which they are linked by the internal conjunctive relation of manner:means). The texts are then organised by the external temporal: successive relations linking each element to the next within the IMPLICATION

SEQUENCES. This reflects the simple serial structure of the *Transformational: Linear Explanation*.

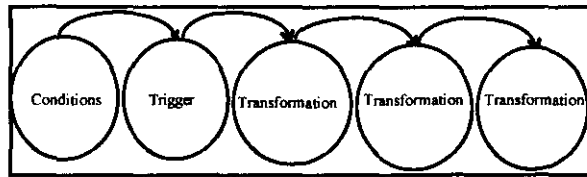


Figure 6.26 Serial structure of Transformational Linear Explanations

Within the Conditions, Trigger and Transformation elements, events are linked by external succession, consequence and simultaneity conflated with consequence.

In the sound texts, in addition to the sandwich structure of internal reformulation and internal consequence relating the IMPLICATION SEQUENCES as simultaneously the reformulation of the Phenomenon Exemplification and the rhetorical means for the Conclusion, internal consequence is also used both in linking elements within the IMPLICATION SEQUENCES and in linking events within those elements. In both of these contexts implication sequences related by external conjunction are collectively the rhetorical means for relating those events by external simultaneity/consequence to a reconstrual at a higher level of abstraction. The occurrence of this within the Compression element of the IMPLICATION SEQUENCES is shown in Figure 6.27.

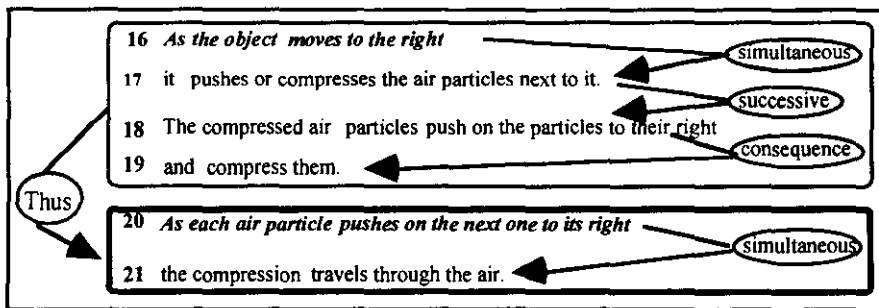


Figure 6.27 Orchestration of internal and external conjunction in reconstrual of events at a higher level of abstraction in a secondary sound text

Here 16-19 is the rhetorical means for relating by external simultaneity/ consequence, the same events, realised as 20, to a reconstrual at a higher level of abstraction in 21. In the same way the Compression and Rarefaction elements related by external succession, are collectively the rhetorical means for the progression to Seriation element, in which observable events are related to the abstract event complex by external simultaneity/consequence. This orchestration of external and internal conjunctive relations

in the progressive reconstrual of events at higher levels of abstraction is fundamental to this *Realisational* type of explanation and reflects the "nested" serial structure of the IMPLICATION SEQUENCES.

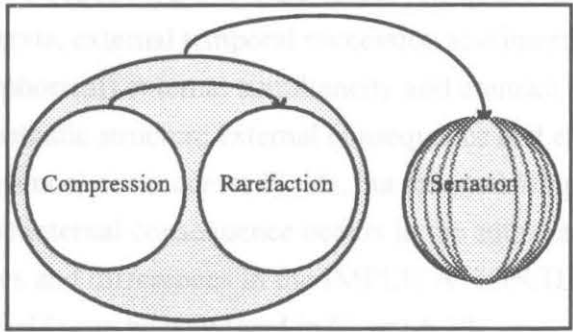


Figure 6.28 Nested serial structure of IMPLICATION SEQUENCES in an explanation of sound waves

Internal conjunction occurred most extensively in the seasons texts. Internal consequence occurred within elements of structure in the IMPLICATION SEQUENCES stage, where the causal relationship between events frequently had to be deduced on the basis of prior knowledge of intervening events in the causal chain, and where such event sequences were the rhetorical means for relating the results of orientational changes between the Earth's hemispheres and the sun to the commonsense experience of summer and winter. Conjunctive relations between elements of structure in the IMPLICATION SEQUENCES were (metaphorical) external simultaneity (not conflated with consequence) and external contrast, reflecting the more orbital structure of this *Oriental* explanation type.

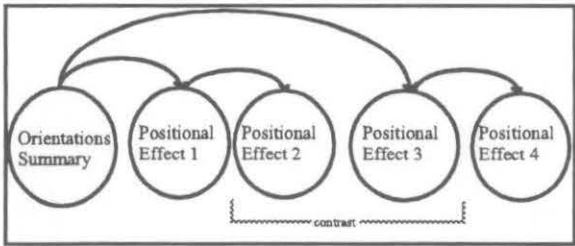


Figure 6.29 Orbital structure of IMPLICATION SEQUENCES in an explanation of the seasons

The organisation of the coal texts reflects mainly the unfolding of events over time, while the organisation of the sound texts involves the inter-relationship of the sequencing of events and rhetorical relations among events at different levels of abstraction, and the organisation of the seasons texts reflects the rhetorical development of sets of deductions first from events occurring simultaneously but under opposing conditions and then from the same simultaneous events under the reverse conditions. These differences are reflected

in the deployment of internal conjunction, which is minimal in the coal texts, more prominent in the sound texts and most extensive in the seasons texts. The differences are also reflected in the conjunctive relations linking elements of schematic structure in the IMPLICATION/DEDUCTION SEQUENCES stage. These are external temporal succession in the coal texts, external temporal succession and internal consequence in the sound texts, and (metaphorical) external simultaneity and contrast in the seasons texts. Within elements of schematic structure external consequence and external simultaneity (conflated with consequence) occur across Fields, but external temporal succession occurs only in coal texts, while internal consequence occurs in the sound and seasons but not coal texts. These similarities and differences in the IMPLICATION/DEDUCTION SEQUENCES across Fields can be compared in Figure 6.30.

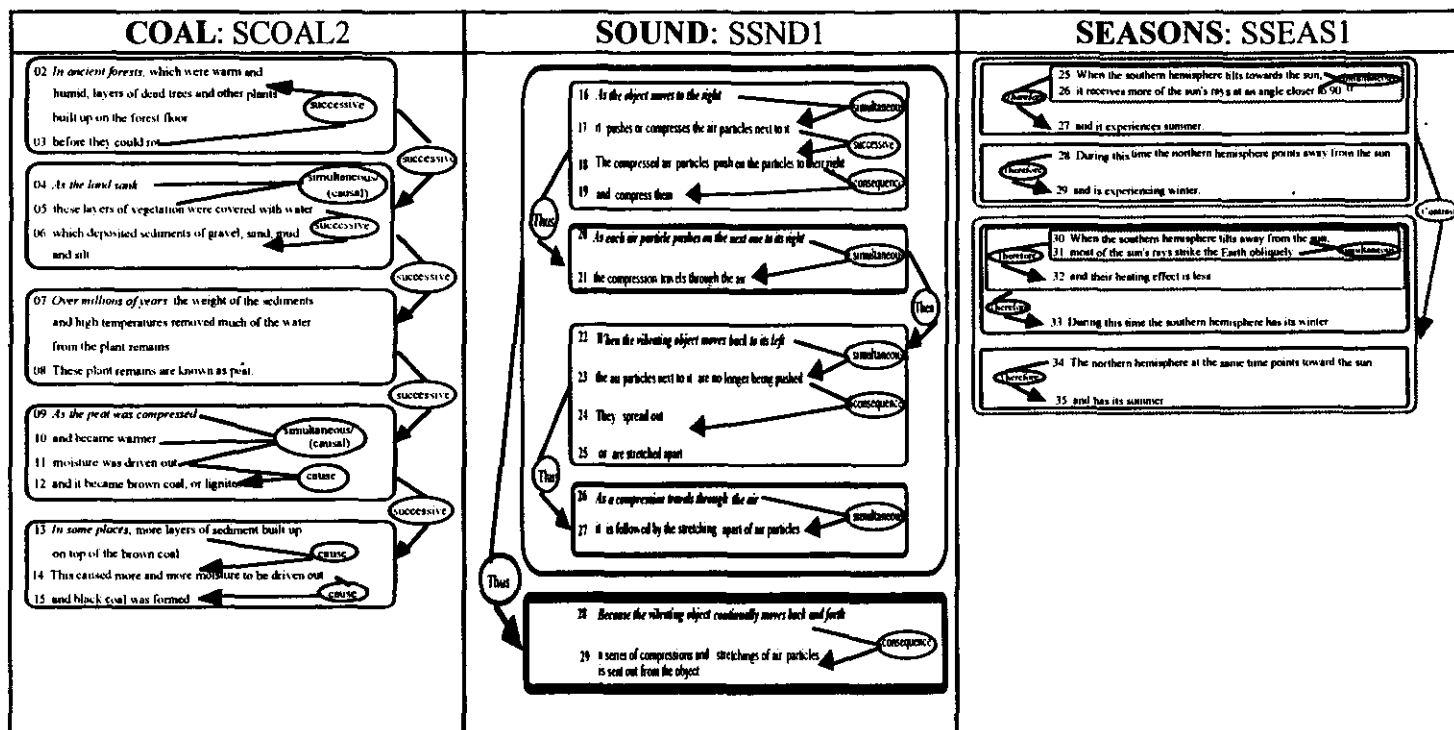


Figure 6.30 Comparison of conjunctive relations across Fields in secondary texts

The pattern of conjunctive relations in coal explanations was fairly consistent across the secondary texts, although the first coal text did include internal relations of concession and exemplification in the Conditions element and the "sandwiching" of the IMPLICATION SEQUENCES as a whole by the internal reformulation and internal consequential conjunctive relations (This "sandwich" structure also occurred in two of the Sounds texts but in none of the Seasons texts).

In both the Sound and the Seasons explanations, although there was some commonality, significant disparities in the deployment of conjunction occurred across the texts within each Field. The second two Sound texts for example, made less use of internal consequential relations and were therefore not as successful in the progressive reconstrual of technical events at higher levels of abstraction. The second two seasons texts also made less use of internal consequence and did not include the external simultaneity/consequence linking the inclination of the particular segment of the Earth's surface to the sun and the angle of incidence of the sun's rays to that segment, as did occur in SSEAS1 (Figure 6.31).

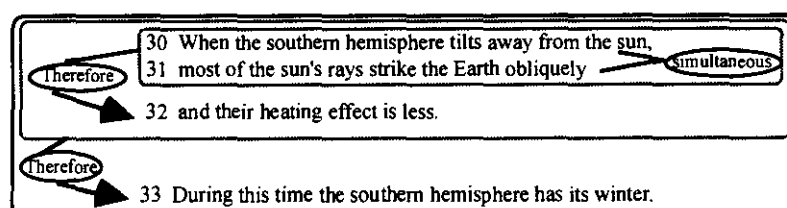


Figure 6.31 Pattern of internal and external conjunction in SSEAS1

These events and the external conjunctive relation between them are necessary for the construction of the subsequent logical deductions realised by internal consequential conjunction, linking the uncommonsense events to commonsense experience of the seasons.

The effect of Field on variation in the deployment of conjunctive relations across primary and secondary levels was not very great for the Coal texts but very substantial in the case of Sound and Seasons. In both primary and secondary coal texts external succession linked elements of schematic structure within the IMPLICATION SEQUENCES stage, but in two of the primary texts there were no external consequential relations *within* these elements of structure due to the minimisation of the inclusion of elaborative meanings. The deployment of conjunction in the primary Sound texts was markedly different from that in the secondary texts. In the primary texts there were no internal consequential relations at all and the external simultaneity related only to a shift in abstraction at the first level - from commonsense to unobservable technical events. Hence the use of conjunction in these texts did not permit the explanation of sound waves through the progressive reconstrual of congruent technical events at greater levels of abstraction. There was also considerable

variation in the use of conjunction in the IMPLICATION SEQUENCES across the primary texts in as indicated in Table 6.2. PSND1 used more consequential than temporal conjunction, while the reverse was the case for PSND2, and PSND3 used only metaphorical consequence.

Text	CRUs	Conjunctive relations			
		Temporal		Consequential	
		Congruent	Metaphorical	Congruent	Metaphorical
PSND1	10	4	0	1	4
PSND2	6	3	1	1	1
PSND3	2	0	0	0	1

Table 6.2 Variation in conjunction in IMPLICATION SEQUENCES in primary sound texts

Only one primary seasons text (PSEAS3) approximated the use of internal consequence and external simultaneity/consequence as evidenced in the secondary text SSEAS1 and shown in Figure 6.31 above. The comparison of the primary and secondary texts is shown again in Figure 6.32.

The first primary seasons text included more congruent external consequential relations focussed in the first part of the DEDUCTION SEQUENCES dealing with the Earth's inclination on its axis and its rotation causing differences in the length of days and nights. Internal consequence then occurred in the second part of the DEDUCTION SEQUENCES, where the seasons were distinguished in terms of the relative lengths of day and night at those times of the year. In the second primary seasons texts the reasoning in the DEDUCTION SEQUENCES was significantly masked by the use of embedding and metaphorical realisations and a reliance on the readers' inferring of consequential relations.

Metaphorical modes of reasoning in school science explanations were indicated in previous work (Shea:1988; Veel: in press a). However, as discussed in Chapter two, these studies did not address the relative incidence of the various divergent grammaticalizations of conjunction, nor their relative distribution with respect to Field, schematic structure or school level of the texts. The present study showed that, although the metaphorical realisation of conjunctive relations was quite variable within and across school levels in the sound and seasons texts, it was clearly deployed to a very minor extent in the coal texts, as indicated in Figure 6.33, showing the proportions of logical metaphor per clause in the primary and secondary texts.

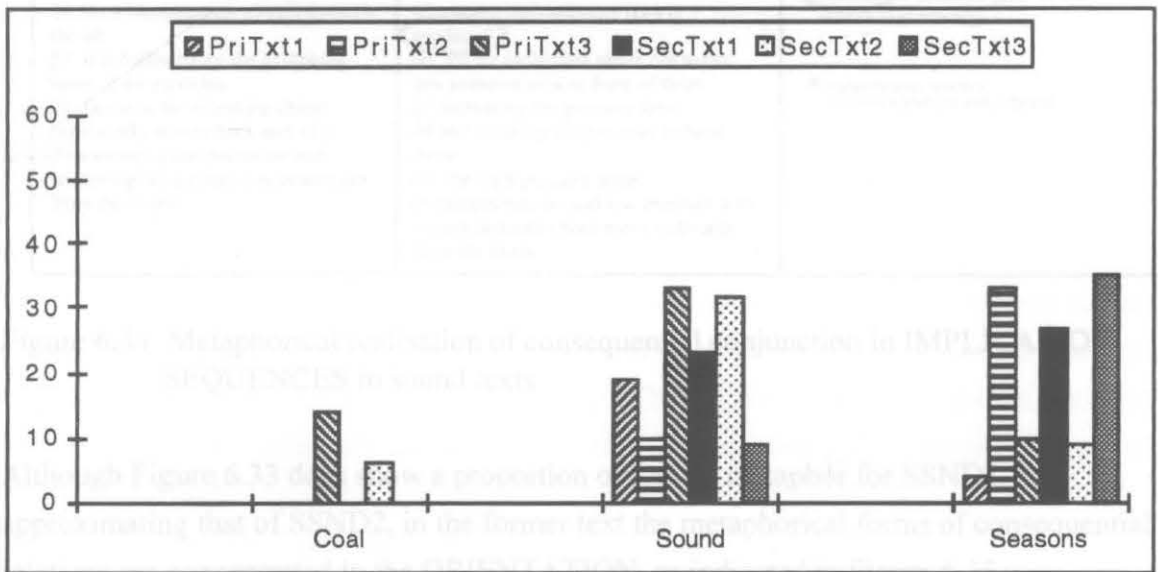


Figure 6.33 Proportions of logical metaphor across Fields

Metaphors dealing with external consequence were the most frequent in all texts, although metaphors dealing with external temporal relations also occurred in the sound and seasons texts. Metaphorical realisations of external contrast occurred in the seasons texts only.

In the sound texts which evidenced greater depth of treatment of the topic and greater delicacy of focus in the explication of the progressive reconstrual of technical events at greater levels of abstraction (SSND1, SSND3), the metaphorical realisations of consequence were confined to elements of structure in the ORIENTATION and did not occur in the IMPLICATION SEQUENCES. By contrast, those texts in which the depth of treatment was less and delicacy of focus grosser, such as SSND2 and the primary sound texts, the metaphorical realisations of consequence were also distributed in the IMPLICATION SEQUENCES, as indicated in Figure 6.34.

Secondary:SSND1	SecondarySSND2	PrimaryPSND1
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.	<i>Fig 8.31</i> <i>04a A hacksaw blade is clamped in a vice</i> <i>04b and plucked</i> <i>04c As the blade moves to the right (middle diagram)</i> <i>04d it compresses the air molecules</i> <i>04e producing a high pressure area in the direction of motion and a low pressure area on the other side</i> <i>04f As the blade flicks back (right diagram)</i> <i>04g a new high pressure area is produced on the left, a new low pressure one on the right.</i> <i>05 As the high pressure area is produced</i> <i>06 the air molecules move out to the low pressure area in front of them</i> <i>07 increasing the pressure there</i> <i>08 and reducing the pressure behind them.</i> <i>09 The high pressure areas (=compressions) and low pressure area (=rarefactions) both move outwards from the blade.</i>	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 20 * to move the next molecule]]. 21 They are called sound waves. 22 As the sound waves get weaker 23 the sound gets softer 24 until it disappears completely. 25 The strength of the initial vibration affects the distance [[the sound waves will travel]]. * EMBEDDING MASKS CONSEQUENTIAL RELATIONS

Figure 6.34 Metaphorical realisation of consequential conjunction in IMPLICATION SEQUENCES in sound texts

Although Figure 6.33 does show a proportion of logical metaphor for SSND1 approximating that of SSND2, in the former text the metaphorical forms of consequential relations are concentrated in the ORIENTATION, as indicated in Figure 6.35.

ORIENTATION	
Phenomenon Identification	What causes and transmits sounds?
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
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 or 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.
PHENOMENON EXEMPLIFICATION	15 Figure 15.1 shows a vibrating object [[producing sound waves]].

Figure 6.35 Metaphorical realisations of consequential conjunction in the ORIENTATION of SSND1

In the seasons texts the three which have the greatest proportion of logical metaphor as indicated in Figure 6.33, are also those which evidence the greatest depth of treatment of the topic. However the use of logical metaphor in the first secondary text (SSEAS1) contrasts with the common pattern of use in the second primary text (PSEAS2) and the third secondary text (SSEAS3). Metaphorical realisations of external contrast occur in the DEDUCTION SEQUENCES in PSEAS2 ("the opposite is true") and SSEAS3 ("The position is reversed each six months") to construct the reasoning for the occurrence of some of the seasons. However, in SSEAS1 the only metaphorical realisation of external contrast ("the reverse") occurred in the Conclusion element since the accounts of summer and winter in both hemispheres were all realised explicitly. This explicit account, which builds up to the metaphor in the summary element, seems more appropriate to less experienced primary readers. The higher proportion of logical metaphor associated with the greater depth of treatment in SSEAS1 is partially due to the greater use of metaphorical realisations of external simultaneity related to the explicit accounts of summer and winter in both hemispheres. The four occurrences of the external consequential metaphor "the heating effect" in SSEAS1, which is realised congruently in SSEAS3 also contributes to the comparatively high proportion of logical metaphor in the former text. Apart from "the heating effect", metaphorical realisations of external consequence clustered in the Explanation Summary element of the ORIENTATION stage in the seasons texts.

Distinctive patterns of conjunctive relations and logical metaphor scaffold the schematic structures of the three different types of explanation proposed. In each case different types

of conjunction linked elements of structure in the IMPLICATION/DEDUCTION SEQUENCES stage and different types of conjunction linked events within these elements of structure. Logical metaphor was much more associated with the *realisational* explanations of sound and the *orientational* explanations of the seasons than with the *linear transformational* explanations of coal formation. In the texts which explained sound waves in greatest depth, and in the seasons texts, the metaphorical realisations of consequential relations clustered in the ORIENTATION stage. While there was minimal metaphorical realisation of temporal succession in the IMPLICATION SEQUENCES of some of the sound texts, in the seasons texts there seemed to be a trade-off in the DEDUCTION SEQUENCES between explicit accounts of summer and winter in both hemispheres using metaphorical realisations of external simultaneity and implicit accounts using metaphorical realisations of external contrast.

The pattern of deployment of conjunction in coal texts was more consistent within and across school levels than was the case for the other two Fields. The lack of any external consequential relations in two of the primary sound texts does not result in any change from the schematic structure of the secondary texts, since in all texts at both levels, consequential relations occurred *within* elements of structure. The primary sound texts differed most from their secondary counterparts, all failing to include the patterns of conjunctive relations necessary to scaffold the explanation of sound waves through the progressive reconstrual of technical events at higher levels of abstraction. Only one primary seasons text, PSEAS3, approximated the pattern of conjunction in the secondary texts (PSEAS1 focussed on a different aspect of the Field - differing lengths of night and day, and PSEAS2 omitted a significant proportion of nuclear meanings).

6.1.4 "Depth" of explanation

It is not feasible to try to compare in general terms the depth of treatment of the explanations across Fields. What is clear from the semantic mapping of ideational meanings and comparison across texts within each Field is that there is wide variation in the depth of treatment within Fields at both secondary and primary levels. A comparison of the extent of this variation will be made to provide some idea of the relative variation across Fields. A further comparison will then be made of the effect of Field on variation in depth of treatment across school levels. The "depth" of treatment has also been considered from the perspective of the extent of literal accessibility of nuclear meanings within the text. A comparison across Fields, within and across school levels will also be made of this indicator.

At the secondary level one text in each Field dealt comprehensively with the nuclear meanings involved and at least one text provided a comparatively skeletal account. An idea of the similarity in variation across Fields can be obtained by comparing these extremes of within-Field variation. The extremes of within-Field variation for the secondary texts are shown in Figures 6.36 - 6.38. (Nuclear meanings are shown in thick dark lines, elaborative meanings in regular lines and meanings not included in the particular texts are indicated by faint lines.)

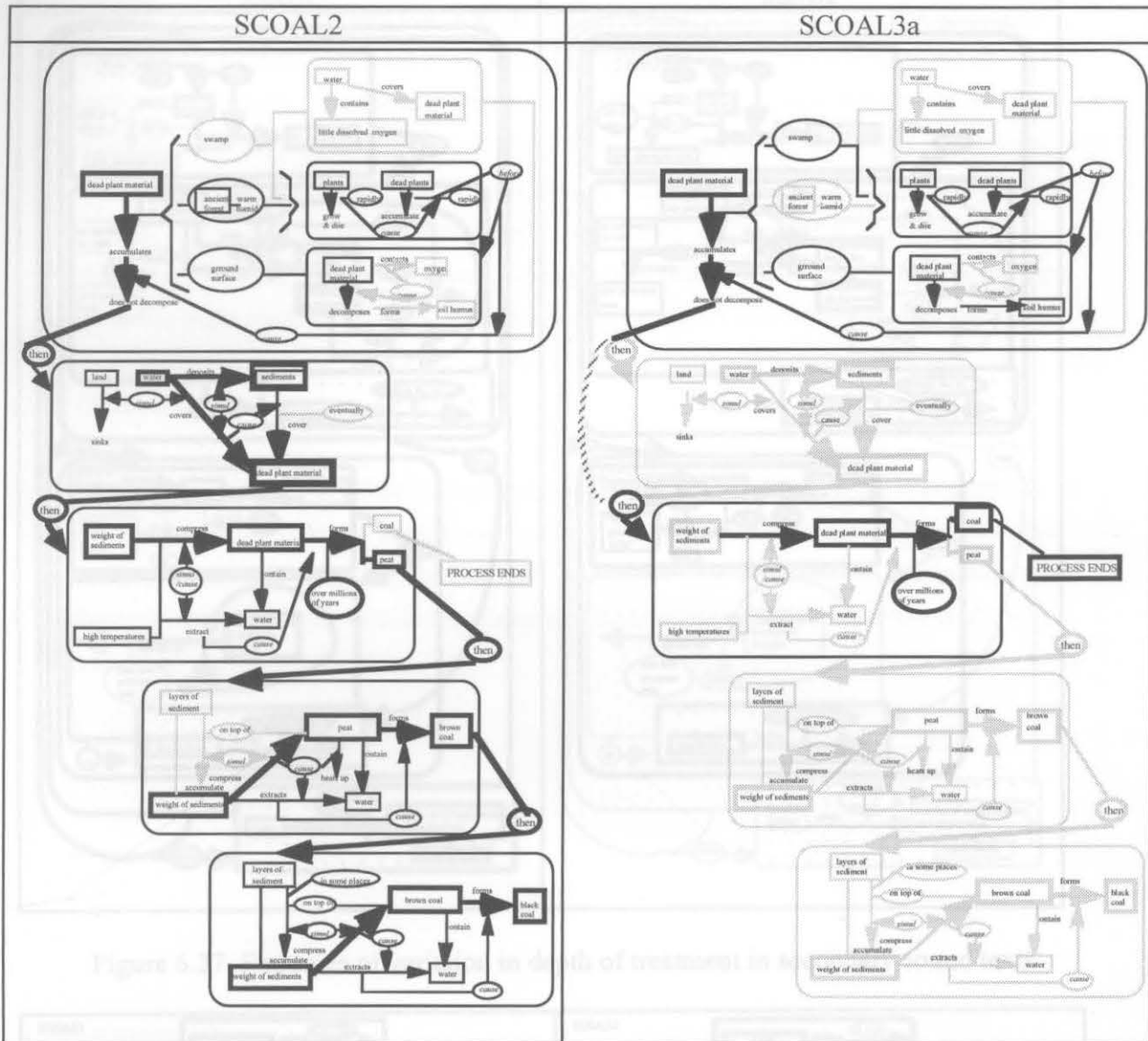


Figure 6.36 Extremes of variation in depth of treatment in secondary coal texts

Figure 6.38 Extremes of variations in depth of treatment in secondary sections texts

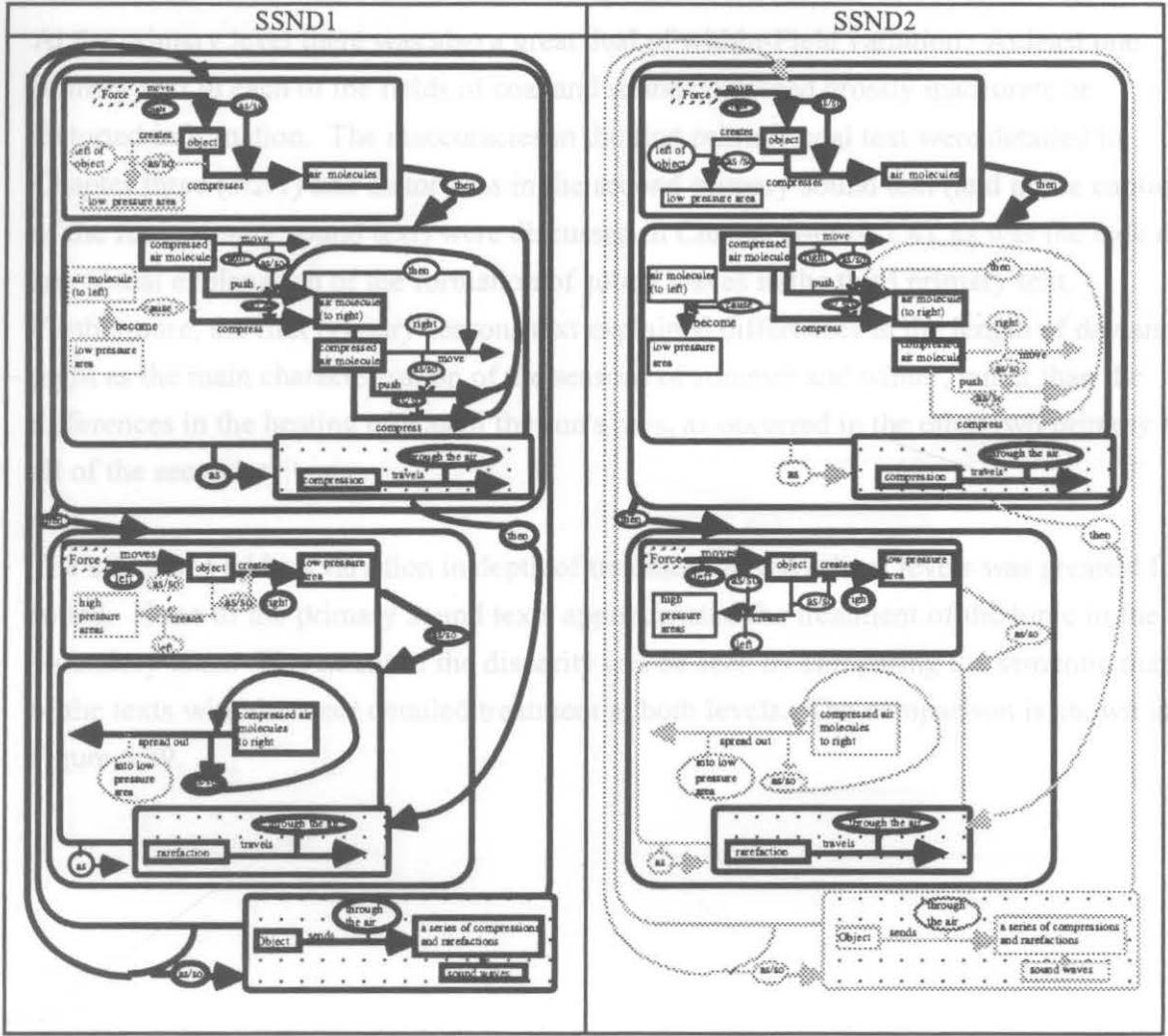


Figure 6.37 Extremes of variation in depth of treatment in secondary sound texts

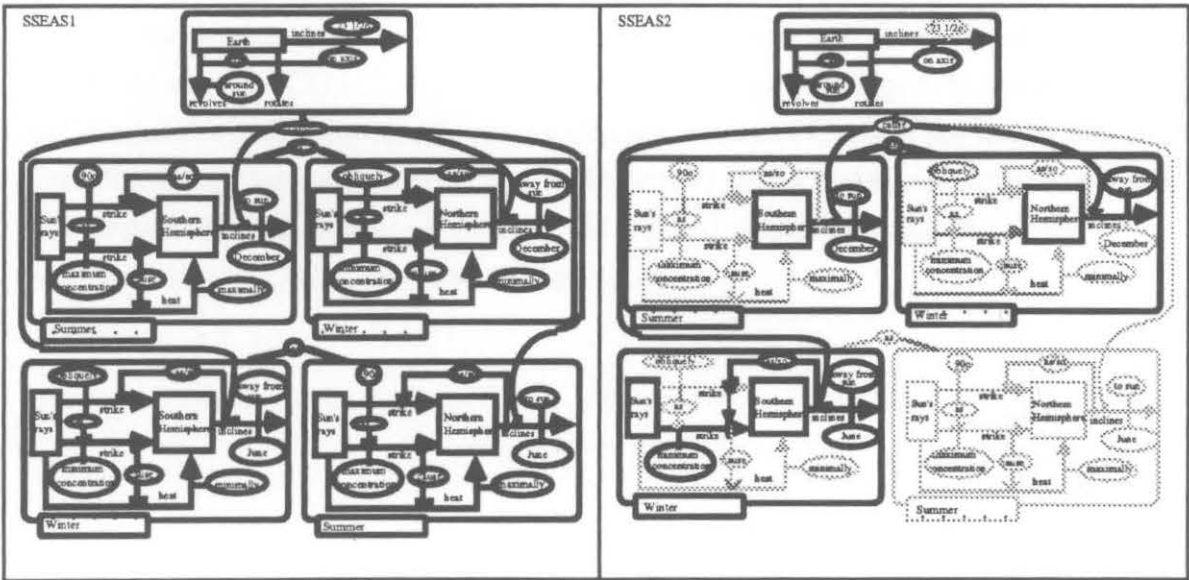


Figure 6.38 Extremes of variation in depth of treatment in secondary seasons texts

At the primary level there was also a great deal of within-Field variation. At least one primary text in each of the fields of coal and sound contained grossly inaccurate or distorted information. The inaccuracies in the first primary coal text were detailed in Chapter three (3.2.1) and distortions in the second primary sound text (and in the caption of the first primary sound text) were discussed in Chapter four (4.2.4), as was the lack of any actual explanation of the formation of sound waves in the third primary text. Furthermore, the first primary seasons text explained differences in the length of day and night as the main characterisation of the seasons of summer and winter, rather than the differences in the heating effects of the sun's rays, as occurred in the other two primary and all of the secondary texts.

The effect of Field on variation in depth of treatment across school levels was greatest for sound. None of the primary sound texts approximated the treatment of the topic in the secondary texts. The extent of the disparity can be seen by comparing the semantic maps of the texts with the most detailed treatment at both levels. The comparison is shown in Figure 6.39.

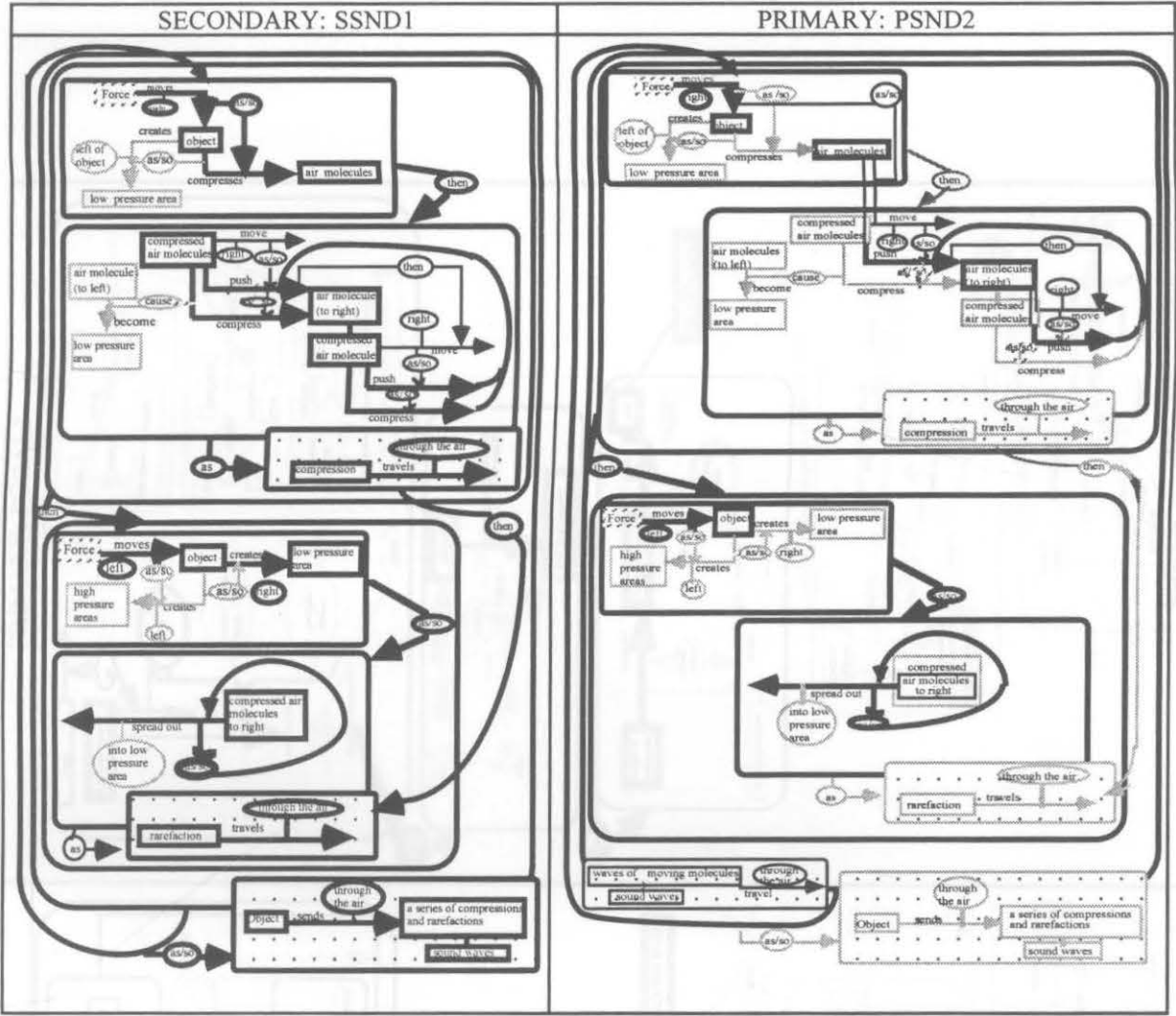


Figure 6.39 Greatest depth of treatment in primary and secondary sound texts

None of the primary coal texts included the extent of iteration of the Transform element which occurred in SCOAL2, and none included elaborated meanings to the extent of those in the secondary texts, however a comparison across school levels of the texts in which the Transformations were collapsed into a single element shows that the inclusion of nuclear meanings in PCOAL3 (and to a lesser extent (PCOAL2) approximated that of the secondary text SCOAL1, as shown in Figure 6.40.

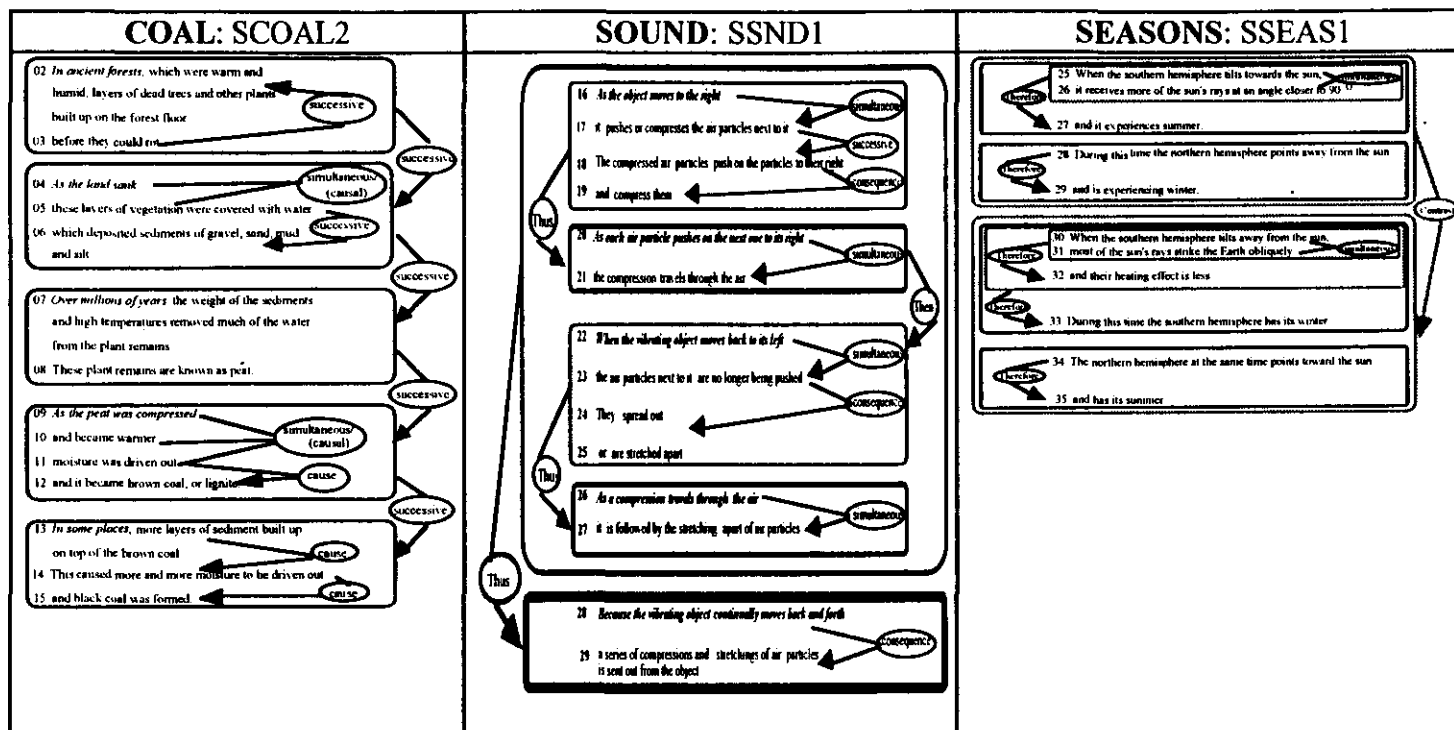


Figure 6.30 Comparison of conjunctive relations across Fields in secondary texts

The pattern of conjunctive relations in coal explanations was fairly consistent across the secondary texts, although the first coal text did include internal relations of concession and exemplification in the Conditions element and the "sandwiching" of the IMPLICATION SEQUENCES as a whole by the internal reformulation and internal consequential conjunctive relations (This "sandwich" structure also occurred in two of the Sounds texts but in none of the Seasons texts).

In both the Sound and the Seasons explanations, although there was some commonality, significant disparities in the deployment of conjunction occurred across the texts within each Field. The second two Sound texts for example, made less use of internal consequential relations and were therefore not as successful in the progressive reconstrual of technical events at higher levels of abstraction. The second two seasons texts also made less use of internal consequence and did not include the external simultaneity/consequence linking the inclination of the particular segment of the Earth's surface to the sun and the angle of incidence of the sun's rays to that segment, as did occur in SSEAS1 (Figure 6.31).

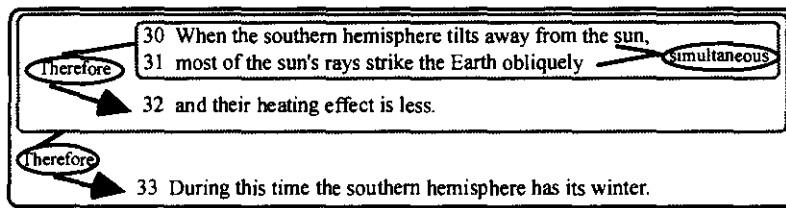


Figure 6.31 Pattern of internal and external conjunction in SSEAS1

These events and the external conjunctive relation between them are necessary for the construction of the subsequent logical deductions realised by internal consequential conjunction, linking the uncommonsense events to commonsense experience of the seasons.

The effect of Field on variation in the deployment of conjunctive relations across primary and secondary levels was not very great for the Coal texts but very substantial in the case of Sound and Seasons. In both primary and secondary coal texts external succession linked elements of schematic structure within the IMPLICATION SEQUENCES stage, but in two of the primary texts there were no external consequential relations *within* these elements of structure due to the minimisation of the inclusion of elaborative meanings. The deployment of conjunction in the primary Sound texts was markedly different from that in the secondary texts. In the primary texts there were no internal consequential relations at all and the external simultaneity related only to a shift in abstraction at the first level - from commonsense to unobservable technical events. Hence the use of conjunction in these texts did not permit the explanation of sound waves through the progressive reconstrual of congruent technical events at greater levels of abstraction. There was also considerable

variation in the use of conjunction in the IMPLICATION SEQUENCES across the primary texts in as indicated in Table 6.2. PSND1 used more consequential than temporal conjunction, while the reverse was the case for PSND2, and PSND3 used only metaphorical consequence.

Text	CRUs	Conjunctive relations			
		Temporal		Consequential	
		Congruent	Metaphorical	Congruent	Metaphorical
PSND1	10	4	0	1	4
PSND2	6	3	1	1	1
PSND3	2	0	0	0	1

Table 6.2 Variation in conjunction in IMPLICATION SEQUENCES in primary sound texts

Only one primary seasons text (PSEAS3) approximated the use of internal consequence and external simultaneity/consequence as evidenced in the secondary text SSEAS1 and shown in Figure 6.31 above. The comparison of the primary and secondary texts is shown again in Figure 6.32.

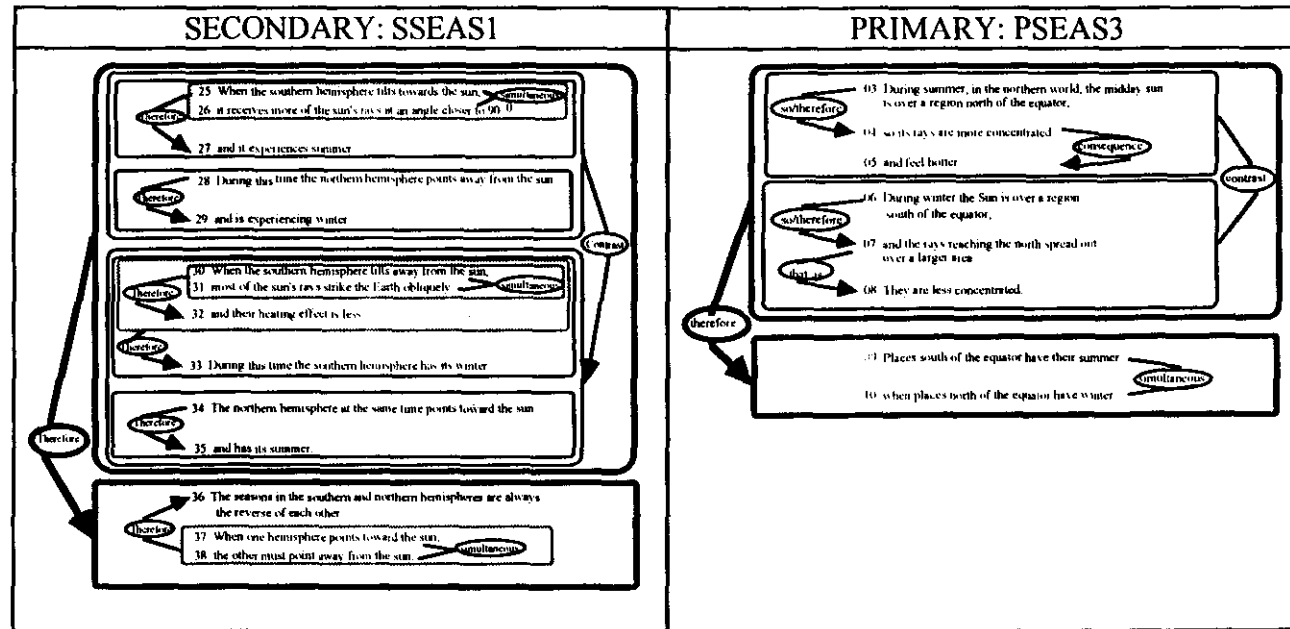


Figure 6.32 Comparison of conjunction in IMPLICATION SEQUENCES in SSEAS1 and PSEAS3

The first primary seasons text included more congruent external consequential relations focussed in the first part of the DEDUCTION SEQUENCES dealing with the Earth's inclination on its axis and its rotation causing differences in the length of days and nights. Internal consequence then occurred in the second part of the DEDUCTION SEQUENCES, where the seasons were distinguished in terms of the relative lengths of day and night at those times of the year. In the second primary seasons texts the reasoning in the DEDUCTION SEQUENCES was significantly masked by the use of embedding and metaphorical realisations and a reliance on the readers' inferring of consequential relations.

Metaphorical modes of reasoning in school science explanations were indicated in previous work (Shea:1988; Veel: in press a). However, as discussed in Chapter two, these studies did not address the relative incidence of the various divergent grammaticalizations of conjunction, nor their relative distribution with respect to Field, schematic structure or school level of the texts. The present study showed that, although the metaphorical realisation of conjunctive relations was quite variable within and across school levels in the sound and seasons texts, it was clearly deployed to a very minor extent in the coal texts, as indicated in Figure 6.33, showing the proportions of logical metaphor per clause in the primary and secondary texts.

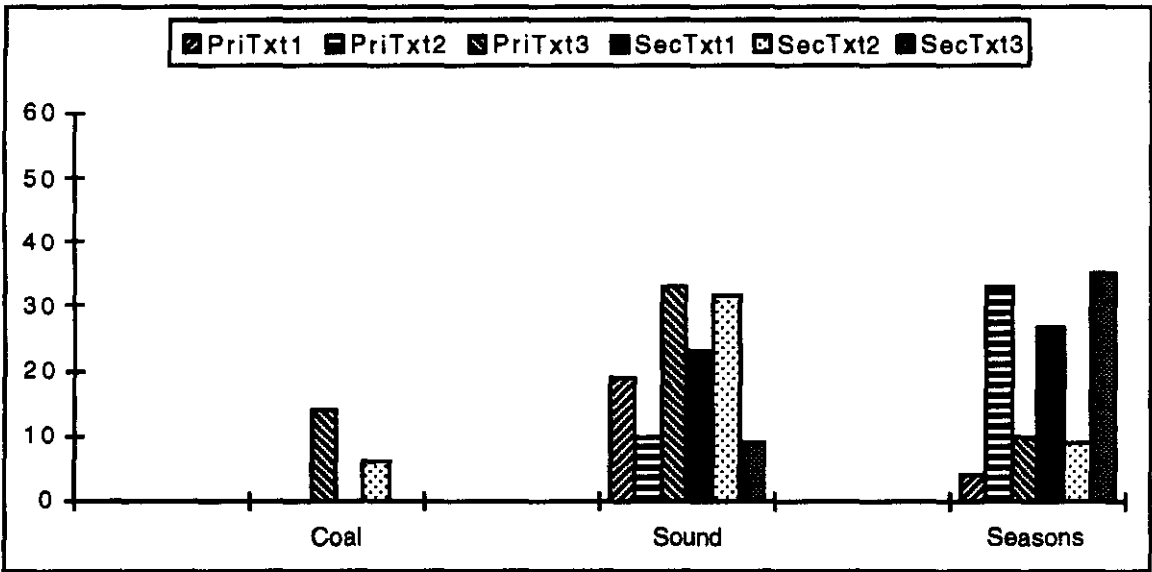


Figure 6.33 Proportions of logical metaphor across Fields

Metaphors dealing with external consequence were the most frequent in all texts, although metaphors dealing with external temporal relations also occurred in the sound and seasons texts. Metaphorical realisations of external contrast occurred in the seasons texts only.

In the sound texts which evidenced greater depth of treatment of the topic and greater delicacy of focus in the explication of the progressive reconstrual of technical events at greater levels of abstraction (SSND1, SSND3), the metaphorical realisations of consequence were confined to elements of structure in the ORIENTATION and did not occur in the IMPLICATION SEQUENCES. By contrast, those texts in which the depth of treatment was less and delicacy of focus grosser, such as SSND2 and the primary sound texts, the metaphorical realisations of consequence were also distributed in the IMPLICATION SEQUENCES, as indicated in Figure 6.34.

Secondary:SSND1	SecondarySSND2	PrimaryPSND1
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.	<i>Fig 8.31</i> <i>04a A hacksaw blade is clamped in a vice</i> <i>04b and plucked</i> <i>04c As the blade moves to the right (middle diagram)</i> <i>04d it compresses the air molecules</i> <i>04e producing high pressure area in the direction of motion and a low pressure area on the other side</i> <i>04f As the blade flicks back (right diagram)</i> <i>04g a new high pressure area is produced on the left, a new low pressure one on the right.</i> <i>05 As the high pressure area is produced</i> <i>06 the air molecules move out to the low pressure area in front of them</i> <i>07 increasing the pressure there</i> <i>08 and reducing the pressure behind them.</i> <i>09 The high pressure areas (=compressions) and low pressure area (=rarefactions) both move outwards from the blade.</i>	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]]. * EMBEDDING MASKS CONSEQUENTIAL RELATIONS

Figure 6.34 Metaphorical realisation of consequential conjunction in IMPLICATION SEQUENCES in sound texts

Although Figure 6.33 does show a proportion of logical metaphor for SSND1 approximating that of SSND2, in the former text the metaphorical forms of consequential relations are concentrated in the ORIENTATION, as indicated in Figure 6.35.

ORIENTATION	
Phenomenon Identification	What causes and transmits sounds?
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
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.
	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]].

Figure 6.35 Metaphorical realisations of consequential conjunction in the ORIENTATION of SSND1

In the seasons texts the three which have the greatest proportion of logical metaphor as indicated in Figure 6.33, are also those which evidence the greatest depth of treatment of the topic. However the use of logical metaphor in the first secondary text (SSEAS1) contrasts with the common pattern of use in the second primary text (PSEAS2) and the third secondary text (SSEAS3). Metaphorical realisations of external contrast occur in the DEDUCTION SEQUENCES in PSEAS2 ("the opposite is true") and SSEAS3 ("The position is reversed each six months") to construct the reasoning for the occurrence of some of the seasons. However, in SSEAS1 the only metaphorical realisation of external contrast ("the reverse") occurred in the Conclusion element since the accounts of summer and winter in both hemispheres were all realised explicitly. This explicit account, which builds up to the metaphor in the summary element, seems more appropriate to less experienced primary readers. The higher proportion of logical metaphor associated with the greater depth of treatment in SSEAS1 is partially due to the greater use of metaphorical realisations of external simultaneity related to the explicit accounts of summer and winter in both hemispheres. The four occurrences of the external consequential metaphor "the heating effect" in SSEAS1, which is realised congruently in SSEAS3 also contributes to the comparatively high proportion of logical metaphor in the former text. Apart from "the heating effect", metaphorical realisations of external consequence clustered in the Explanation Summary element of the ORIENTATION stage in the seasons texts.

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of conjunction linked elements of structure in the IMPLICATION/DEDUCTION SEQUENCES stage and different types of conjunction linked events within these elements of structure. Logical metaphor was much more associated with the *realisational* explanations of sound and the *orientational* explanations of the seasons than with the *linear transformational* explanations of coal formation. In the texts which explained sound waves in greatest depth, and in the seasons texts, the metaphorical realisations of consequential relations clustered in the ORIENTATION stage. While there was minimal metaphorical realisation of temporal succession in the IMPLICATION SEQUENCES of some of the sound texts, in the seasons texts there seemed to be a trade-off in the DEDUCTION SEQUENCES between explicit accounts of summer and winter in both hemispheres using metaphorical realisations of external simultaneity and implicit accounts using metaphorical realisations of external contrast.

The pattern of deployment of conjunction in coal texts was more consistent within and across school levels than was the case for the other two Fields. The lack of any external consequential relations in two of the primary sound texts does not result in any change from the schematic structure of the secondary texts, since in all texts at both levels, consequential relations occurred *within* elements of structure. The primary sound texts differed most from their secondary counterparts, all failing to include the patterns of conjunctive relations necessary to scaffold the explanation of sound waves through the progressive reconstrual of technical events at higher levels of abstraction. Only one primary seasons text, PSEAS3, approximated the pattern of conjunction in the secondary texts (PSEAS1 focussed on a different aspect of the Field - differing lengths of night and day, and PSEAS2 omitted a significant proportion of nuclear meanings).

6.1.4 "Depth" of explanation

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At the secondary level one text in each Field dealt comprehensively with the nuclear meanings involved and at least one text provided a comparatively skeletal account. An idea of the similarity in variation across Fields can be obtained by comparing these extremes of within-Field variation. The extremes of within-Field variation for the secondary texts are shown in Figures 6.36 - 6.38. (Nuclear meanings are shown in thick dark lines, elaborative meanings in regular lines and meanings not included in the particular texts are indicated by faint lines.)

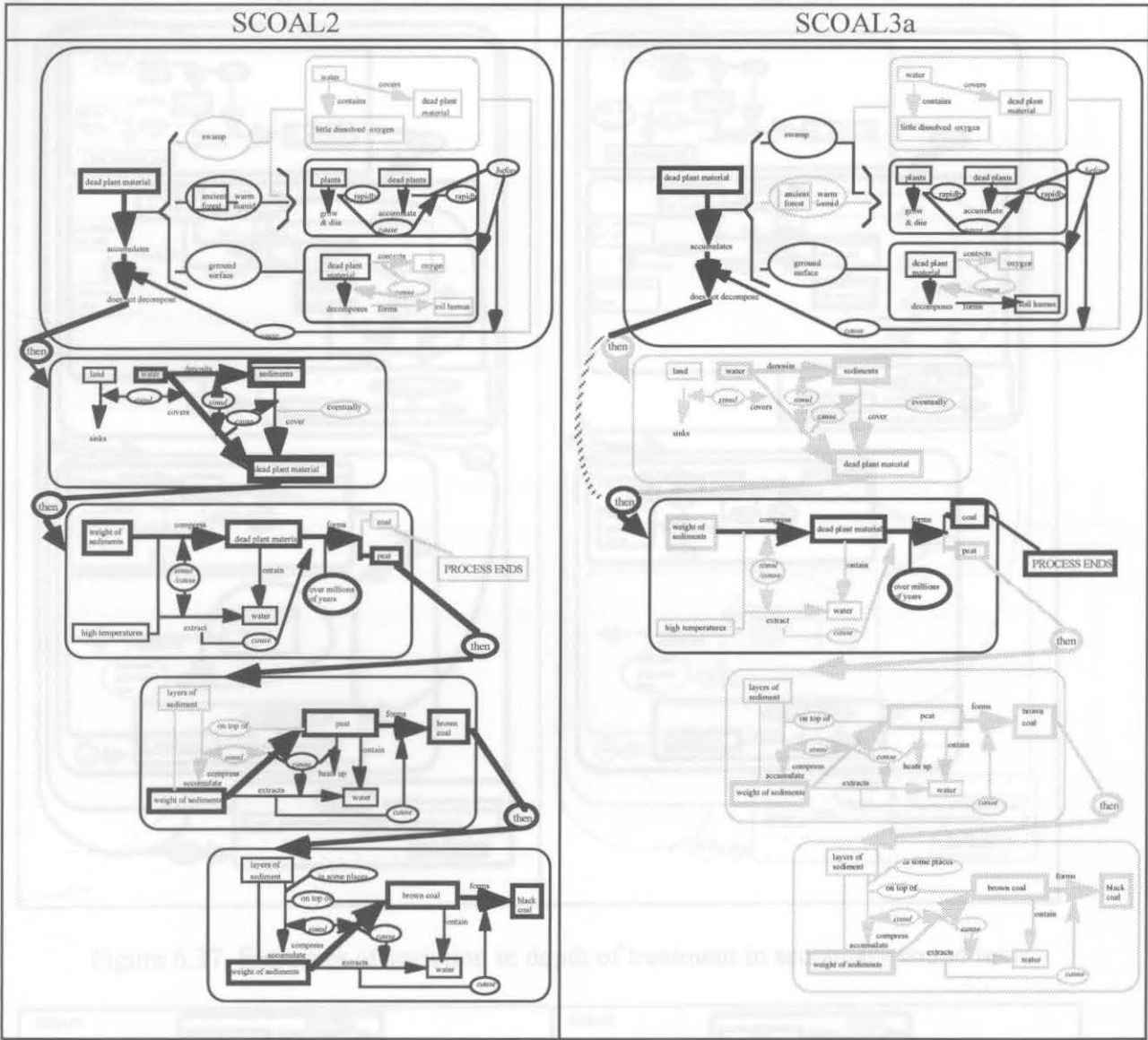


Figure 6.36 Extremes of variation in depth of treatment in secondary coal texts

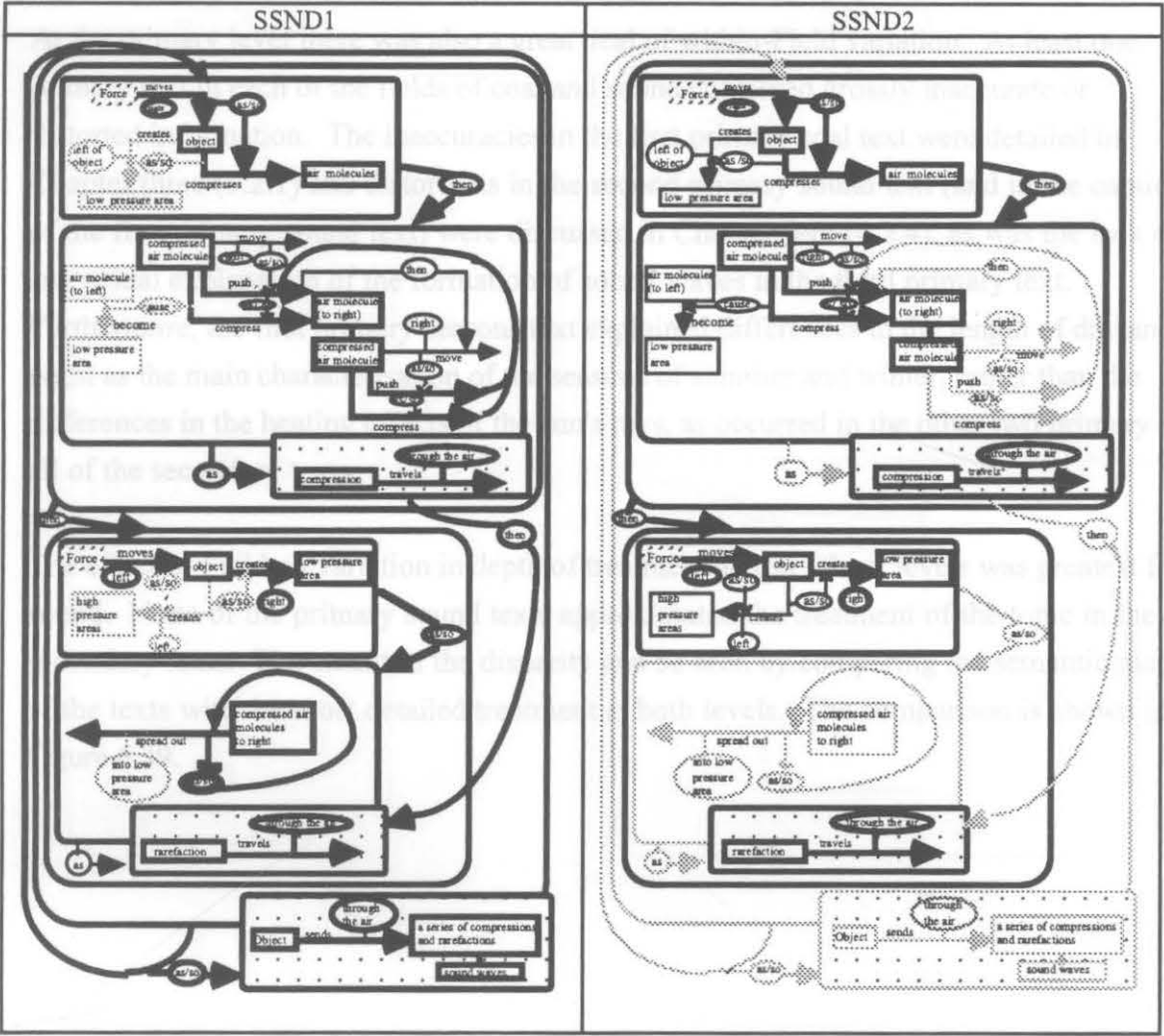


Figure 6.37 Extremes of variation in depth of treatment in secondary sound texts

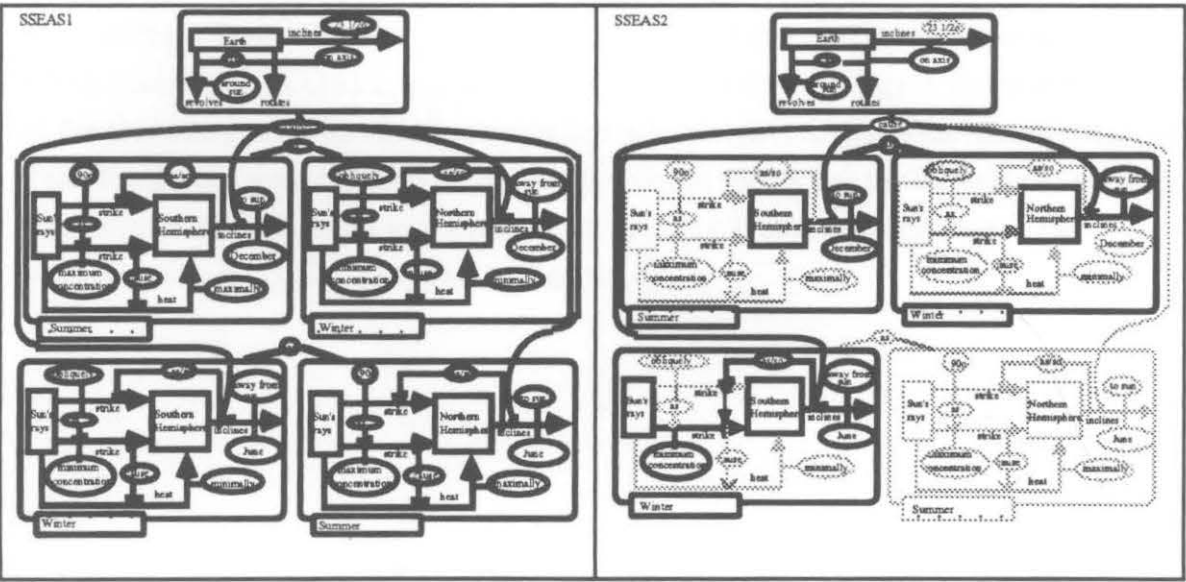


Figure 6.38 Extremes of variation in depth of treatment in secondary seasons texts

At the primary level there was also a great deal of within-Field variation. At least one primary text in each of the fields of coal and sound contained grossly inaccurate or distorted information. The inaccuracies in the first primary coal text were detailed in Chapter three (3.2.1) and distortions in the second primary sound text (and in the caption of the first primary sound text) were discussed in Chapter four (4.2.4), as was the lack of any actual explanation of the formation of sound waves in the third primary text. Furthermore, the first primary seasons text explained differences in the length of day and night as the main characterisation of the seasons of summer and winter, rather than the differences in the heating effects of the sun's rays, as occurred in the other two primary and all of the secondary texts.

The effect of Field on variation in depth of treatment across school levels was greatest for sound. None of the primary sound texts approximated the treatment of the topic in the secondary texts. The extent of the disparity can be seen by comparing the semantic maps of the texts with the most detailed treatment at both levels. The comparison is shown in Figure 6.39.

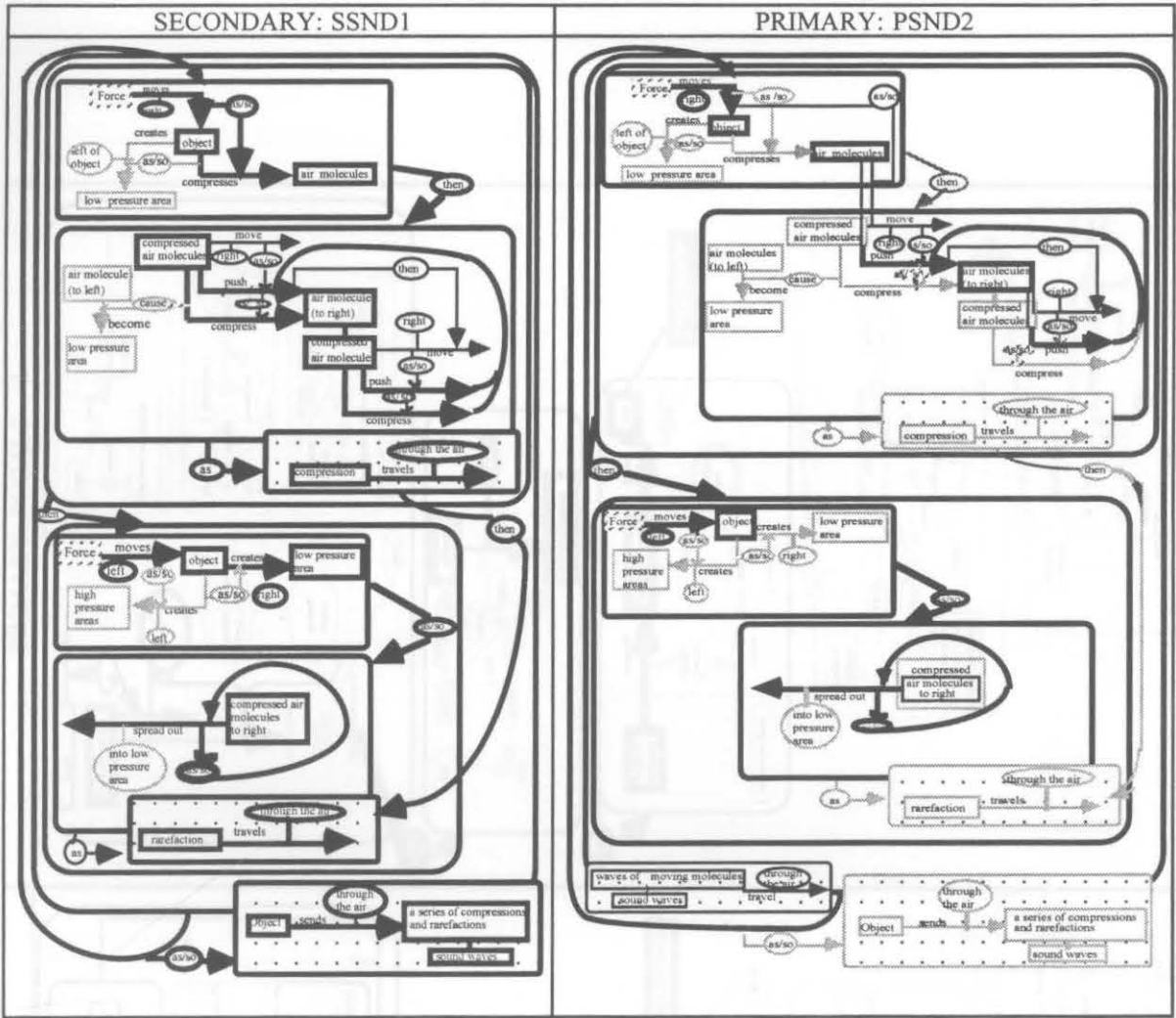


Figure 6.39 Greatest depth of treatment in primary and secondary sound texts

None of the primary coal texts included the extent of iteration of the Transform element which occurred in SCOAL2, and none included elaborated meanings to the extent of those in the secondary texts, however a comparison across school levels of the texts in which the Transformations were collapsed into a single element shows that the inclusion of nuclear meanings in PCOAL3 (and to a lesser extent (PCOAL2) approximated that of the secondary text SCOAL1, as shown in Figure 6.40.

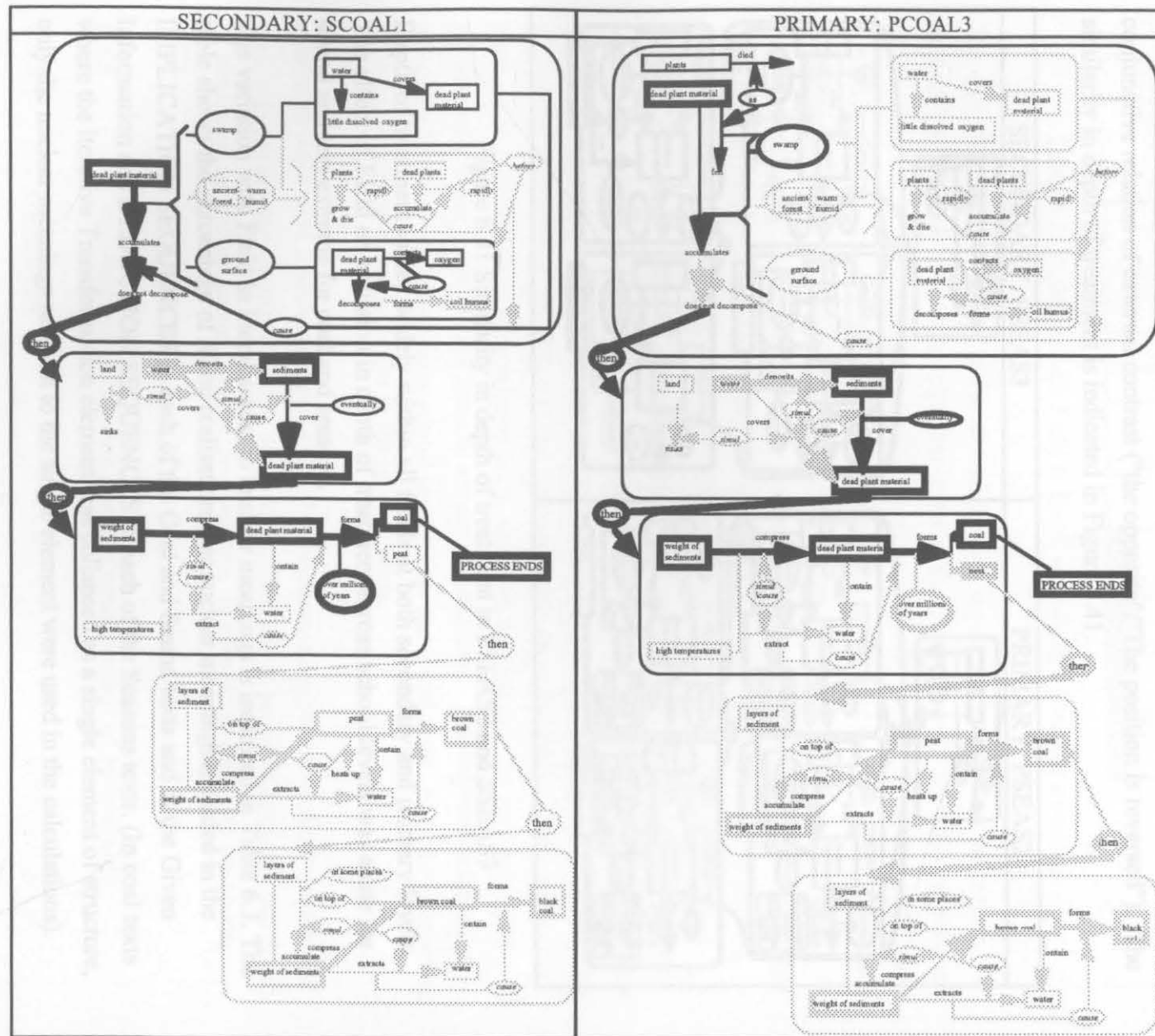


Figure 6.40 Similarity in depth of treatment in SCOAL1 and PCOAL3

Again, none of the primary seasons texts approximated the comprehensive account of nuclear meanings in SSEAS1 in which summer and winter in both hemispheres were dealt with explicitly, but there was some similarity in depth of treatment between PSEAS2 and SSEAS3 in which summer and winter in one hemisphere are dealt with explicitly and in the other hemisphere are constructed by text reference and the metaphorical realisation of the conjunctive relation of external contrast ("the opposite"/"The position is reversed"). The similarity in depth of treatment is indicated in Figure 6.41.

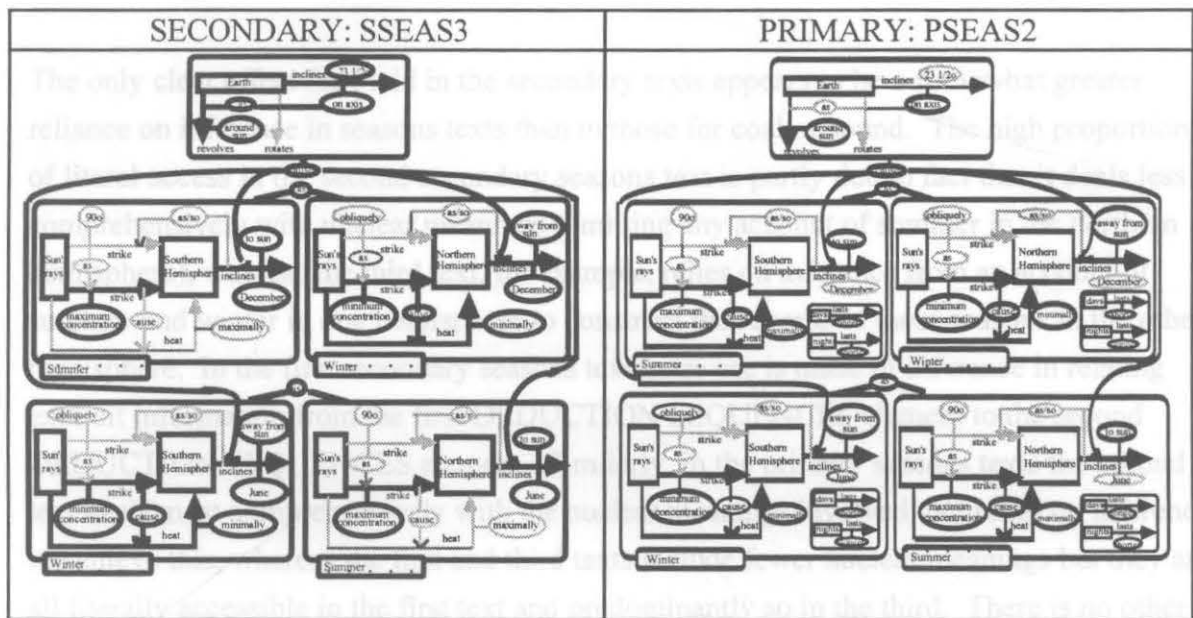


Figure 6.41 Similarity in depth of treatment in PSEAS2 and SSEAS3

Depth of treatment varied widely within all fields at both secondary and primary levels. The effect of Field on variation in depth of treatment across school levels was acute for sound and less extreme for coal and seasons.

The variation with Field in literal access to nuclear meanings is indicated in Table 6.3. The table shows the percentage of literal realisations per nuclear meanings included in the IMPLICATION SEQUENCES in each of the Coal and Sound texts and in the Given Information and DEDUCTION SEQUENCES in each of the Seasons texts. (In coal 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).

	Texts	COAL	SOUND	SEASONS
Primary	1	60	69	100
	2	77	67	64
	3	71		79
Secondary	1	86	85	65
	2	75	83	87
	3	90	76	43
	3b	68		

Table 6.3 Variation with Field in literal realisation of nuclear meanings

The only clear effect for Field in the secondary texts appears to be a somewhat greater reliance on inference in seasons texts than in those for coal or sound. The high proportion of literal access in the second secondary seasons text is partly due to fact that it deals less comprehensively with nuclear meanings (omitting any account of summer in the northern hemisphere), whereas the third text, for example, relies on inference from an account of summer and winter in one hemisphere to construct the reverse of these seasons in the other hemisphere. In the first secondary seasons text more use is made of inference in relating explicit information from the first DEDUCTION SEQUENCES element to the second DEDUCTION SEQUENCES element. Similarly, in the primary seasons texts the second text deals most comprehensively with the nuclear meanings involved, but relies on inference to achieve this, whereas the first and third texts include fewer nuclear meanings but they are all literally accessible in the first text and predominantly so in the third. There is no other clear effect for Field within the primary texts, although the first primary coal text has a significantly lower proportion of literally accessible meanings. The only indication of an effect for Field on variation across school levels is for the sound texts. Here the proportion of literal access seems to be lower in the primary texts.

Although there were inaccuracies and a heavy reliance on inference in the first primary coal text, it is the primary sound texts that are most problematic in terms of accuracy and depth of treatment, as well as greater reliance on inference, in comparison with the secondary texts.

6.1.5 Grammatical realisation and the construction of technicality

6.1.5.1 Transitivity

The major effect of Field on transitivity selections is the low proportion of Material processes and high proportion of Relational: attributive processes in the seasons texts compared with the dominance of Material processes and low proportion of Relational:

attributive processes in the other two Fields. The variation in the proportion of Material processes across Fields is indicated in Figure 6.42.

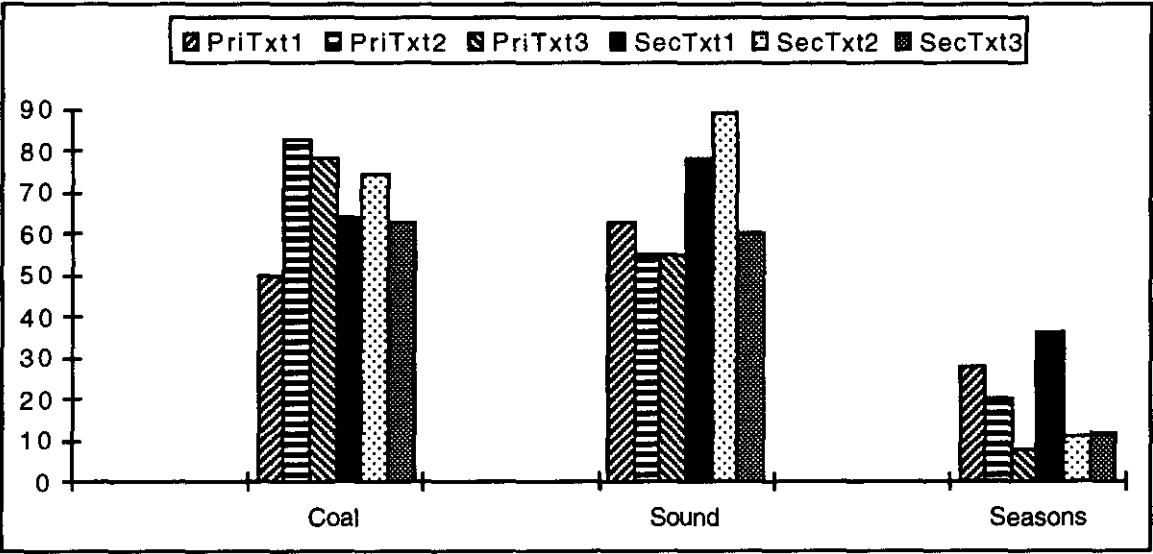


Figure 6.42 Variation in the proportion of Material processes across Fields

In the coal and sound texts the proportions of effective and middle Material processes were comparable, and in both Fields the proportion of effective processes was higher, as shown in Figure 6.3a in Appendix 6 (The aberrant selection of a greater proportion of middle Material processes in the third primary coal text was discussed in Chapter three (3.2.5.1)) . But while in the coal texts the proportions of effective Material processes in the IMPLICATION SEQUENCES were fairly consistent across texts and school levels, this was not the case for the sound texts, as indicated in Figure 6.43.

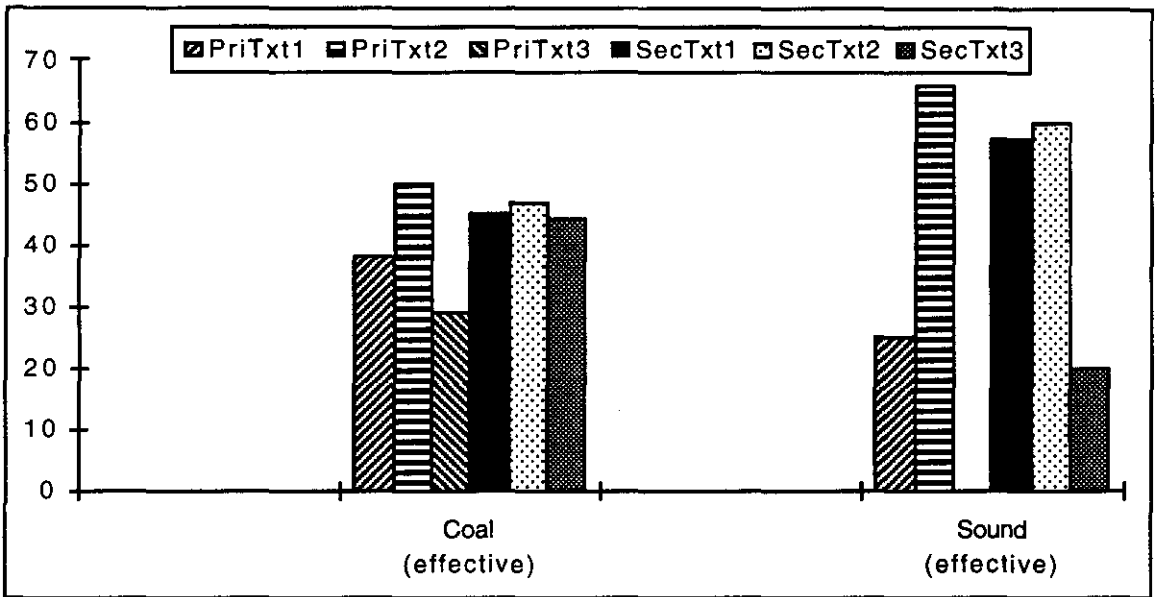


Figure 6.43 Proportion of effective Material processes per total number of processes in IMPLICATION SEQUENCES in coal and sound texts.

The absence of effective Material processes in the third primary text reflects its minimal explanation of sound waves in an IMPLICATION SEQUENCES element consisting of two clauses;

- 03 These ripples are called "sound waves"
 04 and are caused by [[the air vibrating]]. (PSND3)

The low proportion in the first primary text and the third secondary text is partly due to their more commonsense orientation to the Field. This is reflected in greater use of, frequently anthropomorphic, lexical metaphors, which involve middle Material and Relational: attributive processes. This can be seen in the use of the middle Material process "bounce" in SCOAL3 and Relational: attributive processes in clauses 19 and 21 in PSND1:

- 11 The particles of air are pushed outwards
 12 crowding against and bashing into their neighbours
 13 before they bounce back. (SSND3)

- 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..... (PSND1)

Although the proportion of effective Material processes in the second primary text and the first and second secondary texts are comparably high, the actual number and the lexical items are quite different across texts, reflecting quite different orientations to the construction of technicality in each case. The variation in the selection of effective Material processes in these texts can be seen in Table 6.4.

Primary - PSND2	Secondary - SSND1	Secondary - SSND2
squash or press together squashes producing is passed	pushes or compresses push on compress pushes on are being pushed are stretched apart is sent out	compresses producing is produced is produced increasing reducing

Table 6.4 Effective Material processes in IMPLICATION SEQUENCES in PSND1, SSND1 and SSND2

In the primary text the processes are fewer and more commonsense in orientation, so that the events are realised in less detail and less technically. The process "producing" is also a metaphorical realisation of consequential conjunction, further limiting the delicacy of focus in the construction of technicality. Half of the effective Material processes in SSND2 also realise this metaphorical consequential conjunctive relation, again resulting in this decreased delicacy of focus in the construction of technicality, as indicated in section 6.3 above. In the sound texts then, variation in the proportion of effective Material processes in the IMPLICATION SEQUENCES, as well as variation in the lexical choices and the extent to which the processes were metaphorical realisations of conjunctive relations, affected the extent and delicacy of focus of the construction of technicality. On the other hand, in the coal texts, as noted in relation to Figure 6.43, the only substantial variation in the proportion of effective Material processes was that in the third primary text. There were only two instances of the metaphorical realisation of consequential conjunction in the IMPLICATION SEQUENCES across all of the texts (one in SCOAL1 and one in PCOAL3). But there were differences in the lexical choices of the effective Material processes which affected the relative technicality of the texts, as discussed in Chapter three and illustrated in Table 3.8.

The distribution of effective and middle Material processes in the IMPLICATION SEQUENCES in the coal and sound texts is also related to the differences in the deployment of conjunction in these texts, again reflecting them as examples of different explanation types. Firstly, it should be noted that the middle Material processes are much more concentrated in the initial element of the IMPLICATION SEQUENCES in the coal texts, whereas in the sound texts they are more evenly distributed throughout. This is

exemplified in Figure 6.44 showing the IMPLICATION SEQUENCES for SCOAL2 and SSND1.

Secondary: SCOAL2	Secondary:SSND1
2 In ancient forests, <<2.1>>layers of dead trees and other plants built up on the forest floor	16 As the object moves to the right
2.1 <<which were warm and humid>> before they could rot.	17 it pushes or compresses the air particles next to it.
4 As the land sank	18 The compressed air particles then push on the particles to their right
5 these layers of vegetation were covered with water	19 and compress them.
6 which deposited sediments of gravel, sand, mud and silt.	20 As each air particle pushes on the next one to its right
7 Over millions of years the weight of the sediments and high temperatures removed much of the water from the plant remains.	21 the compression travels through the air.
8 These plant remains are known as peat.	22 When the vibrating object moves back to its left
9 As the peat was compressed	23 the air particles next to it are no longer being pushed.
10 and became warmer	24 They spread out
11 moisture was driven out	25 or are stretched apart
12 and it became brown coal, or lignite.	26 As a compression travels through the air
13 In some places, more layers of sediment built up on top of the brown coal.	27 it is followed by the stretching apart of air particles.
14 This caused more and more moisture to be driven out	28 Because the vibrating object continually moves back and forth
15 and black coal was formed.	29 a series of compressions and stretchings of air particles is sent out from the object.

Figure 6.44 Distribution of middle Material processes in IMPLICATION SEQUENCES in SCOAL2 and SSND1

In both texts a middle Material process begins the sequence of middle followed by effective processes.

04 As the land sank (SCOAL2)

16 As the object moves to the right (SSND1)

These indicate the point from which grammaticalization of causality through agency is relevant to the explanation. What caused the land to sink or the object to move to the right is not significant to the progression of the explanation at hand, but from this point on agency is crucial in the construction of the causal chain. In the coal text the sequence of events linked by external conjunctive relations of consequence or simultaneity conflated with consequence is always from those realised by middle Material processes to those realised by effective processes and from effective to effective processes. There is never such a link from events realised by effective material processes leading to those realised by middle material processes. This is illustrated in Figure 6.45, showing the progression in IMPLICATION SEQUENCES in SCOAL2 (Middle Material processes are circled and effective Material processes are boxed).

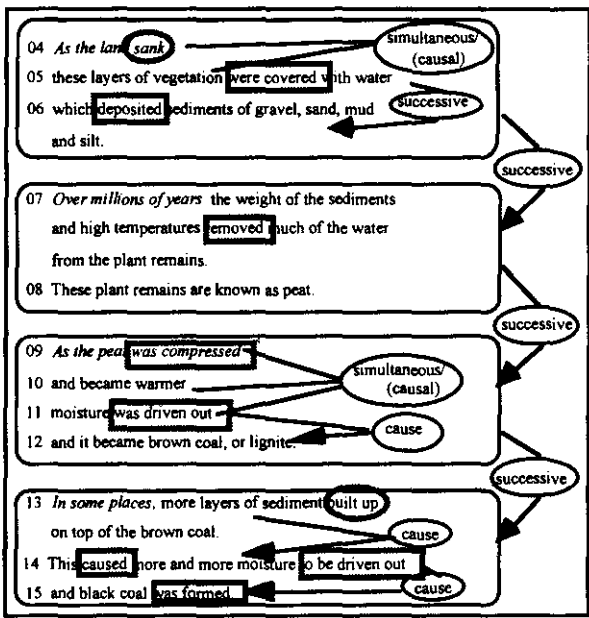


Figure 6.45 Progression from middle to effective Material processes in IMPLICATION SEQUENCES in SCOAL2

On the other hand in the sound text, as discussed in Chapter four (4.1.5.1), effective Material clauses form an "agentive chain" linking a commonsense observable event realised by a middle Material clause to a metaphorical macro technical event realised again by a middle Material clause. This is illustrated again in Figure 6.46, showing the first element in the IMPLICATION SEQUENCES in SSND1.

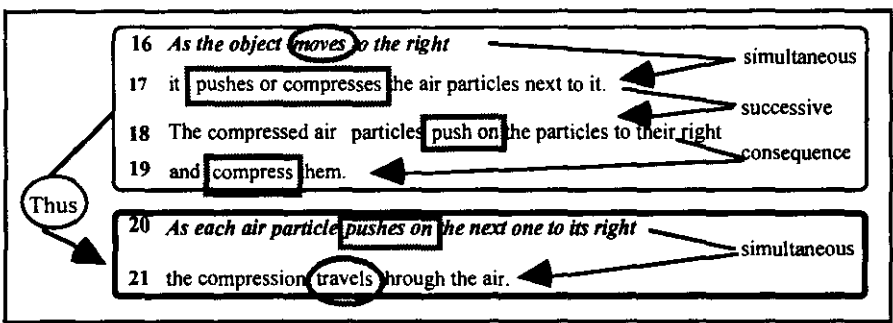


Figure 6.46 Agentive chain in SSND1: Effective Material processes as "links" between middle Material processes

The linking of the effective Material clause 20 to the middle Material clause 21 by external simultaneity/consequence, in fact constructs a kind of Value/Token relationship between the two clauses, so that 21 is a more abstract reconstrual of 20, which is actually a summary of 17-19. The internal consequential conjunctive relation constructs 16-19 as the rhetorical means for this reconstrual. This combined patterning of transitivity and conjunction (and grammatical metaphor in the nominalisation "compression") suggest a

distinctive deployment of resources characteristic of these *realisational* explanations, whereas *transformational* explanations, such as the coal text, are characterised by external consequence and simultaneity/consequence linking from middle to effective or effective to effective clauses without the use of internal conjunction or grammatical metaphor.

In the secondary seasons texts few Material processes occurred in the DEDUCTION SEQUENCES and those that did were effective, while middle Material clauses were focussed in the Given Information. The somewhat higher proportion of material processes in the first of the secondary seasons texts is due partly to the Material processes in the Analogic Account. The pattern was similar for the primary texts except that some of the small proportion of Material processes in DEDUCTION SEQUENCES were middle.

Relational: attributive processes dominated the seasons texts at both school levels, occurred much less frequently in the coal texts and were in the lowest proportions in the sound texts. The variation in the proportions of Relational: attributive processes with Field is shown in Figure 6.47.

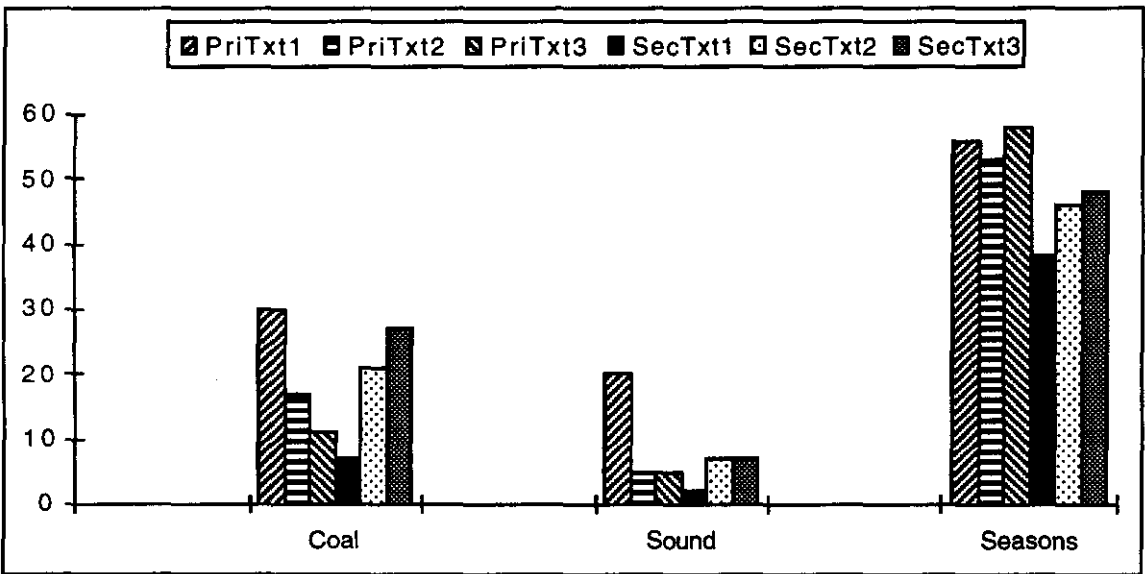


Figure 6.47 Variation in the proportion of Relational: attributive processes across Fields

In the seasons texts the Relational: attributive processes also dominate the DEDUCTION SEQUENCES. In Chapter five (5.2.5.1) it was shown that the DEDUCTION SEQUENCES potentially included four elements dealing with winter and summer in the northern and southern hemispheres and each of these elements progressed through a number of steps. Not all of the elements, nor all steps in these elements, were included in all texts. Furthermore, some of the steps were realised explicitly and some needed to be inferred, and the pattern of explicit and inferential realisation also varied across texts.

However each of the steps were characterised by particular distributions of process types and within the steps there was little variation in the grammatical realisation across primary and secondary texts. This patterning of process selection is summarised again in Table 6.5.

STEPS	MEANINGS	PROCESS SELECTIONS	REALIZATIONS
1 Contextual STATE	Inclination of particular hemispheres to the sun	Relational: Intensive: Attributive Relational: Circumstantial: Attributive	the southern hemisphere is inclined towards the sun in December (SEAS1) the southern hemisphere tilts towards the sun (SSEAS1)
2 Simultaneous EVENT	Sun's rays strike the Earth's surface at an oblique or perpendicular angle	Material: effective	it receives more of the sun's rays at an angle closer to 90 0 (SSEAS1)
3 Consequential STATE	Sun's rays are concentrated or spread out at the Earth's surface	Relational: Intensive: Attributive Relational: Possessive: Attributive	they are spread over a larger area (SSEAS1) The area further away from the Sun has fewer rays for a given area (SSEAS3)
4 Consequential EVENT	Ray's heating effect is relatively high or low (Relatively more or fewer light rays from the sun are absorbed by the Earth and converted to heat energy)	Relational: Intensive: Attributive	the heating effect is less (SSEAS1)
5 Consequential Behavioural EVENT	Particular hemispheres experience summer or winter	Behavioural	and it experiences summer (SSEAS1) During this time the southern hemisphere has its winter (SSEAS1)

Table 6.5 Process selections in elements in DEDUCTION SEQUENCES in seasons texts

Here there is really only one event - the sun's rays striking the Earth (The conversion of light energy to heat energy is not actually dealt with as an event sequence but the result is realised as an Attribute ("less") of a metaphorical Thing - "the heating effect.."). The steps involved in the explanation of summer and winter in both hemispheres are concerned with the same event but at different times at which the orientation of particular hemispheres to the sun is also different. So the role of the Relational: attributive processes is firstly to construct these orientations. They then describe the attributes (more concentrated; spread out) of the participants in the events (the sun's rays) as the orientations change, and the resulting attributes of the hemisphere concerned (cooler; hotter).

There are very few instances in any of the DEDUCTION SEQUENCES in which contiguous steps are explicitly realised. Hence the progression from one step to the next, where the intervening step(s) is/are omitted, involves reasoning from prior knowledge and this reasoning is realised by internal consequential conjunctive relations. This only occurs when the progression of the steps which are included, and hence the sequence of the selection of process types, maintains the sequence indicated in Table 6.5. This is consistently the case in SSEAS1, which has the most clearly elaborated chain of internal

consequence in realising the DEDUCTION SEQUENCES. In dealing with the southern winter, four of the five steps are explicitly realised but only two of the steps are explicit in dealing with the northern summer. However in both cases the ordering of steps and process selections is maintained, as indicated in Table 6.6.

STEPS	PROCESS SELECTIONS	Southern Winter	Northern Summer
1 Contextual STATE	Relational: Intensive: Attributive Relational: Circumstantial: Attributive	30 When the southern hemisphere tilts away from the sun,	34 The northern hemisphere at the same time points toward the sun
2 Simultaneous EVENT	Material: effective	31 most of the sun's rays strike the Earth obliquely	
3 Consequential STATE	Relational: Intensive: Attributive Relational: Possessive: Attributive		
4 Consequential EVENT	Relational: Intensive: Attributive	32 and their heating effect is less.	
5 Consequential Behavioural EVENT	Behavioural	33 During this time the southern hemisphere has its winter.	35 and has its summer

Table 6.6 Ordering of steps and process selections for the southern winter and northern summer in SSEAS1

The highly elaborated chain of internal reasoning in these elements is shown in Figure 6.48. Contiguous steps are linked by external conjunction, internal consequence links non-contiguous steps and internal consequence also indicates that 30-32 are the rhetorical means for 33. The internal consequence linking 34 to 35 conflates the latter function with that of internal reasoning on the basis of prior knowledge.

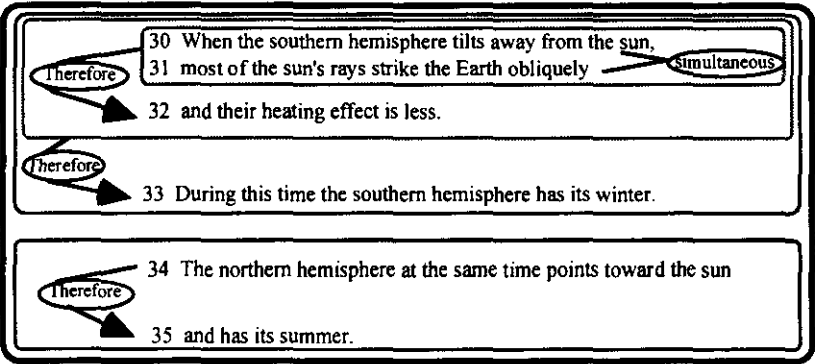


Figure 6.48 Elaborated internal conjunction in elements of the DEDUCTION SEQUENCES in SSEAS1

This relationship between the patterning of process selections through the IMPLICATION SEQUENCES and the elaboration of internal conjunctive relations can also be demonstrated for SSEAS3 and the primary text PSEAS3. On the other hand the breakdown of internal reasoning corresponding to the disruption of the pattern of process selection in the sequence of steps involved in the explanation of the occurrence of the seasons can be seen in texts like SSEAS2, illustrated in Figure 6.49.

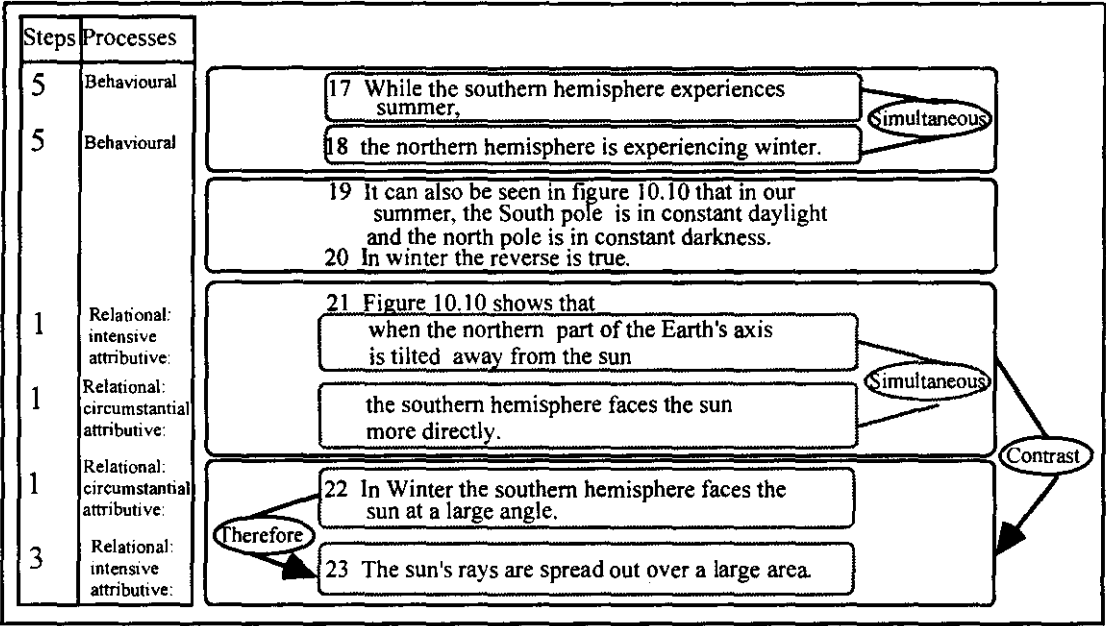


Figure 6.49 Disrupted pattern of process selection and reduced internal conjunction in DEDUCTION SEQUENCES in SSEAS2

Again, in the seasons texts distinctive skewing in the selection of process types and characteristic co-patterning of process selections and conjunctive relations in the DEDUCTION SEQUENCES distinguishes these *Orientational* explanations of the seasons from the *Linear Transformational* explanations of coal formation and the *Realisational* explanations of sound waves.

6.1.5.2 Grammatical Metaphor

The density of grammatical metaphor per clause for each text is compared across Fields in Figure 6.50.

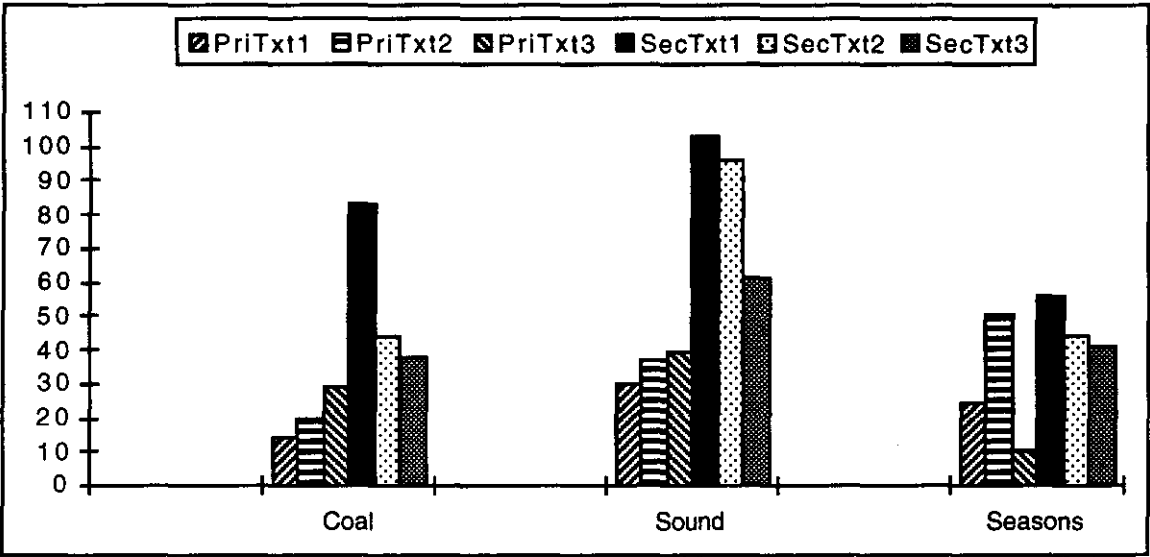


Figure 6.50 Density of grammatical metaphor per clause across Fields

At the secondary level sound texts are the most metaphorical and then, with the exception of the highly metaphorical first secondary coal text, the density of metaphor in the secondary coal and seasons texts does not seem to be very different. Secondary texts make more use of grammatical metaphor than primary texts in all Fields, but the difference is greater in the case of the sound texts. At the primary level the coal texts are less metaphorical than sound and seasons, but variability in the primary seasons texts makes it difficult to differentiate between these and the sound texts.

Field also affected the type of grammatical metaphor that was more prominent. The proportion of logical metaphor was significant but variable across the sound and seasons texts at both levels, whereas it occurred only to a very minor extent in the coal texts, as discussed in 6.3 above. The nominalisation or shift to Thing was most frequent in the sound texts, somewhat less so in the coal texts and very infrequent in the seasons texts as indicated in Figure 6.51.

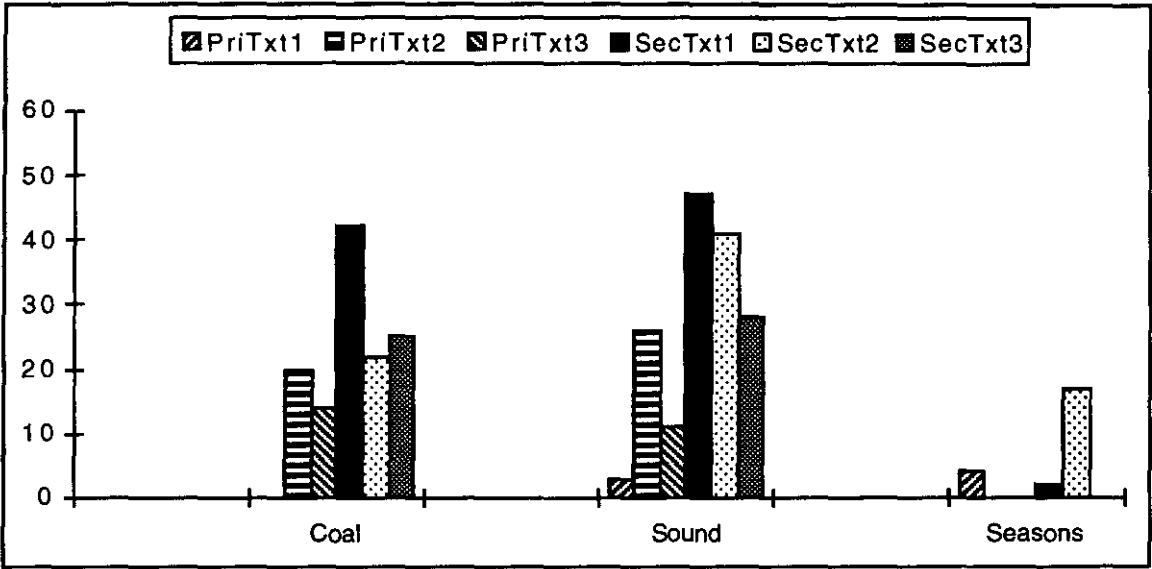


Figure 6.51 Proportions of grammatical metaphor involving shift to Thing

Overall, sound texts make more use of grammatical metaphor, particularly nominalisation, and it is in this Field that the density of grammatical metaphor differentiates the primary and secondary texts most clearly. The differences in the deployment of nominalisation reflect differences in the nature and role of definitions of technical terms across Fields.

6.1.5.3 Naming and defining technical terms

The analyses of the deployment of resources for constructing technicality are detailed and discussed in Chapters three through five. A comparison of the results across Fields is provided in Table 6.3a in Appendix 6 and is summarised in Table 6.7 below, which aggregates the instances of naming and defining of technical terms as well as instances of undefined technical terms across the texts within each Field at both primary and secondary level.

	Coal	Sound	Seasons
Instances of naming and defining of technical terms			
Secondary	10	11	8
Primary	1	7	0
Instances of undefined technical terms			
Secondary	4	2	14
Primary	9	1	13

Table 6.7 Summary comparison of instances of naming and defining of technical terms and of undefined technical terms aggregated across texts at primary and secondary level.

At the secondary level the most use was made of grammatical and discourse semantic resources for naming and defining technical terms in the sound texts, then the coal texts, and least use was made in the seasons texts. There were only two undefined technical terms in the sound texts and three in the coal texts and, although there were more in the seasons texts, terms such as "axis" and "hemisphere" seemed to reflect commonly assumed technical knowledge. The construction of technicality seemed to be most significant in the explanations of sound, and the secondary texts provided a fairly effective apprenticing of young readers to the technical discourse of this Field. At the primary level the use of resources for naming and defining in the coal and seasons texts was negligible and, although some use was made of nominal and verbal group parataxis in the primary sound texts, the use of relational identifying clauses did not construct effective definitions of technical terms, as discussed in Chapter four (4.2.5.1.1). Only in the coal texts were there significantly more undefined technical terms in the primary compared with the secondary texts. In the seasons texts again, these technical terms seemed to indicate a core of commonly assumed technical knowledge. On the whole, across Fields, the primary texts did not effectively deploy linguistic resources for apprenticing young readers to the technical discourse of science.

The relevance of the definitions included and the role of grammatical metaphor in their construction also varied with Field. In the seasons texts, as discussed in Chapter five (5.1.5.1.1), the definitions were either peripheral ("This is called the celestial pole.") or were introduced in the Given Information and were not taken up in the subsequent explanation ("This movement is called revolution."). Only the definition of revolution involves grammatical metaphor. The others, like the "celestial pole" involve renaming commonsense, congruent realisations as technical terms:

The path around the sun is called an orbit.

Every fourth year is called a leap year. (SSEAS2)

In the coal and sound texts, definitions occur in the IMPLICATION SEQUENCES, as well as in the Conclusion and in the Phenomenon Identification (coal) and the Analogic Account (sound). In the case of the coal texts however, a number of instances of grammatical metaphor in the definitions are the nominalised form of commonsense lexical items:

These plant remains are known as peat. (SCOAL2)

The first stage of the change to coal is peat. (SCOAL3a)

In the sound texts the grammatical metaphor in the definitions is predominantly the nominalised form of technical processes:

17 it pushes or compresses the air particles next to it
 ...
 21 the compression (SSND1)

But one secondary text also includes the more commonsense nominalisation "stretchings" which tends to mask the mode shifting of grammatical metaphor to maximal experiential distance:

These compressions and stretchings make up a sound wave (SSND1).

This form of nominalisation also occurs in the primary text PSND2, but not in the context of such an explicit definition of sound waves:

09 producing a whole series of squashes and stretches
 10 as the sound is passed through the air. (PSND2)

Since grammatical metaphor is fundamental to the construction of these *realisational* explanations of sound waves, the use of these intermediary forms using underived verbal nouns and other forms such as nominalised imperfective clauses, as discussed by Fuller (1992), should be explored in developing recontextualizations of explanations of this type for primary school children.

6.1.6 Causal conjunction, "depth" of explanation and relative technicality

In the coal texts at the secondary level it was shown that there was no systematic relationship between the deployment of temporal and consequential conjunction and the relative depth of treatment of the topic or technicality of the texts. Consequential conjunction occurred only within elements of schematic structure in elaborative meanings or in making causal links between elaborative and nuclear meanings. Some 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 conjunction in some elements.

In the sound texts also there was no simple relationship between the proportion of external consequential conjunction and the relative depth of treatment or technicality. It was argued that in the first secondary sound text, the relationship between depth of treatment and

causal conjunction was 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 consequence. None of the primary texts dealt adequately with the nuclear meanings involved in the secondary texts and only one text included one internal consequential conjunctive relation of concession. While the depth of explanation in the secondary texts appeared to be related to greater use of internal consequential conjunctive relations, it was not possible to relate the decreased depth of treatment and technicality in the primary texts to a more sequential rather than a causal orientation to explanation.

In the seasons texts on the basis of the relative depth of treatment as indicated by the semantic maps, and the relation of this to the deployment of conjunction, it was shown that while there was no clear correlation in the primary texts, in the secondary texts greater use of external temporal and consequential relations and of internal consequential relations were all associated with greater depth of treatment of the topic. But the greater emphasis on external temporal relations in SSEAS1, indicates that greater depth of treatment of this topic is not incompatible with a more temporally oriented explanation.

In the secondary sound and seasons texts it seems that greater depth of treatment may be related to increased use of internal consequence. However, there is no clear evidence in the analyses of the texts in the three Fields investigated that decreased depth of treatment of the topic is related to increased use of temporal conjunction and decreased use of causal conjunction. This is possible but not necessarily the case with the primary coal texts. The recontextualization of explanations in these Fields for primary children cannot be simply thought of as a shift from "causal" to "sequential" explanations.

6.2 Summarising salient aspects of the emerging account of explanations in school science books

6.2.1 Typology, topology and recontextualization

The results of this study support the identification and explication of different types of explanation in school science books, extending the initiating work by Veel (in press a) and the direction implicit in the work of Cross (1992). However, the findings in the present study also suggest the value of a complementary topological approach, emphasising the commonality of some linguistic features across explanation types. In the present study also the specification of linguistic dimensions of recontextualization of explanations at different levels of schooling has been extended beyond the seminal work of Cross (1992), which was based on comparisons of whole texts in relation to genre and semantic analyses

but restricted to the ORIENTATE element in the comparison of lexicogrammatical realisation. The extended, comparative analyses of texts across school levels have enabled some clarification of dimensions of recontextualization suggested by Veel (in press a).

The distinctive patterns in the selection of process types and conjunctive relations in the IMPLICATION/DEDUCTION SEQUENCES stage, as well as differences in the deployment of grammatical and logical metaphor, support the categorisation of the explanations in the Fields investigated as different explanation types. The more delicate analysis of schematic structure, particularly in identifying Field sensitive elements of structure within the IMPLICATION SEQUENCES stage, and the nature of the particulate structuring among these elements, suggests the categorisation of these explanation types as *Linear Transformational*, *Realisational* and *Orientalational* explanations. Key differences among these types of explanation in relation to conjunction, transitivity and grammatical and logical metaphor, which were detailed in 6.1.3 and 6.1.5 above, are briefly sketched to provide a simplified, synoptic overview in Table 6.8.

Field	Coal	Sound	Seasons
Explanation Type	Linear Transformational	Realisational	Orientalational
Conjunction <i>between</i> elements in IMPLICATION SEQUENCES	Ext. Successive	Ext. Successive Int. Consequential	Ext. Simultaneous Ext. Contrast
Conjunction <i>within</i> elements in IMPLICATION SEQUENCES	Ext. Successive Ext. Simultaneous Ext. Consequence	Ext. Successive Ext. Simultaneous Ext. Consequence Int. Consequence	Ext. Simultaneous Ext. Consequence Int. Consequence
Transitivity: Main Process Types in IMPLICATION SEQUENCES	Material	Material	Relational: Attributive
Grammatical Metaphor: Nominalisation	Moderate use in IMPLICATION SEQUENCES; Conclusion	Significant use in Phenomenon Identification; IMPLICATION SEQUENCES; Conclusion	Minimal use in Given Information
Logical Metaphor	Minimal	Ext. Consequence - clustered in ORIENTATION esp. in Phenomenon Identification	Ext. Consequence - clustered in ORIENTATION esp. in Explanation Summary Ext. Contrast - in IMPLICATION SEQUENCES ; Conclusion

Table 6.8 Lexicogrammatical and discourse semantic correlates of different explanation types

Further more subtle differences discussed in the foregoing sections, such as the different patterning of effective and middle Material processes in the IMPLICATION SEQUENCES of Linear Transformational and Realisational explanations, are masked in the simplified presentation of Table 6.8. The essential point is that these genres are quite different in terms of the patterning of their selections from the resources of lexicogrammar and discourse semantics.

The additional categories of explanation proposed here are quite tentative due to the small number of texts analysed. However the proposal may prove more utilitarian than the approach by Veel (in press, a) of regarding all such explanations as causal, as opposed to sequential explanations, especially given the acknowledgment of the problematic nature of this distinction (Veel, in press a:144-45), which was discussed in Chapter two (2.2.3.2.3).

Although the analysis of schematic structure at an intermediate level of delicacy revealed field-sensitive functional elements related by distinctive particulate structures which distinguished the different explanation types, there were sufficient similarities in the ORIENTATION and CLOSURE to identify common functional elements at this level across explanation types, as discussed in 6.1.1 and summarised again in Figure 6.52.

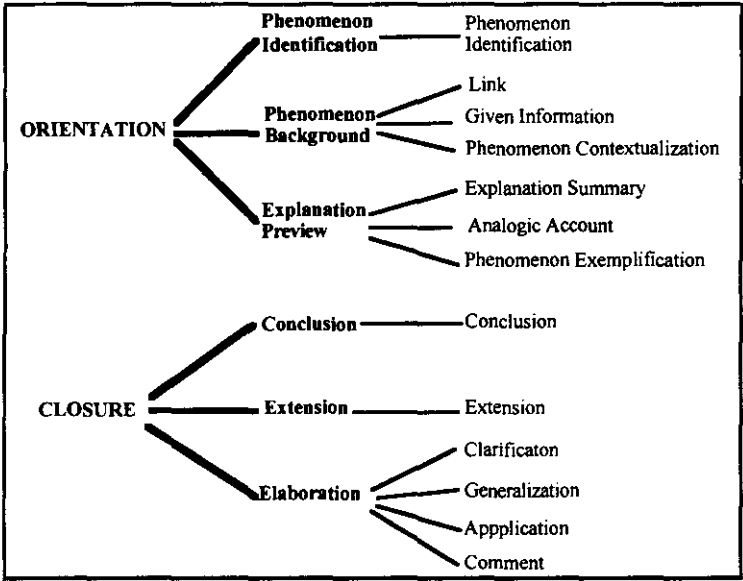


Figure 6.52 Levels of delicacy in analysis of schematic structure of ORIENTATION and CLOSURE

Analysis at this intermediate level of delicacy accommodates the range of structural elements identified in previous work discussed in Chapter two (2.2.1) (Macken et al, 1989.; Shea, 1988; Macken and Rothery, 1991; Cross, 1992 and Christie et al, 1992) and additional elements identified in the present study.

There was also commonality across explanation types in the hierarchy of periodicity, with Macro-Themes, predicting Hyper-Themes and these in turn predicting Thematic selection at the clause rank, while marked Themes typically introduced elements of structure within the IMPLICATION SEQUENCES, as shown in 6.1.2. In addition it was shown that at least one explanation of each type accumulated Rhematically introduced new information

as a Hyper-New. These results indicate this aspect of texturing illustrated by Martin (1993b) is a common feature in explanations of these kinds.

Recontextualization within the junior secondary school level involved a surprising degree of variation across the range of dimensions investigated. This has been detailed for each Field in Chapters three through five and compared across Fields in section 6.1. In most cases this variation was due to dysfunctional selections within these dimensions of recontextualization in one or more of the texts in each Field. Only in the explanations of coal formation were there two alternative recontextualizations (SCOAL1 and SCOAL2) in which there were no significantly dysfunctional aspects in either text. In each of the other two Fields there was only one text in which this was the case.

Recontextualization at the primary level also involved extensive variability across texts, including gross inaccuracy of information in one of the coal texts (PCOAL1), misleading distortions in two of the sound texts (PSND1 and PSND2) and in one of the seasons texts (PSEAS1), a failure to address integral meanings dealt with in all other texts. Although to a large extent the remaining coal texts and, to a lesser extent, the remaining seasons texts provided functional approximations to the secondary explanations, all of the primary sound texts were quite dysfunctional explanations. This may be partly due to amenability of the form of the Linear Transformational (coal) and Orientational (seasons) explanations, but not the Realisational (sound) explanations, to the recontextualizing strategies of those responsible for the primary texts. The most obvious and consistent recontextualizing strategy appears to be to keep the explanations short and to do this by leaving elements of the explanation out where this seems feasible. The schematic structure of the coal explanations adapts well to this by permitting the collapsing of the iterative Transformation into a single element and the elimination of the Comment element constituting the CLOSURE. The extensive elaborative meanings in the secondary texts were eliminated in PCOAL2 and PCOAL3 and one essential nuclear meaning in the Conditions element (the non-decomposition of dead plant material) was also omitted in both texts. Somewhat similar adaptations are facilitated by the form of the Orientational explanations of the seasons.

The way in which the form of orbital structure linking elements of the DEDUCTION SEQUENCES in the seasons explanations accommodates the recontextualization strategy of elimination was indicated in 6.1.1 in relation to the primary text PSEAS3. The length of this text is considerably reduced by dealing with the summer and winter in the northern hemisphere only. Of course, this results in a partial explanation, but leaving out the seasons in the southern hemisphere leaves a modified but functional schematic structure intact. The length of the primary texts is also reduced by leaving out the Link and Analogic

Account elements in the ORIENTATION, but the omission of the Given Information element is dysfunctional since this assumes prior knowledge not assumed in the secondary texts. The extensive peripheral meanings in the second and third secondary seasons texts are eliminated in their primary level counterparts, and again both primary texts eliminated one essential nuclear meaning (the angle of incidence of the sun's rays on the Earth's surface relative to the orientation of that surface to/away from the sun).

In the recontextualization of both the coal and seasons texts at the primary level, the negotiation of grammatical metaphor was not a significant issue. In the secondary seasons texts nominalisation was minimal and confined to the Given Information and the same use of logical metaphor (external consequence in the Explanation Summary and external contrast in the IMPLICATION SEQUENCES) occurred at both school levels. In the secondary coal texts nominalisations were primarily terms such "plant remains", where the metaphorical realisations were not essential to the explanation and were reduced in primary texts by using congruent forms such as "dead vegetation". This is not to say that there were not problematic aspects in these more appropriate recontextualizations at the primary level. For example, the inappropriate selection of middle Material processes in PCOAL3 was discussed in Chapter three (3.2.5.1), the ineffective deployment of conjunctive relations in PSEAS2 was discussed in Chapter five (5.2.3), and the negligible use of resources for the naming and defining of technical terms compared with the secondary texts was noted in 6.1.5.3 above. Nevertheless, the amenability of the form of these explanations to the recontextualizing strategies of the primary school text producers, meant that some of the primary coal and seasons texts are moderately useful apprenticing texts at appropriate levels of approximation to the secondary explanations.

The form of the Realisational explanations of sound waves is not amenable to the recontextualizing strategy of elimination. As pointed out in 6.1.1, the nested serial structure of the IMPLICATION SEQUENCES means that the Compression and Rarefaction elements are, in combination, the nucleus for the Seriation element. The problem is that both PSND2 and PSND3 leave out the Rarefaction element (and in PSND1 neither the Compression nor the Rarefaction elements effect a reconstrual of events to the level of abstraction necessary for their further reconstrual in the Seriation element). Leaving out an element renders dysfunctional the IMPLICATION SEQUENCES stage as a whole. In contrast to the secondary texts, all of the primary texts omitted the Phenomenon Exemplification element. This not only meant there was no specific instance of the production of sound waves on which to anchor the explanation, but it also meant that textually there was no Hyper-Theme predictive of clause rank Theme selection in the progression of the explanation. The semantic mapping of the secondary sound texts (Chapter four, 4.1.4.1, Figure 4.11) showed that there were very few elaborative and

peripheral meanings in these texts, obviating one target for reducing the length of the primary texts. The skeletal selection of nuclear meanings in the primary texts has been detailed in Chapter four (4.2.4) and illustrated again in Figure 6.39 in section 6.1.4. These problems are exacerbated by the central role of grammatical metaphor in the IMPLICATION SEQUENCES constructing the explanation of sound waves in the secondary texts. The crucial nominalisations effecting the reconstrual of congruently realised technical events as macro-events (compression; rarefaction) were approximated only in PSND2 by the use of "squashes" and "stretches" as nominalisations (Unfortunately, as discussed in Chapter four (4.2.5.2) this was undercut by the absurdity of the selection of "Sounds" as Agent with the Material process "squash"). A more principled application of the use of these commonsense nominalisations as bridges to the technical nominalised forms, in combination with an appreciation of the essential nuclear meanings to be included and the nature of the schematic structure of explanations of this kind, could result in functional explanations of sound waves at the primary level.

The primary level explanations of sound waves are not Sequential recontextualizations of what are Causal explanations at the secondary level, and if more effective primary explanations were to be constructed, they could not be Sequential Explanations. This is also the case for primary explanations of the seasons. There is some evidence from the analysis of the primary coal text PCOAL2, that elimination of elaborative meanings can result in the elimination of consequential conjunctive relations, resulting in a sequential version of the explanation of this phenomenon. Considering the three Fields investigated however, it seems difficult to sustain the view that there is a fairly fixed sequence of occurrence of types of explanation in school science with sequential explanations occurring first and causal explanations later (Veel, in press a:112, 114; in press b:15) and the implication that explanations in primary school science will be sequential explanations (Veel, in press a:118).

6.2.2 Further semiotic dimensions in the recontextualization of scientific explanation in school science books

Additional research is needed to investigate the functions of images (photographs, figures, diagrams etc.) in pedagogic explanations and how these vary within and across school levels and across Fields. All of the texts analysed were accompanied by an image of some kind. In some cases this was a single photograph (PCOAL2; SCOAL1) and others included diagrams consisting of several frames (PCOAL3; SCOAL2). These images can be investigated as semiotic systems in their own right, using the analyses derived from the theoretical principles of systemic-functional linguistics, which are currently being developed by Kress and Van Leeuwen (1990; in press) and Lemke (1994). But Martin

(1994:16-17) indicates that diagrammatic representations can also be interpreted as projections of the "content" developed in the text, bypassing its actual wording. Some such diagrams provide an alternative consolidating form of representation for meanings that have been discursively developed as text. Martin goes on to elaborate the potential of this approach for theorising the nature of the collaboration among these semiotic systems:

Treating these images as projected meanings allows us to focus on the semantic dependency between these images and the texts including them (which is of course mediated by the captions relating these projections to the texts projecting them, and any wording included in the images themselves); (Martin: 1994:17-18).

These complementary approaches are essential to further theorising the semiosis of pedagogic explanations in school science books as they are recontextualized for students at different levels of schooling.

Further research should also address variation in the deployment of linguistic resources constructing interpersonal meanings. In the coal texts for example, modalization seems to be integral to the explanation of the initiating conditions in coal formation, as indicated by the Thematic Modal Adjuncts in the following secondary text segments:

Usually dead plant leaves and stems, when they fall to the ground, are broken down and become part of the soil humus (SCOAL3a).

Normally, if plant material is left on the ground surface in contact with the air (oxygen), it decomposes (SCOAL1).

In the seasons texts on the other hand, the use of modal verbs has more to do with differences in the interpersonal positioning of the reader in different texts:

You may have seen (Figure 2.6) that the Earth is drawn with its axis "tipped over" or tilted (SSEAS3).

As seen in Figure 10.9, the Earth's axis remains tilted in the same direction throughout its orbit (SSEAS2).

The same kind of variation is found in the primary texts in this Field:

To discover the cause of the seasons, we must look again at the Earth in its orbit around the sun (PSEAS1).

The seasons are caused by the Earth's orbit around the sun (PSEAS3).

But some of the coal and sound texts also deploy the resources of Mood and Modality to construct particular interpersonal positionings of the reader, as illustrated in the selection of Modal Adjuncts in the following text segments:

You can even hear sound travelling through wood (PSND3).

Thus coal is merely carbonized plant remains (SCOAL1).

More systematic research is needed to explicate the patterning of the construction of interpersonal meaning in these texts and its variation across Fields and school levels.

Additional research addressing these further dimensions of recontextualization would also be enhanced by extending the ecological perspective, which explores the ways in which these explanation genres are related to surrounding texts which make up the chapter/book of which they are a part. This local intertextuality (Lemke, 1985) was briefly addressed by Cross (1992:80). She noted that one possibility was that the sample texts were completely separate or discrete from the other texts. The other possibility she identified was two forms of continuity. The first was where the sample texts were subtexts of another larger text, signalled in part by subheadings, which Cross labelled non-continuous. The other form of continuity was where the sample text forms a vignette that is part of a larger text but not marked off by subheadings, which was labelled continuous. In her thirteen texts Cross (1992:81) found only one that was discrete and one that was continuous. She noted that the continuous text did not have an ORIENTATION element in its schematic structure, and since it was intended for younger readers, that this might be characteristic of such texts (Cross, 1992:155). Of the eighteen texts in the present study, one was discrete (PSND2) and two were continuous (PCOAL2; SCOAL3a). While there was no ORIENTATION in the secondary text SCOAL3a, the primary did include an Explanation Summary element of the ORIENTATION but no separate Phenomenon Identification realised by a subheading. Of greater educational import would be an exploration of the functional relationship of these explanations to surrounding texts, such as explanations enhancing a preceding report, being extended by a historical recount of the development of the explanation, or being elaborated by review questions derived from the explanation etc. Such an approach has been suggested in Martin's (1994) modelling of the structure of

longer texts, which theorises how "elemental" genres, such as the explanations studied here, are combined into what he calls macro-genres.

This outline, of course, does not exhaust the further dimensions of recontextualization of educational significance, but it does indicate viable and productive directions for expansion of the educational linguistic research base currently underlying the emerging account of explanation in school science books.

6.3 Facilitating access to the language of school science explanations: Linguistic analysis and educational intervention

The increasing and constructive engagement of educational researchers and teacher educators (Luke, 1993; Wells, 1994), and those involved in science education in particular (Parker, 1992), with systemic-functional linguistic perspectives on learning, has raised a number of inter-related theoretical and practical imperatives in teacher education and professional development and in educational linguistic research. These have assumed some urgency in recent years in the states of New South Wales (NSW) and Queensland with the introduction of syllabi in English for the primary school in NSW (NSW Board of Studies, 1994) and for the primary and junior secondary school in Queensland (Queensland Department of Education, 1994), in which a systemic-functional model of language is a fundamental basis. A pedagogical perspective on what needs to be done to develop linguistic knowledge as a technology for learning and teaching was recently outlined by Wells:

The reorganisation of the grammar and the concomitant reconstrual of experience that are required in order to use written text as a tool for thinking and communicating do not occur spontaneously for most children. In order to master this new mode, they need to perceive it as functional for them in relation to activities that they find both challenging and personally meaningful. They also need to be given guidance and assistance in carrying out those parts of these activities that they are unable to manage on their own (Wells, 1994:82).

Wells raises issues of balancing explicit teaching with opportunities for collaborative and independent learning and of situating explicit linguistically-based teaching in relation to a pastoral pedagogy (Hunter, 1994) in which intervention in the construction of literate abilities is also responsive to the orientations to language and learning that children bring to classroom contexts. While the importance of such issues is acknowledged, they cannot be pursued here. What is implicit in Wells' agenda and germane to the educational implications of this study is the reciprocal extension of educationists' engagement with functional linguistics and of linguists' exploration of pedagogic discourses.

On the one hand this requires teachers and teacher educators to develop the kind of linguistic understanding that will allow them to construct learning experiences which will shunt back and forth from the dynamic modes of realisation of commonsense knowledge to the more synoptic modes of specialised knowledge, and at the same time gradually develop learners' explicit knowledge about language as a means of demystifying educational discourse (Halliday: 1993a:55). On the other hand, for this to be a realistic task even for educationists with substantial linguistic knowledge, theoretical accounts of the range of genres prominent in schooling need to be refined and extended to address existing and emerging learning contexts. These complementary demands in fact align with the transdisciplinary character of systemic-functional linguistic research projects conducted in educational contexts (Halliday, 1993d; Martin, 1993a).

... they have shown how a grammatics can open up access to the elaborated discourses of education and employment; and in doing so have enriched the theory in its turn (Halliday, 1993c:78).

This mutually intrusive relationship between educational and linguistic issues and understandings permeates the findings and implications of the present study. However, some of the findings suggest specific enhancements to some current practices in teaching knowledge about language in the context of classroom teaching/learning sequences in science education. The contrastive analyses of texts in the same Field also emphasise the need for the teaching of critical reading of science texts. But a more encompassing potential for educational intervention in the production, selection and use of explanations in school science books may arise from greater understanding of the semiotic dimensions of the essentially pedagogic, apprenticing character of these texts. The beginnings of such an account of the semiosis of recontextualization are emerging from the present study through the description of the alignments and discontinuities in the linguistic dimensions of texts within and across school levels. Even these initial results can be used to encourage critique and renovation of pedagogic explanations in school science books. Outcomes of this study relevant to advancing the teaching of knowledge about language, developing critical reading and exploring the semiosis of recontextualization as an agenda for critique and renovation of pedagogic texts, are briefly outlined in the following sections.

6.3.1 Teaching knowledge about language as technology for learning

A principal theoretical concern of this study involved tentative proposals for enhancing complementary typological and topological perspectives on the schematic structure of different explanation types. The extended typology of school science explanations was shown to be necessary because the initial modelling did not account for the range of explanatory texts encountered in school science books (Veel, in press b) and the sequential/causal categorisation proposed by Veel (in press a) was acknowledged as a highly problematic distinction. Clearer distinctions among a range of explanation types and more delicate analyses of the "explanation sequence" stage such as those proposed here, along with the work of Cross (1992), will alert educators to correspondences and differences in schematic structure among the explanatory texts used as models in deconstruction activities, texts constructed jointly with children to scaffold writing development and the explanatory tasks teachers set for children's independent writing. This would avoid the incongruities among such texts in these teaching sequences which were evident in some curriculum materials (Christie et al, 1992) as discussed in Chapter one (1.5.2.2). The more delicate description of the "explanation sequence" would also enhance the explicit linguistic knowledge students could be taught to use in their composition and comprehension of such texts. However, this needs to be balanced by the complementary instructional benefits of a topological perspective. The similarities in schematic structure among explanation types, at the least delicate level of analysis, are essential in early work with students in differentiating genres such as reports, explanations, expositions etc. But I have also suggested that, even in more advanced work dealing with explanation types, an intermediate level of analysis of elements in the ORIENTATION and CLOSURE stages, would allow students to see the continuities across different explanation types and hence allow them to focus on the significant differences at this intermediate level in the IMPLICATION SEQUENCES, without their being overwhelmed by the extent of variation in the schematic structure as a whole at the more delicate level of analysis.

The descriptive work in this study has extended and clarified some aspects of previous accounts of the deployment of lexicogrammatical and discourse semantic resources in the construction of textual and ideational meanings in different explanation types. Again this can enhance teaching of knowledge about language. As a topological parameter, Martin's (1992:434-460; 1993b: 241-251; 1994; 1995) account of the hierarchy of periodicity in Theme selection in terms of Macro-Theme, Hyper-Theme and Theme selection at the clause rank, was fairly consistent in texts across explanation types and across school levels (except for primary sound texts), as was the exclusive use of marked Themes to introduce elements of structure within the IMPLICATION SEQUENCES. Since current curriculum documents in Queensland and New South Wales include the teaching of Theme at the

clause rank (Queensland Department of Education, 1994:4; NSW Board of Studies, 1994:43-44), an extension of this to include Hyper-Theme and Macro-Theme could be incorporated into teacher-led class deconstructions of the kinds of explanations described here, as part of the curriculum cycle (Macken et al, 1989; Christie et al, 1992). This would help students to see the relationship between the text's method of development and its schematic structure. Understanding the textual functioning of the Explanation Preview elements of structure (such as the Explanation Summary and the Phenomenon Exemplification) as Hyper-Theme, predictive of Themes at the clause rank provides students with an explicit basis for enhancing their use of prediction strategies fundamental to psycholinguistic models of reading as meaning construction (Goodman, 1982a; 1982b; 1982c; Smith, 1982; 1985). Following demonstration and collaborative deconstruction of model texts, students could be shown a new text up to the Explanation Summary or Phenomenon Exemplification, and the remainder of the text as a "cloze" passage with Themes completely or partially deleted, or they could simply be asked to predict the likely beginnings of subsequent elements of structure. The explicit knowledge of texturing built up through this kind of work also provides students with a very practical resource for organising their own writing.

The contribution of this study to a clarification of the division of labour between internal and external conjunction, and among different types of logico-semantic relations within and between elements of schematic structure has begun to address some of the ambiguity in this area, which was pointed out in Chapter two (2.2.3.2.3) in the work of Veel (in press a:138). More research with a greater number of texts in more Fields is clearly needed to confirm the emerging trends. But it seems likely that students can now be taught for example, that only external temporal: successive conjunctive relations link across elements of structure in the IMPLICATION SEQUENCES of Linear Transformational explanations, while these and external consequential relations occur within such elements in the three explanation types identified. Similarly, the distinctive patternings of internal consequence in the sound and seasons texts can be taught in relation to the schematic structure of these explanations.

Current curriculum documents (New South Wales Board of Studies, 1994:131; Dept. of Education, Queensland, 1994:78) and recent professional publications for teachers (Butt, *et al*, 1995:141; Knapp and Watkins, 1994:81; Derewianka, 1990: 62) do not differentiate explanation genres and simply list the logico-semantic types of conjunctive relations that can occur without relating them to schematic structure, nor distinguishing among internal and external conjunction. The relationships between conjunction and schematic structure derived from the present study could be incorporated into current teaching practice through the use of adaptations of the diagrammatic representations presented here. An example of

a progressive teaching sequence for Linear Transformational explanations is indicated in Figure 6.53. The first stage involves the teacher working with students to identify elements of schematic structure and then explicit, external conjunction *within* elements of schematic structure. The next stage introduces the notion of *implicit*, external conjunction within elements of schematic structure, by showing students how appropriate conjunctions could be inserted, as indicated in frame two. Then, thirdly the implicit external conjunction *between* elements of schematic structure is introduced and finally the implicit internal conjunctive relation of reformulation can be addressed. These stages are not necessarily all included in one lesson and could be dealt with progressively over several lessons and using different examples of Linear Transformational explanations.

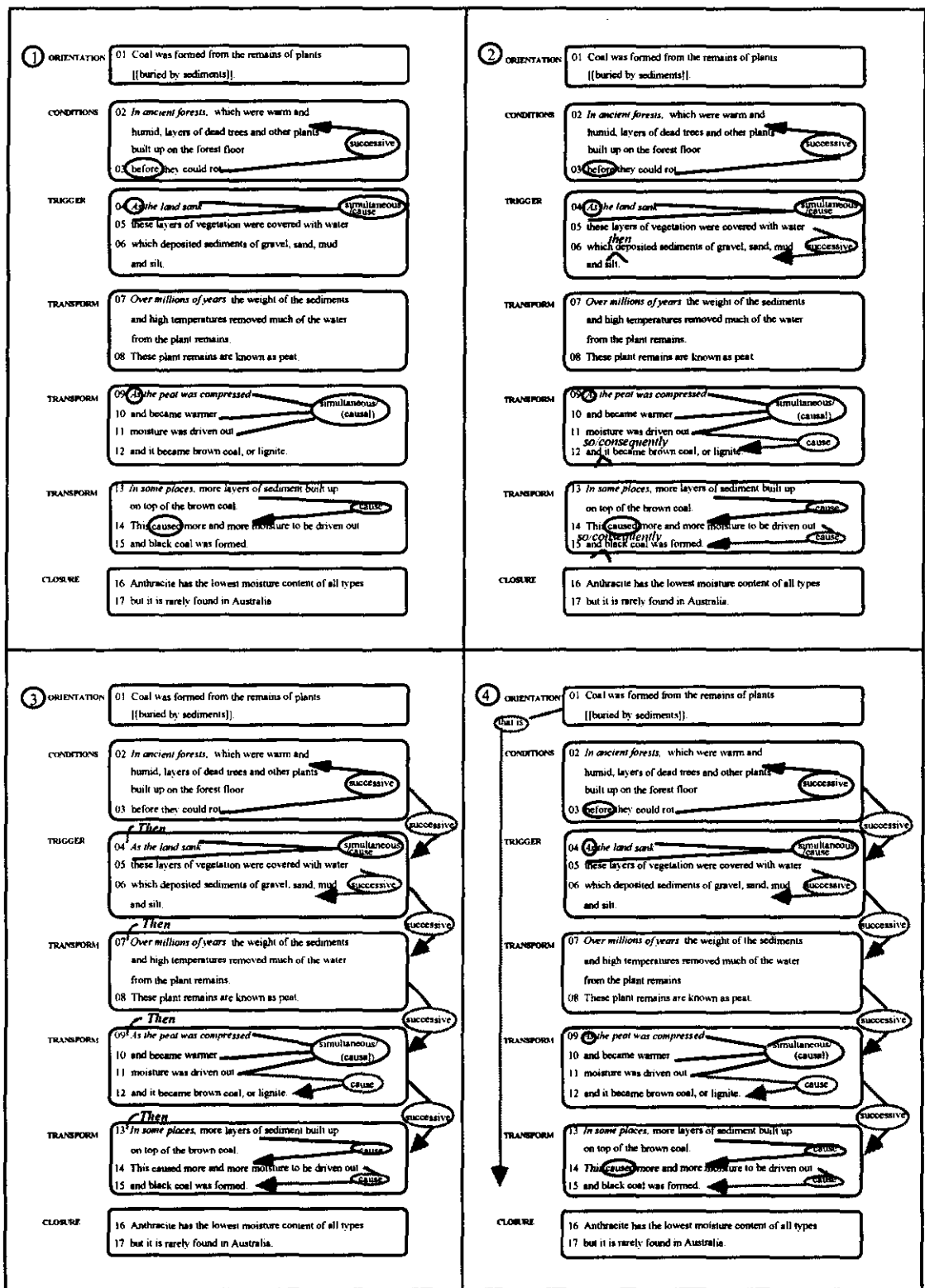


Figure 6.53 Example of a diagram relating conjunction and schematic structure adapted for pedagogical purposes

Consolidation tasks might initially provide students with similar diagrams but using different texts and simply require them to fill in the logico-semantic conjunctive relations (Figure 6.54), to scaffold their eventual independent construction of such diagrams.

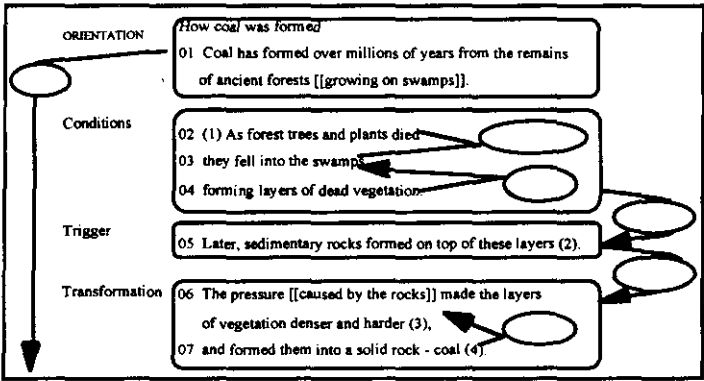


Figure 6.54 Student practice diagram relating conjunction to schematic structure

The more extensive internal conjunctive relations in Realisational and Orientational explanations would be introduced after students had developed confidence in identifying and using those in Linear Transformational explanations.

The transitivity analysis showing the predominance of Relational:attributive processes in the seasons texts underlines the need for a more differentiated account of explanation types and the obvious concomitant need to problematize current descriptions of the (sic) explanation genre which "uses mainly Material processes to indicate action" (New South Wales Board of Studies, 1994:132, Dept. of Education, Queensland, 1994:78). However, Material processes were dominant in both the sound and seasons texts. Here, advanced teaching of the genre could draw attention to the respective roles of middle and effective Material processes in both explanation types. The challenge would be to incorporate this ergative perspective into the pedagogical applications of systemic-functional grammar currently being introduced to schools. Nevertheless the deployment of effective and middle Material processes was a discriminator of effective explanations of these types. As previously noted, the inappropriate selection of middle Material processes distinguished the third primary coal text, which in other respects was a useful apprenticing text approximating the secondary explanations. In addition the "agentive chain" constructed through the patterning of middle - effective - middle Material processes in clausal progression in the IMPLICATION SEQUENCES of the first secondary sound text, clearly contributed to the effectiveness of the explanation of sound waves through the progressive reconstrual of events at higher levels of abstraction. In these explanation types a significant part of the explaining is establishing the role of agency, albeit implicitly in some of the coal

texts. The linguistic explication of this, again would put students in a more powerful position with respect to their efforts in comprehending and composing such texts.

As suggested above, implications for teaching actually pervade the results of the study and a good deal of teasing out of specific suggestions for practice could be pursued. A number of practical implications follow from the analyses of grammatical metaphor for example. The use of nominalisation in factual genres is pointed out in the Queensland and New South Wales syllabi (Queensland Department of Education, 1994:4; NSW Board of Studies, 1994:167). In this study the difference in the significance of nominalisation in explanations across Fields suggests an order of teaching of these topics in the primary school, with the need for a good deal of preparatory work to scaffold the introduction of these metaphorical forms which are integral to the explanation of sound waves. The logogenesis (Halliday and Matthiessen, in press:18) of the nominalisation "compression" in SSND1 compared with the other secondary texts (Chapter four: 4.1.5.2), suggests the benefits of this kind of co-textual scaffolding in supporting students developing familiarity with metaphorical realisations. Once teachers can distinguish texts on this kind of basis they can be used to demonstrate the building up of the metaphorical forms and to teach students how to deploy such resources in their own writing through strategies such as the type of progressive cloze task illustrated in Figure 6.55.

①	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 particle pushes on the next one to its right 21 the compression travels through the air.
②	16 As the object moves to the right 17 it pushes or compresses the air particles next to it, 18 The c-----d air particles then push on the particles to their right 19 and c-----s them. 20 As each particle pushes on the next one to its right 21 the c-----n travels through the air.
③	16 As the object moves to the right 17 it pushes or ----- the air particles next to it, 18 The ----- air particles then push on the particles to their right 19 and ----- them. 20 As each particle ----- the next one to its right 21 the ----- travels through the air.

Figure 6.55 Progressive cloze task targeting grammatical metaphor

Again these stages might be introduced in successive lessons with a further consolidating stage repeating stage three but using a different text, before students write their own explanations independently.

In a similar manner the consistent clustering of metaphorical realisations of consequential conjunction in Explanation Preview elements of schematic structure and their "unpacking" in elements of the IMPLICATION SEQUENCES suggests a facilitative context for explicit teaching of logical metaphor. But the more general point is that in an educational linguistics based explicitly on the view that in order to access knowledge of any kind you have to control the semiotic resources which construe that knowledge, curriculum must necessarily be designed around those resources, and hence in this kind of research, linguistic analyses and implications for educational intervention tend to coalesce.

6.3.2 Critical reading of science texts

Two broad arenas for the development of critical reading were suggested by the contrasting results from a number of the analyses undertaken. The first related to the contradiction and omission of ideational meanings in ostensibly compatible accounts of the same phenomenon in different texts. The second arena concerned the understanding that texts may provide only a selection of relevant ideational meanings and their realisations in explaining phenomena in various Fields. The first arena will be illustrated by reference to analyses of the coal texts and the second by reference to the sound texts.

The most obvious contradictory meanings resulted from the inaccuracy in the first primary coal text which indicated that coal was formed from "decayed (sic) plants and animals". However, more subtly problematic were the competing elaborative meanings concerning the reasons for dead plant material which eventually formed coal, remaining undecomposed. As discussed in Chapter three (3.1.4) the first secondary coal text indicated that this was due to the accumulation of the plant remains in a swamp, where it was covered with water containing little or no oxygen. The second text suggested that the plant remains built up on the forest floor before they could rot and implied that this was due to the forests being warm and humid. Then the possible explanation of the variation in the reasons given being due to the different locations of the swamp and the forest was apparently obviated by the third text which suggested that the plant remains in the swamps were being produced faster than they could break down. A similar problem occurs in relation to the second Transformation element in the second and third coal texts. Here one text indicates that increased sedimentation caused the further compression of peat to brown coal, while the other text omits any suggestion of further sedimentation. In these cases either one of both causes may be valid but there is no acknowledgment of the alternative/complementary causes in any of the texts.

The analysis of schematic structure at the intermediate level of delicacy discussed above, provides students with one critical resource for identifying omissions at the level of genre. This was very significant in the case of the secondary coal texts since SCOAL3a and SCOAL3b omitted the integral Trigger element in the IMPLICATION SEQUENCES.

The understanding that explanations may be based on a selection of relevant ideational meanings was illustrated in the comparison of the semantic maps of the secondary sound texts. The common convention in these pedagogic explanations is to attend to what occurs to the right of the vibrating object only and to ignore the simultaneous events to the left of the object. The second secondary sound text is the only one which includes elaborative meanings concerning what happens to the left of the vibrating object. This was shown in Figures 4.11 and 4.16 in chapter four and is illustrated again in Figure 6.56, which compares corresponding segments of the first and second sound texts.

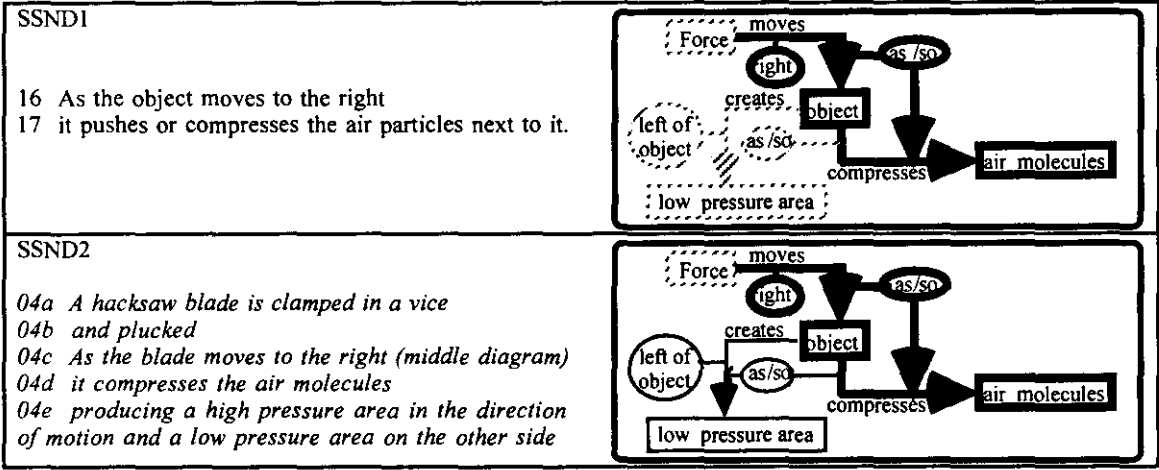


Figure 6.56 Selection of meanings concerning events to the left of the vibrating object in SCOAL2 and their omission in SCOAL1

Findings such as these indicate the need for students to read, discuss and deconstruct a range of explanatory texts on the same topic to develop a critical resistance to the compliant reading position engendered by the explanation genre. Practical classroom work towards this end can be implemented using less technical versions of semantic mapping which are widely known in the pedagogical literature (Heimlich and Pittelman, 1990; Hawk, 1986; Lunzer and Gardner, 1984; Nist et al, 1983; Hanf, 1971).

6.3.3 Exploring the semiosis of recontextualization as an agenda for renovation of pedagogic texts

It has been argued that if science books are to support the gradual apprenticing of students to the language of scientific English as they progress through the primary and secondary school, it is necessary to establish a clearer specification of the gradient of semiotic approximation to scientific English which should characterise the progression of texts used at successive levels of schooling. As an initial move toward this, the present study examined the variety and functionality of selected dimensions of recontextualization in explanations of the same phenomena at two levels of schooling. The variability at the secondary school level was predominantly due to dysfunctional linguistic choices in all but one text in each of two of the Fields investigated and two texts in the other Field. The identification of problematic aspects of texts does improve the basis on which teachers can make discriminating selections of books for classroom use and does provide a focus for encouraging critical, resistant readings of these texts when they are used in teaching. But an appreciation of the co-ordination of semiotic choices which produce clearly functional apprenticing explanations at this level, suggests an agenda for the renovation of texts at this level as well as some indication of what should not be assumed in recontextualizations for less experienced students. In this section, salient features of the first secondary sound (SSND1) and seasons (SSEAS1) texts which distinguish them as effective apprenticing texts will be briefly noted (since the primary level recontextualizations in these Fields were appreciably more problematic than those dealing with coal formation). It will then be shown that many of the features of the secondary texts that support inexperienced learners are precisely those which do not occur in the primary texts. Again this suggests the beginning of an agenda for text renovation at the primary level.

At the level of genre in both cases the first secondary sound and seasons texts include the most extensive Analogic Account elements of all texts at both primary and secondary level. But these texts also provide the greatest depth of treatment of the topic as indicated by the semantic mapping analyses (Figure 4.21; Figure 5.20). What seems to be happening here is that the greater amount of text space invested in bridging from commonsense is ultimately balanced by an explanation at greater depth. But it is also significant that this increased bridging is incorporated at the level of schematic structure. In the sound text it was pointed out (Chapter four, 4.1.5.1) that the semiotic reconstrual from familiar grammatical metaphors to congruently realised technical implication sequences, to abstract events involving more technical metaphors, which were then related back to the original familiar metaphorical realisations, involved three discrete "passes" (the Link; Analogic Account and Implication Sequences elements) with greater delicacy of focus in each segment. What is being provided here is a sequence of "advance organisers" to scaffold the progressive

increase in technicality. In the seasons text, rather than discrete "passes" there is a gradual build up, as meanings constructed through the Analogic Account and the first Deduction Sequences element are incorporated into the second Deduction Sequences element (Chapter five: 5.1.4.2). These kinds of "graduated shifts" from the more familiar commonsense perspectives towards a more systematic scientific view are not matched in the other secondary or primary texts. Especially in the sound texts, there is more of a "melding" of commonsense and scientific orientations at the level of lexicogrammatical realisation through lexical selection of commonsense items and the use of (frequently anthropomorphic) lexical metaphors, as discussed in 6.1.5.1 above.

The effective apprenticing characteristic of "graduated shifts" also penetrated more subtly to the level of lexicogrammatical realisation in SSND1 and SSEAS1. In the sound texts this has been illustrated by the way in which the co-patterning of transitivity choices, internal and external conjunction and the logogenesis of technical nominalisations construct the reconstrual of technical events at progressively higher levels of abstraction (6.1.5.1). In SSND1 this produced an unambiguous realisation of events underlying the macro technical event complex:

29 a series of compressions and stretchings of air particles is sent out from the object.

However in the other secondary texts "repair strategies" were required to clarify that the air particles did not actually travel away from the object (Chapter four: 4.1.3.2) and in the primary texts quite absurd grammaticalizations occurred such as the selection of "sound" as Agent in pressing "together a package of air" (PSND2).

In the same way that linguistic choices in SSND1 scaffolded readers' understanding of the technical nominalisation "compression" through its construction in the text, SSEAS1 withheld the use of the metaphorical realisation of external contrast ("the reverse") until the Conclusion element so that the logical meaning had been constructed (albeit implicitly) in linking the accounts of the southern summer and northern winter to those of the southern winter and northern summer. In the other secondary and primary texts this was not the case and the logical metaphor was used so that it was only necessary to realise an account of summer and winter in one hemisphere. Dealing explicitly with summer and winter in both hemispheres before introducing the logical metaphor as occurred in SSEAS1 would appear to be a more appropriate strategy for primary school readers.

Both texts of course, include other linguistic choices, such as the hierarchy of periodicity of Theme selection, which scaffold readers' interpretations and which are shared to a greater or lesser extent with other texts. But in none of the other texts is there such consistent

scaffolding across the range of linguistic resources investigated. In fact both were written by the same authors of the same secondary school science series (Chapter 2, Table 2.2). And one of the more effective secondary coal texts (SCOAL1) was also written by them. Now this indicates that effective writing of pedagogic explanations in school science books is not a haphazard matter of chance. Further research in identifying and explicating the nature of the effectiveness of such texts may well be a step toward establishing a practical agenda for the reform of secondary science explanations in the direction of greater functionality as resources for apprenticing students to the discourse forms of scientific English.

The prospects for the reform of primary science books however, seem somewhat less optimistic, although as indicated in 6.2.1, some of the primary coal and seasons texts were shown to be moderately useful apprenticing texts at appropriate levels of approximation to the secondary explanations. Nevertheless, the fundamental contradiction is that the primary texts on the whole make little use of the very resources identified as scaffolding novice readers' negotiation of the scientific English of the secondary texts. This seems to be largely due to an apparent need to keep the primary level texts short. What is most surprising is that the linguistic feature which is most commonly thought of as indexing text difficulty - technical terms (Halliday, 1993f:70), was much more likely to be explained within the secondary texts than within the primary texts in this study (Table 6.7). As suggested in 6.2.1 the production of successful apprenticing texts at the primary level also seemed to be more of a haphazard matter in that the schematic structures of some forms of explanation seemed to be more amenable to this apparently naive recontextualizing strategy which seemed to assume that making the text short was making it accessible. From this perspective the sound texts were bound to be more problematic, but it is surprising that all of the secondary texts adhered to the well established pedagogical principle of providing specific "concrete" examples of sound production (in the Phenomenon Exemplification element) on which to anchor the explanations and yet none of the primary texts included such specific instances. The apparent concern for brevity may explain why none of the primary texts included the kinds of "graduated shifts" of the secondary sound and seasons texts from commonsense to technicality at the level of genre or at the level of discourse semantic and lexicogrammatical realisation. Given the confused and distorting explanations in the primary sound texts compared with the extent of scaffolding embodied in the linguistic choices in SSND1, and the apparent comparability of access between other secondary texts like SCOAL2 and the primary counterparts, one must seriously ask whether primary school students would not be better served by being introduced to the secondary texts. If further research supports the kinds of contradictions outlined here, such a provocative proposal may be warranted in emphasising the need for reform in the

production of pedagogic explanations in primary science books based on principled recontextualization strategies.

6.4 Conclusion

This study provides some linguistic evidence to support the distinction of at least three agnate explanation genres in school science books: transformational, realisational and orientational explanations. In so doing it suggests some modifications to the description of some of the range of explanation genres in secondary school science books proposed by Veel (in press, a; in press, b) and extends the work of Cross (1992) which described the category of explanations dealing with "cycles" in school science books.

The proposed description of schematic structure at the least delicate level (after Cross:1992) was ORIENTATION ^ IMPLICATION/DEDUCTION SEQUENCES ^ CLOSURE, which accommodated the variability of previous descriptions at this level. A further description at an intermediate level of delicacy took 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 was described in terms of Phenomenon Identification, Phenomenon Background and Explanation Preview and the CLOSURE in terms of Conclusion, Extension and Elaboration. It was the description of the IMPLICATION/DEDUCTION SEQUENCES at the intermediate level of delicacy which was peculiar to the different explanation types, such as the Conditions ^ Trigger ^ Transformation¹ elements in the *Linear Transformational* explanations of coal formation. Although this suggests a proliferation of explanation types beyond the range described by Veel (in press, a; in press, b), it does seem on the one hand, that the IMPLICATION/DEDUCTION SEQUENCES stage at a more delicate level of analysis distinguishes elements of schematic structure with their own distinctive discourse semantic and lexicogrammatical patterning, thus characterising different types of explanation. On the other hand, the least delicate account of schematic structure clearly encompasses the various explanation types identified to date, and the elements of structure revealed by analysis of the ORIENTATION and CLOSURE at an intermediate level of delicacy, also capture this commonality. The genre of explanation then, seems to be a broad category embracing a range of explanation types in the same way that story can be thought of as a generic grouping which embraces a range of different types of narrative.

The comparative analyses of secondary texts in the same Field in terms of schematic structure, discourse semantics and lexicogrammar, 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 the Fields of sound and the seasons, and two dealing

with coal, clearly harmonised these choices to produce 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, suggests that composing effective pedagogic explanations is an aspect of expertise which some authors exercise consistently, and which systemic linguistic analyses could bring to conscious awareness, thereby facilitating renovation of this kind of pedagogic writing by other authors.

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 one text in each of the coal and seasons Fields, the others provided functional approximations to the most effective secondary texts in these Fields. 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 shown not to be the case with realisational explanations of sound waves, and all of the primary texts in this Field offered extremely problematic explanations of this phenomenon. On the whole the primary texts compared poorly with the secondary texts in relation to linguistic choices designed to scaffold the novice reader's negotiation of the specialised language of school science.

An extension of the research undertaken in this study, 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 of the study to date already encompass productive bases for enhancing educational practices reflective of a "language-based theory of learning" (Halliday, 1993g; Wells, 1994). To a large extent the suggestions outlined for enhancing the teaching knowledge about language as technology for learning (6.3.1) and for developing critical reading (6.3.2) build on the application of linguistic knowledge and teaching strategies already incorporated in school syllabus documents in New South Wales and Queensland. But the results of this study also show that a more penetrating differentiation, selection and critique of different types of explanation in school science will be facilitated by more detailed knowledge of realisational choices at the levels of genre, discourse semantics and lexicogrammar. With the adoption by State Departments of Education of syllabi based explicitly on systemic-functional accounts of language and growing advocacy of functional linguistic descriptions of language as a technology for teaching and learning in publications such as the Australian Science Teachers Journal (Parker, 1992; Veel, 1992), it is increasingly likely that more teachers will be able to make direct use of the kinds of linguistic descriptions of scientific discourse advanced here.

From this perspective the contributions of the current study to clarifying and extending linguistic accounts of school science book explanations will further assist teachers in discriminating among science books, promoting students' critical reading, "talking out" science texts (Lemke, 1989) to bridge from the discourse forms of oral language and commonsense to those of written language and scientific knowledge, and in deconstructing the texts with students to teach knowledge about language as a means of improving their comprehension and composition of such texts. To the extent that the interface of research and practice characterising the transdisciplinary nature of educational linguistics embraces the range of relevant genres, continues to expand, is taken up in both primary and secondary school contexts, and is accompanied by the renovation of available science books, it will foster linguistically-based, explicit pedagogies that are facilitative of children's gradual apprenticeship to a critical engagement with the discourse of scientific English.

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Appendix 1

Secondary texts in original textbook format

SCOAL1

SEDIMENTARY ROCKS 127

This limestone has been mined for over 100 years and used as a building material (for houses etc.). It is very soft and is merely sawn into blocks. Figure 7.15a shows the cutting equipment being used, and Figure 7.15b shows the blocks stacked on pallets ready for transport and sale.

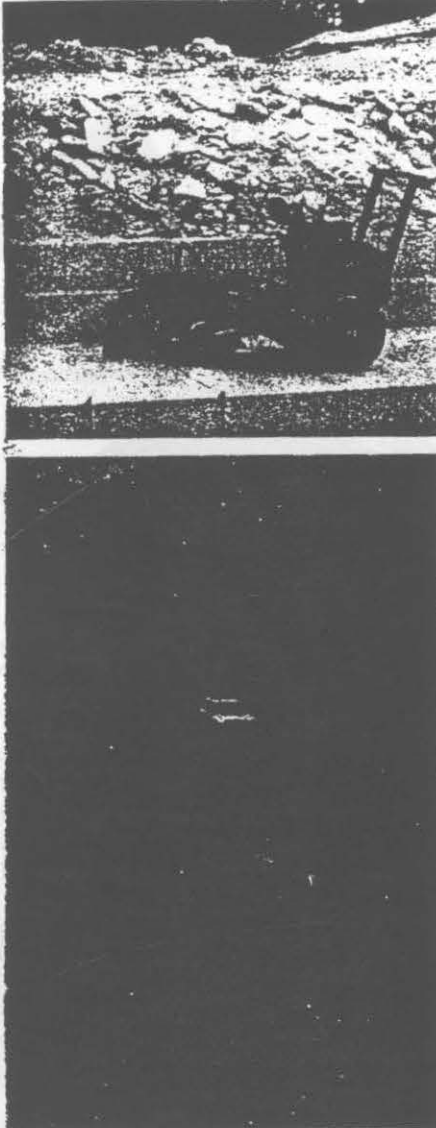


Figure 7.15(a) and (b): Mining corallite limestone at Mt Gambier (South Australia)

COAL

Coal is another very important biochemical sedimentary rock. It is formed from plant remains.

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.

However, if the plant material accumulates in a swamp where it is covered by water containing little or no dissolved oxygen, decomposition is prevented. The plant material will eventually be covered by layers of sediment. The weight of the sediment will compress the plant remains which will, with time, be transformed into carbon — coal. Thus coal is merely carbonised plant remains.

Australia has very large resources of coal: for example, Leigh Creek in South Australia, Yallourn in Victoria, Newcastle in New South Wales, Moura, Blackwater, etc. in Queensland.

Most of the coal in Australia is black, but the coal at Yallourn in Victoria is very young, in geological terms, and is brown in colour.



Figure 7.16: A coal seam (layer)

SCOAL2

ENERGY AND YOU

electricity is produced by burning fuels. The fuels, mostly coal, are burnt in order to change water to steam which drives the turbines that generate electricity. Can you think of some energy sources that are not, or do not need fuels?

The pie chart (or 'sector graph') in figure 9.7 shows energy sources used in Australia since 1985.

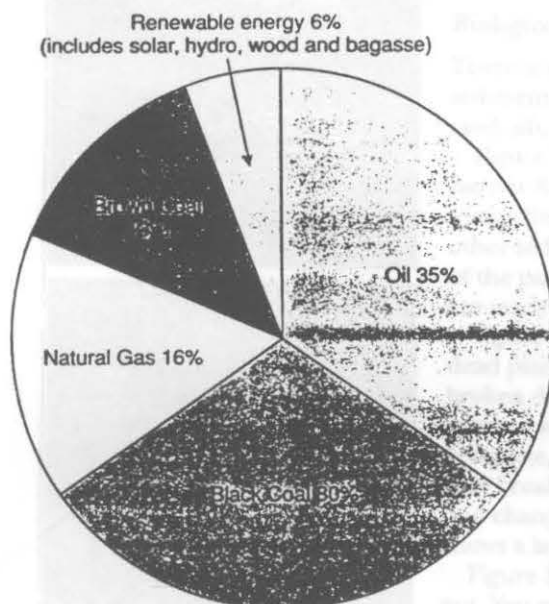


Figure 9.7: How Australians have been using energy since 1985 (Source: Department of Resources and Energy)

You can see that more than 90 per cent of our energy for living comes from under the ground. Most of that energy comes from coal, oil and natural gas. These three are called **fossil fuels** because they are formed from once-living organisms.

Coal

Coal was formed from the remains of plants buried by sediments. In ancient forests, which were warm and humid, layers of dead trees and other plants built up on the forest floor before they could rot. As the land sank these layers of vegetation were covered with water which deposited sediments of gravel, sand, mud and silt. Over millions of years the weight of the sediments and high temperatures removed much of the water from the plant remains. These plant remains are known as **peat**. As the peat was compressed and became warmer, moisture was driven out and it became brown coal, or lignite. In some places, more layers of sediment built up on top of the brown coal. This caused more and more moisture to be driven out and black coal was formed. Anthracite has the lowest moisture content of all types but it is rarely found in Australia.

Most of Australia's coal deposits are black coal although Victorian deposits are predominantly lignite (brown coal). After mining, both types can be used to generate electricity. Black coal has wider industrial use and is exported to other countries.

Some coal can be used to produce gas in areas where natural gas is not available. Coal can also be used to produce oil, but this is an expensive process. Since there is much more coal under the ground than oil, a lot of research is being conducted on producing oil from coal.

When layers of coal, or seams, are close to the surface, as in most Australian mines, open cut mining is used to extract the coal. Overlying rock and soil is blasted or dug away, exposing the coal seams, which can be mined in strips. This is cheaper and safer than underground mining.

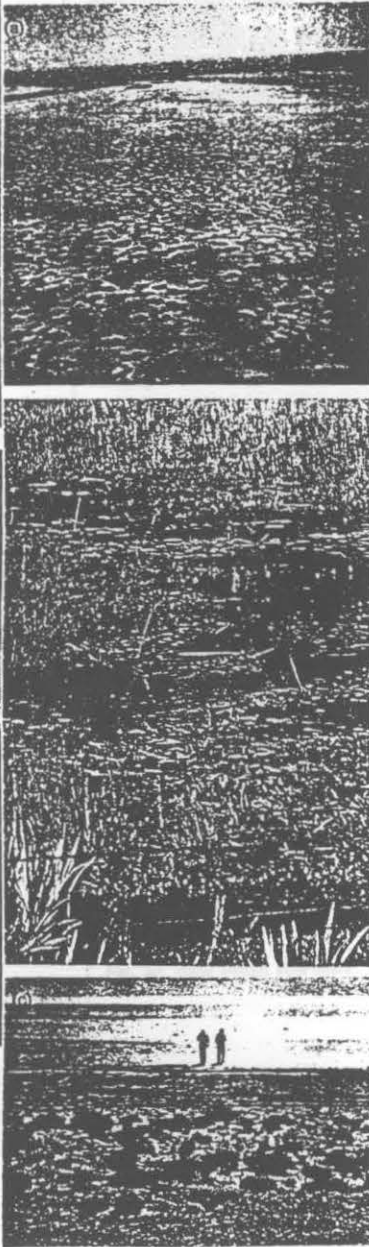


Figure 9.8: How coal is formed over millions of years

SCOAL3a

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Fig. 3.6 Biological and chemical sediments (a) The Great Barrier Reef. (b) Plant remains in a swamp. (c) Salt lake in a desert.



- 3 Give examples of as many of the sedimentary environments as you can (Figure 3.3).
- 4 How does a sediment change into a sedimentary rock?
- 5 What does 'the present is the key to the past' mean?
- 6 A geologist finds a rock made up of grains of mud. In it are several preserved pieces of plant leaves. What does this tell her?
- 7 How would you tell the difference between a sandstone and a siltstone?

Biological and chemical rocks

There are other places over the surface of the Earth where sediments are building up that are *not* mostly made up of gravel, sand, silt, mud or clay.

Figure 3.6 shows three such places. Figure 3.6a shows the Great Barrier Reef. Here, small animals are building up a solid *reef* that is mostly lime. These reefs are often preserved as rocks and, like other sedimentary rocks, tell us of past environments. Such reefs of the past are common in Australia, and the rock of which they are made is called **limestone**. Figure 3.7 shows such a rock.

Figure 3.6b shows plant material building up in a *swamp*. Usually dead plant leaves and stems, when they fall to the ground, are broken down and become part of the soil humus (see Chapter 2). In some swamps, however, it is possible that the breakdown is not complete, because the plant pieces are being produced faster than they break down. Layers of such plant remains can be squeezed and changed over millions of years into the rock, **coal**. Figure 3.8 shows a layer of coal.

Figure 3.6c shows a *salt* lake in central Australia that has dried out. You can see the layer of salt that has been formed. As this process continues, a layer of rock salt is built up. A layer of **rock salt**, then, will tell us the past environment of the place in which it is found. Rocks formed in these ways are also sedimentary rocks.

Overall, sedimentary rocks made up of either grains plus cement, or biological or chemical sediments are very common in Australia, as the map Figure 3.9 shows. Sedimentary rocks cover most of the surface of Australia. This means that if you dig through the soil layers (or beneath buildings and roads) in any of the shaded areas you will, most likely, reach a sedimentary rock. Some of these rocks formed many millions of years ago and others are sediments still forming today.

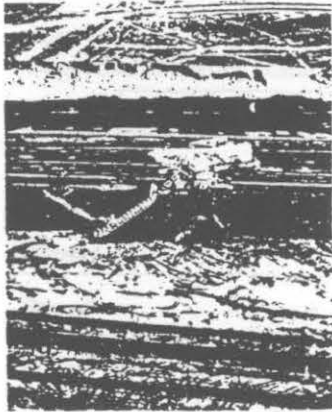


Fig. 30 Coal mining at Yallourn, Victoria This is open-cut mining, which is quite different from the mining shown in Figure 3.15a.

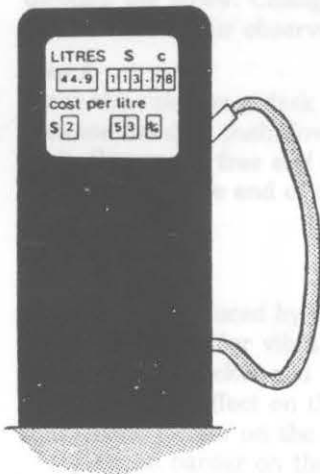


Fig. 3P How would you feel?

Fig. 3N Changing from peat to black coal

Box 3.4 Coal and the future

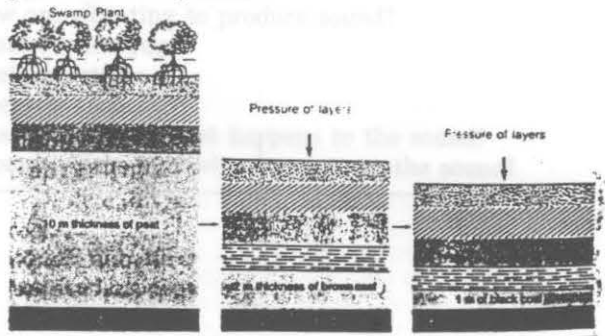
Coal deposits are very common in many areas of Australia. They all start as plant remains that are not fully broken down and put back into the soil. The first stage of the change to coal is peat, which is a watery, spongy black mass of plant material. (Peat can be dried and burnt in the same way as coal, but it does not give out nearly as much heat.) Large areas of peat 'bogs' may take millions of years to form. As other layers of rock are laid on top, the weight of these sediments squeezes the peat into brown coal, then into black coal. These two types of coal make better fuels.

The process is shown in Figure 3N. You can see that the squeezing can cause a 10 m thick bed of peat to form a 2 m thick bed of brown coal and eventually a 1 m thick bed of black coal. We are very lucky in Australia to have such large areas of coal. For example, the La Trobe Valley in Victoria has some of the largest brown coal reserves in the world. They are mined by huge machines as shown in Figure 30.

Australia's coal reserves are so large that some states in Australia should not run out of coal for at least 400 years as long as there is no waste of this fuel, and it is not used to replace other fuels as they run out. Should we, for example, use coal to make oil, a process that results in the loss of a lot of the fuel value of the coal and greatly reduces the likely life of our coal reserves?

The problem we face in the use of our coal in the future comes from the certain shortage of oil, another fuel, over this and the next decade or so. We now use oil for a very wide range of jobs (for example transport, heating, plastics, drugs), and we will need to decide which of these are the most important as oil prices keep on rising. (There may be some falls in prices, but over long periods of time the prices are rising steadily.) Can we keep on letting it be burnt to move just one person around? Will we be able to afford to buy it at all from the countries that still have some left?

Both coal and oil are 'fossil fuels', which means they formed in the past and we will not be able to make any more once they are gone for good. What would you do?



SSND1

PROCEDURE

Step 1

Copy the following results table into your practical notebook.

	Observations
Step 2	
Step 3	
Step 4	

Step 2

Hold the folded bus ticket against your lips and blow. Try adjusting:

- how hard you hold the ticket against your lips
- the width between your fingers as they hold the ticket
- how hard you blow.

Record your observations.

Step 3

Place the split end of the straw in your mouth. Clamp your lips (but not your teeth) on the straw so that the split ends of the straw just meet. Blow through the straw. Change how hard you clamp the straw and how hard you blow. Record your observations.

Step 4

Place the ruler on a desk or bench so that most of it projects beyond the desk. Use one hand to push down on the ruler about 2 cm from the edge of the desk. Strum the free end of the ruler with your other hand. Change the length of the free end of the ruler and how hard you strum it. Record your observations.

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 the sound when you
 - (a) blow harder on the ticket and 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?

What causes and transmits sounds?

To make sounds requires vibrations which disturb the air. Small vibrations cause soft sounds. Large vibrations disturb the air more to produce loud sounds.

Vibrating materials produce sound.

Vibrating materials send sound waves through the air. As the materials vibrate

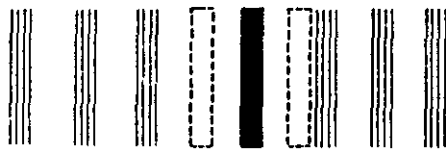
SSND1 (cont.)

SOUND 281

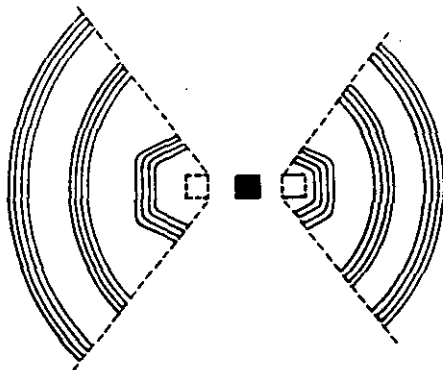
they disturb the air particles near them. These air particles disturb other air particles, and so on. Just like a long chain of dominoes the disturbance or sound wave is passed on from air particle to air particle. Unlike the dominoes, the air particles spring back to their original position.

Sound waves travel through gases, liquids and solids because they all contain particles which will carry or transmit disturbances. However, sound waves will not travel through a vacuum which is an empty space: without particles to transmit the disturbance from a vibrating object, sound waves cannot be formed.

Figure 15.1 shows a vibrating object producing sound waves. As the object moves to the right it pushes or compresses the air particles next to it. The compressed air particles then push on the particles to their right and compress them. As each air particle pushes on the next one to its right the compression travels through the air. When the vibrating object moves back to its left the air particles next to it are no longer being pushed. They spread out or are stretched apart. As a compression travels through the air it is followed by the stretching apart of air particles.



(a) Side view



(b) Top view

Figure 15.1: Sound waves

Because the vibrating object continually moves back and forth a series of compressions and stretchings of air particles is sent out from the object. These compressions and stretchings make up a sound wave. The vibrating object focuses most of the sound waves in the general direction of its vibrations. However, bending of the edges of the sound waves has the effect of sending them out in all directions around the vibrating object. This is shown by the top view of the vibrating object in figure 15.1. The same process can occur with the particles in a liquid or a solid so that they will also transmit sound.

Sound needs a material for its transmission.

In activity 15.1 you would have found out that small vibrations produce soft sounds. The larger the vibration, the louder is the sound it produces. Scientists use the term **amplitude** to describe the size of the vibration or how far the vibrating object moves from its original position during a vibration.

The amplitude of a sound wave will be larger for loud sounds.

The rate at which an object vibrates to produce sound wave is called its **frequency**. In activity 15.1 you would have found that the faster an object vibrates the higher is the sound it emits. Low or deep sounds are emitted by slowly vibrating objects. Scientists use the term **pitch** to describe how high or low a sound is.

The pitch of a sound wave will be higher for faster vibrations.

The frequency of vibrations is measured by the number of vibrations per second and is given the unit of a **hertz (Hz)**. A tuning fork has its frequency marked on its handle. You can hear the pitch of a tuning fork by hitting it on the rubber heel of your shoe and holding its handle on your desk. The higher the frequency of the tuning fork the higher is the pitch of its sound. Another way of hearing the effect of frequency is to hold the vibrating tuning fork gently against a loose sheet of paper.

SSND2



Fig 8.30 The string is passed through holes punched in the bottom of the tin and knotted. The sound passes through the taut string from one tin to the other.

The energy from the vibration of bodies causing sound is passed through a substance in the form of waves which travel at a *constant speed* through each particular substance. (This is true only if the temperature is constant — as temperature increases, the speed increases.)

Speeds of Sound

Substance	Speed of sound
air (at 0°C)	332 m/s
water (at 20°C)	1410 m/s
steel (at 20°C)	5020 m/s

Sound as a Wave Motion

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

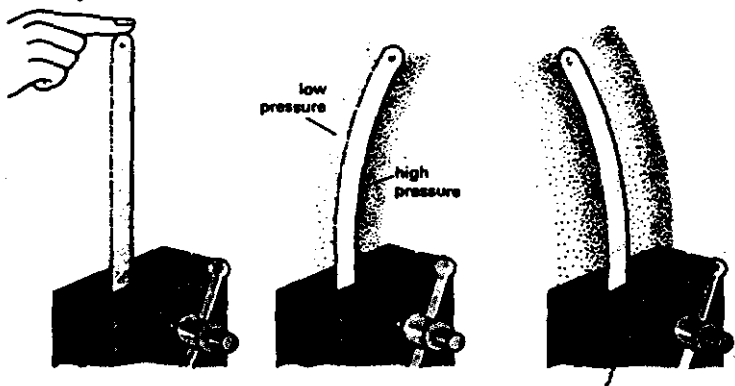
Fig 8.31 shows how pressure differences are produced in the air around a vibrating hacksaw blade. As the high-pressure area is produced, the air molecules move out to the lower pressure area in front of them, increasing the pressure there and reducing the pressure behind them. The high-pressure areas (= **compressions**) and low pressure areas (= **rarefactions**) both move outwards from the blade.

A loudspeaker works in much the same way, vibrating forwards and backwards producing compressions and rarefactions which move out through the air in the room. It is important to note that the *air molecules move backwards and forwards* as the

Fig 8.31 A hacksaw blade is clamped in a vice and 'plucked'.

As the blade moves to the right (*middle diagram*), it compresses the air molecules producing a high-pressure area in the direction of motion, and a low-pressure area on the other side.

As the blade flicks back (*right diagram*), a new high-pressure area is produced on the left, a new low-pressure one on the right.



compressions and rarefactions are transmitted outwards *but the air as a whole does not move* — winds are not set up.

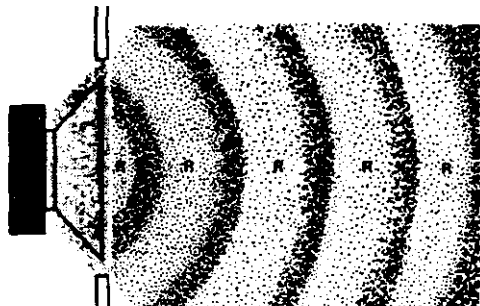


Fig 8.32 A loudspeaker produces rarefactions (R) and compressions (C) which move through the air.

The Ear — How We Hear

The waves of compression and rarefaction which make up the sound are collected by the **pinna** and funnelled into the **auditory canal** where they strike the **eardrum** causing this thin taut skin to vibrate. The vibration is transferred to three movable bones in the middle ear, the **hammer**, **anvil** and **stirrup**. The movement of these magnify (= **amplify**) vibrations and carry them to the **oval window** which passes the vibrations into the fluid-filled **cochlea** in the inner ear. Special sense cells respond to the vibrations in the fluid, sending nerve impulses through the **auditory nerve** to the brain which interprets the nerve impulses as sound.

The **round window** is a 'safety valve' to minimise pressure effects in the cochlea. As the oval window vibrates *in*, the round window bulges *out*; and vice versa.

SSND3

(Figure 5.17a). What happens to a piece of paper placed on the rubber band when it is plucked? How can you change the 'note' produced when the rubber band is plucked?

- 3 Place a ruler over the edge of your desk, and hold the desk end firm (Figure 5.17b). What happens when you push the other end down a short distance and then let go? What causes the sound? How can the 'note' produced be changed?
- 4 Fold a piece of greaseproof paper over a comb. What happens when you blow with your lips close together (Figure 5.17c)? What causes the sound?
- 5 Blow over the end of a large test tube. What happens to the 'note' produced if you half fill it with water?

Sound waves

You have just seen a number of sources of sound, many being produced in a way similar to that of musical instruments. In each case, a **vibration** was needed to produce the sound. Further activity 6 shows how, using a strobe, vibration can be slowed down enough to be seen.

If we look at how a tuning fork produces sound we can learn what sound is and how it moves. By looking closely at one of the prongs you can see that it is moving to and fro (vibrating) (Figure 5.18). As the prong moves outwards, it squashes (compresses) the surrounding air. The particles of air are pushed outwards, crowding against, and thus knocking 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 air goes 'thinner' is called a **rarefaction**, and it 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.

The types of vibration used in musical instruments to produce sound will be studied later. Other interesting sources of sound include sirens and horns. Electric car horns use an electromagnet (see Books 1 and 4) to make a thin sheet of metal vibrate rapidly.

Movement of sound

When sound waves are moving away from their source, we say that the sound is being **transmitted**. An experiment will show us the types of substances through which sound can travel.

Vibrations, Waves and Sound 145

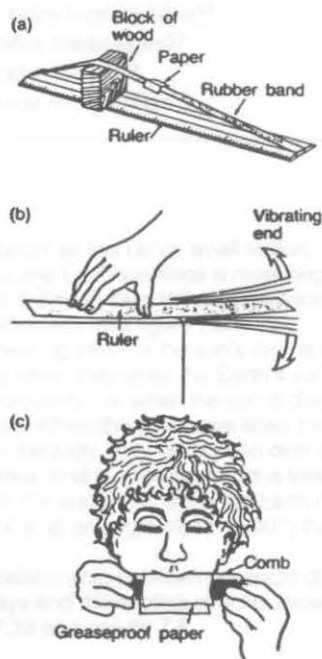


Fig. 5.17 Producing sound
a What happens to the paper as the rubber band is plucked?
b What happens to the sound produced as the length of the vibrating ruler is changed?
c What happens when you blow on the paper?

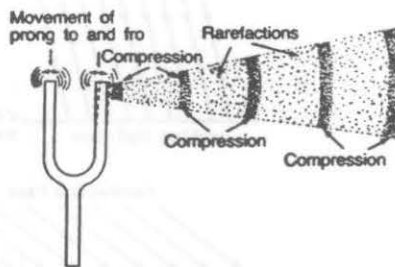


Fig. 5.18 How a tuning fork produces sound The regions of slightly compressed air move away from the sound source.

SSEAS1

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- 2 Does the direction of the horns of the moon change over the period of a lunar month?
- 3 During what phase or phases are the 'highest' high tides (spring tides)?
- 4 During what phase or phases are the 'lowest' low tides (neap tides)?
- 5 During what phase or phases do the greatest tidal ranges occur?
- 6 Draw the relative positions of the sun, Earth and moon for question 3.

Seasons of the Earth

The Earth rotates about its axis which is not vertical but tilted at an angle of $23\frac{1}{2}^\circ$. The angle and direction of tilt of the Earth's axis remain the same as the Earth moves around the sun.

The tilt of the Earth's axis gives rise to the seasons and the varying lengths of day and night at different times of the year. Day lengths and temperatures depend on how long the sun shines and the angle at which the sun's rays strike the Earth.

If you take a smooth, shiny ball and shine a torch on it you will notice that the half facing the torch is lit up. The surface is lit most brightly directly in front of the torch. Although the remainder of that half is illuminated, it is

not as bright as this rather small region. Similarly, the Earth's surface is most brightly lit where the sun's rays strike the surface perpendicularly (see figure 7.23).

The heating effect of the sun's rays is also greatest when they strike the Earth's surface perpendicularly, i.e. when the sun is directly overhead. When the sun's rays strike the surface obliquely, they are spread over a larger area, and the heating effect is less. In summer, the sun's rays strike the Earth more directly (i.e. at an angle closer to 90°) than in winter.

This relationship between the angle of the sun's rays and the heating effect is shown in figure 7.23 and activity 7.6.

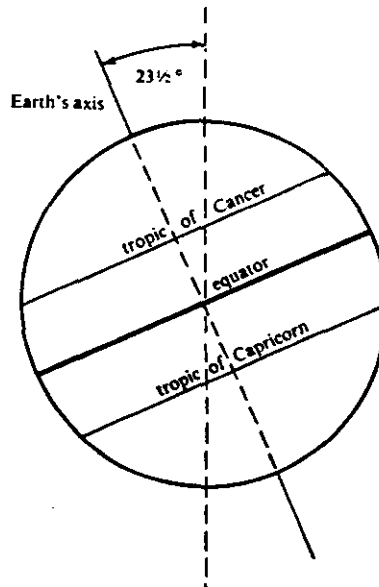


Figure 7.22 Tilt of the Earth's axis.

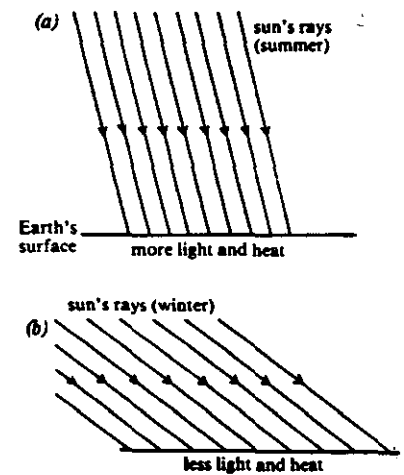


Figure 7.23 The sun's rays striking the Earth's surface, (a) in summer, and (b) more obliquely, in winter.

SSEAS1 (cont)

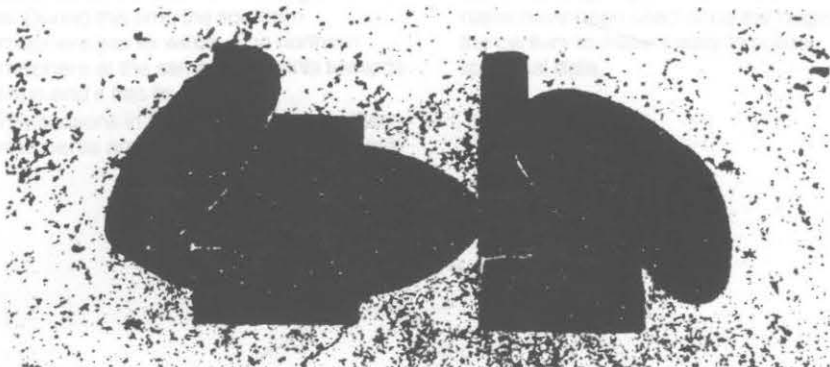
ACTIVITY 7.6**The angle of the sun's rays and their heating effect****MATERIALS**

2 tin lids at least 10 cm in diameter and painted with some dull black paint

2 blocks of wood to act as supports for the lids

PROCEDURE*Step 1*

Set up the two lids, in direct sunlight, as shown in the photograph.



Ensure that one lid faces directly towards the sun so that the sun's rays strike it perpendicularly. The other lid is placed so that the sun's rays strike it obliquely.

Step 2

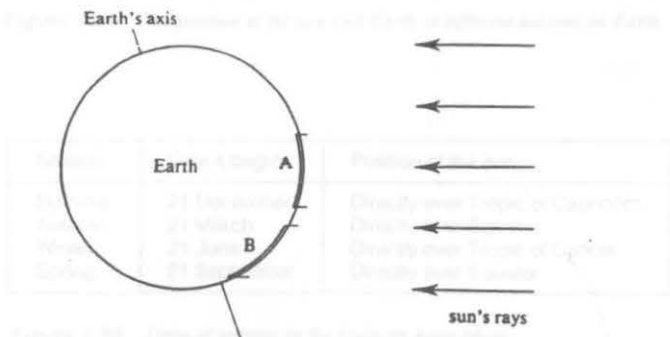
Leave for about fifteen minutes.

Step 3

Pick up the lids, one at a time, and carefully touch them to your arm. Note which lid is hotter.

QUESTIONS

- 1 Which lid was the hotter?
- 2 Why was this lid hotter than the other?
- 3 This is exactly what happens to any piece of ground on the surface of the Earth. In the diagram below, would you expect region A or region B to be the hotter? Explain your answer.



SSEAS1 (cont)

140 THE SOLAR SYSTEM

As a result of the tilt of the Earth's axis, the southern hemisphere is inclined towards the sun in December and away from the sun in June (see figure 7.24). When the southern hemisphere tilts towards the sun, it receives more of the sun's rays at an angle closer to 90° , and it experiences summer. During this time the northern hemisphere points away from the sun and is experiencing winter.

When the southern hemisphere tilts away from the sun, most of the sun's rays strike the surface obliquely and their heating effect is less. During this time the southern hemisphere has its winter. The northern hemisphere at the same time points towards the sun and it has its summer.

The seasons in the southern and northern hemispheres are always the reverse of each

other. When one hemisphere points toward the sun, the other must point away from the sun. Between the two extremes of summer and winter, the two hemispheres are more or less equally heated by the sun and they experience spring or autumn. The dates of the beginnings of the seasons in the southern hemisphere and the position of the sun at these times is given in figure 7.25. In Australia, summer officially begins on December 1, autumn on March 1, winter on June 1 and spring on September 1. These dates have been used since the beginning of the century to make it easy to collect statistical data.

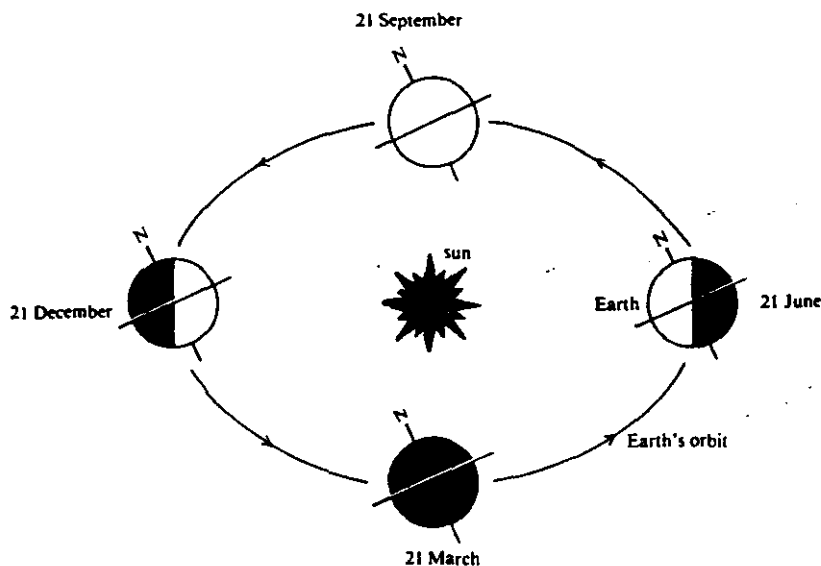


Figure 7.24 The position of the sun and Earth at different seasons on Earth.

Season	Date it begins	Position of the sun
Summer	21 December	Directly over Tropic of Capricorn
Autumn	21 March	Directly over Equator
Winter	21 June	Directly over Tropic of Cancer
Spring	21 September	Directly over Equator

Figure 7.25 Dates of seasons in the southern hemisphere.

Seasons and the Earth's movement

As the Earth rotates, it also moves in space around the sun. This movement is called **revolution** and the path around the sun is called an **orbit**. It takes $365\frac{1}{4}$ days for each revolution. This time interval is called one year. To avoid having the inconvenience of a quarter of a day at the end of each year, the calendar has 365 days in a year. To make up for the missing quarter day, every fourth year is called a leap year and has 366 days.

DID YOU KNOW?

The Earth is rotating through space in a clockwise direction. The Earth's axis is tilted at an angle of about 23.5 degrees to the perpendicular of its orbit around the sun.

It is the Earth's revolution around the sun that gives us our seasons: autumn, winter, spring and summer. As seen in figure 10.9, the Earth's axis remains tilted in the same direction throughout its orbit. This tilt is therefore sometimes towards the sun while at other times away from the sun.

While the southern hemisphere experiences summer, the northern hemisphere is experiencing its winter. It can also be seen in figure 10.10 that in our summer, the South Pole is in constant daylight and the north pole is in constant darkness. In winter, the reverse is true.

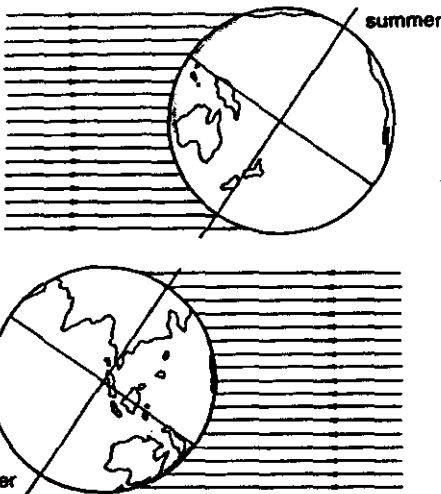


Figure 10.10: In our summer, the surface faces the sun directly. The rays of the sun are spread over a smaller area than in winter. This makes the ground hotter. In our winter, the surface faces the sun less directly than in summer.

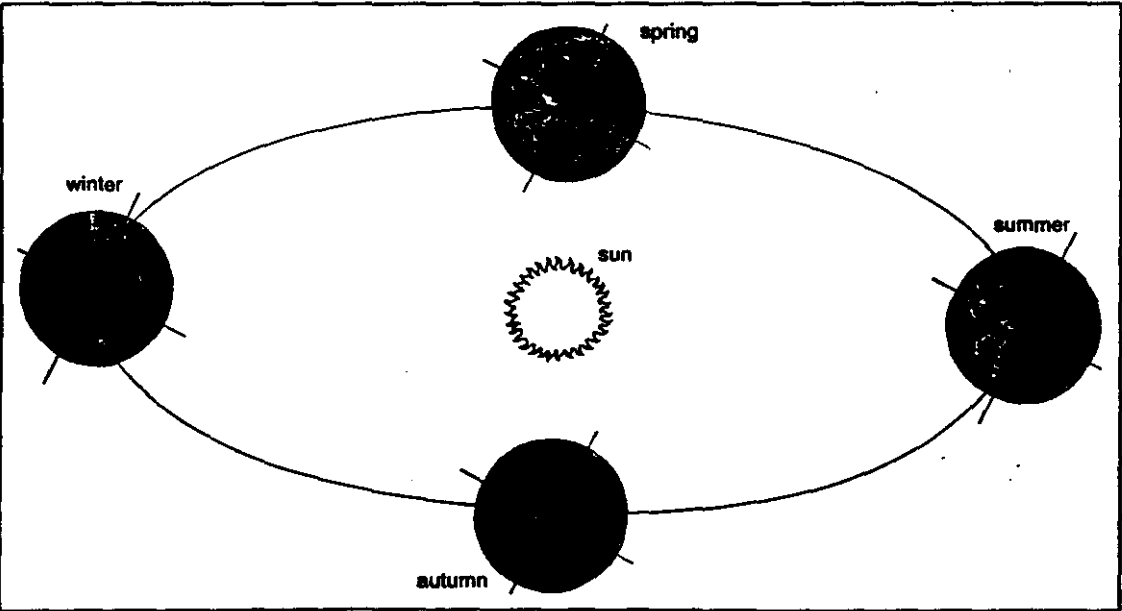


Figure 10.9: Australia experiences summer when the northern part of the Earth's axis is tilted away from the sun. Australia experiences winter when the northern part of the Earth's axis is tilted towards the sun. During spring and autumn the axis is tilted neither towards nor away from the sun.

SSEAS2 (cont)

JACARANDA SCIENCE AND TECHNOLOGY

Figure 10.10 shows that when the northern part of the Earth's axis is tilted away from the sun, the southern hemisphere faces the sun more directly. In winter the southern hemisphere faces the sun at a large angle. The sun's rays are spread out over a large area.

Activity 2

The sun and the seasons

In this activity you will find out how the constant tilt of the Earth's axis affects our seasons.

You will need:

- projector or torch
- globe
- a darkened room
- small sticky labels

What to do:

1. Copy table 10.1 into your workbook.
2. Place a sticky label on the globe in the place where you live. Write 'S' for south on the label.
3. Place a second sticky label on the globe about the same distance north of the equator as you are south. Write 'N' for north on this label.
4. With the top of the Earth's axis tilted towards the projector as shown in figure 10.11, rotate the globe slowly through one turn. Record your observations in table 10.1.

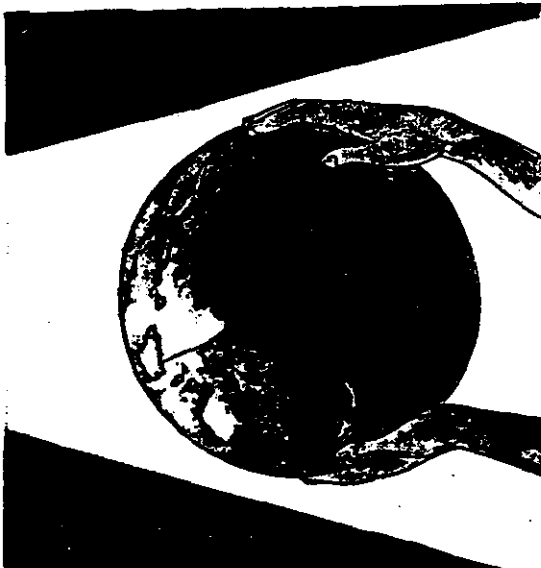


Figure 10.11: The projector represents the sun. Tilt the top of the axis towards the projector.

- (a) Which label experiences the longest 'day'?
 - (b) Which label experiences the longest 'night'?
 - (c) Which label receives rays from the 'sun' most directly?
 - (d) Which label appears to be the brightest?
 - (e) What season does this represent in the southern hemisphere?
5. Repeat step 4 with the top of the Earth's axis tilted away from the projector.
 6. Repeat step 4 with the top of the Earth's axis tilted neither towards, nor away from the projector.

Table 10.1: The sun and the seasons

Step	Position (South or North)		
	4	5	6
longest 'day'			
longest 'night'			
rays most direct			
brightest position			
season/s in southern hemisphere			

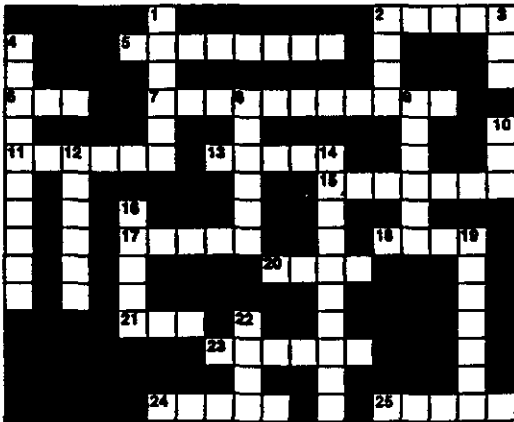
What did you discover?

In which season are the days longest? In which season are the nights longest? When days are longest where you live, what season is it in the northern hemisphere? During which season do the sun's rays strike the Earth most directly? Why do you think that it is hotter in summer than in winter?

REVISION AND EXTENSION

REVIEW QUESTIONS

1. Copy the following crossword into your workbook and complete it.



SSEAS3

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Fig. 2.9 The seasons (Right) During winter in Australia, the northern half of the Earth is tilted towards the Sun. During our summer, the southern half is tilted towards the Sun.

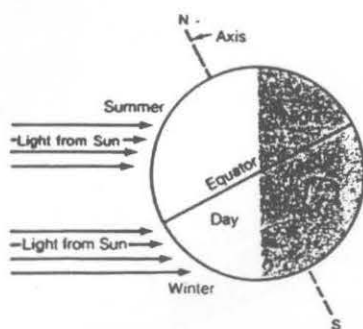


Fig. 2.10 Sunlight and the seasons Because of the Earth's tilt, the rays of light from the Sun are spread over a much larger area in winter than in summer.

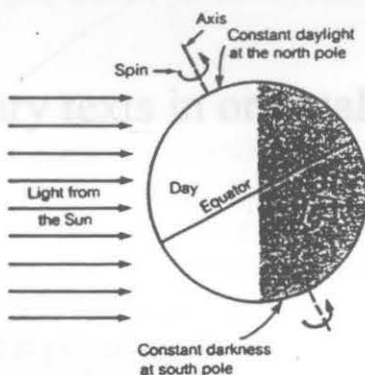
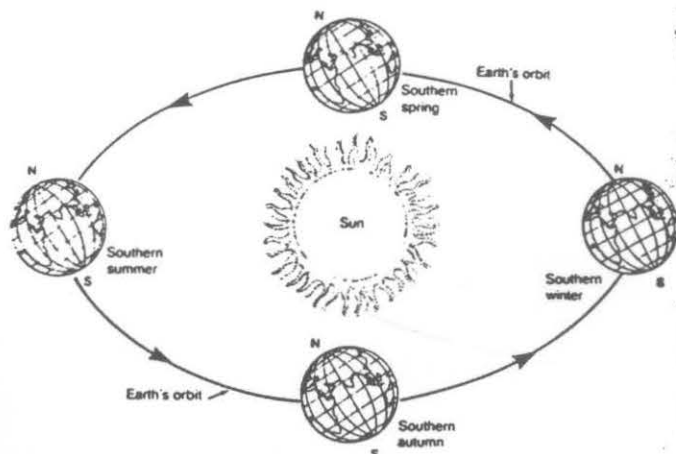


Fig. 2.11 Twenty-four hour daylight During the southern winter, the south pole is unable to receive light from the Sun and so is constantly dark. At the north pole, sunlight is always present at this time of year.



The seasons

You may have seen (Figure 2.6) that the Earth is drawn with its axis 'tipped over' or **tilted**. The angle of tilt is $23\frac{1}{2}^\circ$. As the Earth moves around the Sun, the axis always points to the same place in the sky. This is called the **celestial pole**. Straight above the north celestial pole is the star Polaris, which is called the 'pole star'. The south celestial pole is between the Southern Cross and the star Achernar (Figure 2.55).

The different distances to the Sun caused by the tilting axis of the Earth is *not* the cause of the **seasons**. They are due to the rays of light from the Sun being spread over much larger areas of the Earth's surface in winter when compared to summer (Figure 2.10). This means that the part of the Earth closest to the Sun has more rays for a given area and experiences summer. The area further away from the Sun has fewer rays for the same area and is thus cooler, experiencing winter. The position is reversed each six months (Figure 2.9). Autumn and spring occur when Earth is halfway between the summer and winter positions on its orbit.

Living at the poles

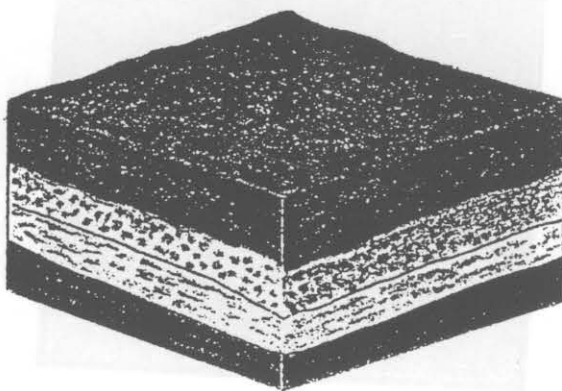
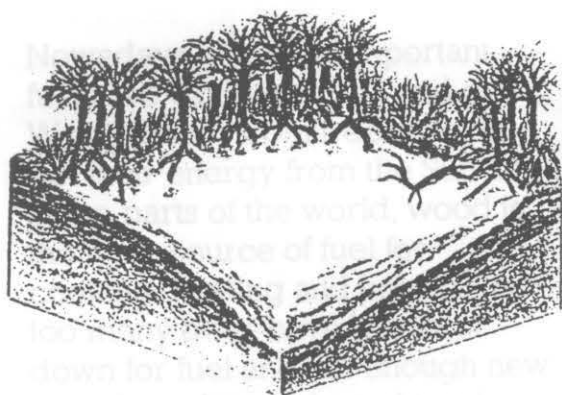
If you were to live in the Arctic (near the north pole) or the Antarctic (near the south pole), you would find the Sun does not go down or set for many weeks. If you were right at the poles, daylight lasts for six months, and then night lasts for six months. These long days and nights are also caused by the tilt of the Earth's axis (Figure 2.11). During summer in the southern hemisphere, the tilt of the Earth causes the south pole to be always in sunlight. At the same time, the north pole is always in darkness. This is changed around each six months.

Appendix 2

Primary texts in original information book format

PCOAL1

Minerals

The formation of coal.**Common Minerals**

Some of the best known minerals include coal, copper, diamond, gold, iron, petroleum and natural gas, nickel, platinum, salt, and uranium.

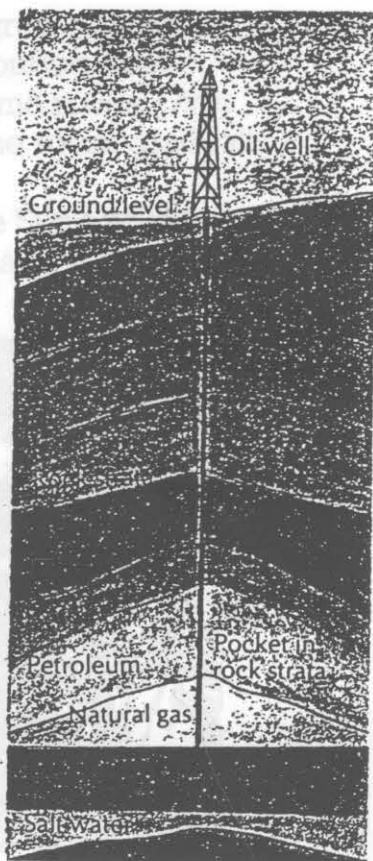
Coal

Coal is a sedimentary rock made up almost entirely of decayed plants and animals. Coal is formed in such places as swamps. As the plant and animal matter that falls into the swamp decomposes over time, it is turned into peat. As more layers of material are added on top of the peat, greater pressure is placed on the layers underneath. It is this pressure that turns the peat into coal.

Coal is a fossil fuel. It is useful to humans as a source of heat. Humans use the heat produced by burning coal in power stations, where it is used in the process of producing electricity.

Petroleum and Natural Gas

Like coal, petroleum and natural gas are fossil fuels and are formed in a similar manner to coal. Today's great demand for energy has meant that a shortage of these minerals has developed.

*Obtaining petroleum.*

PCOAL2

RICHERS OF THE EARTH

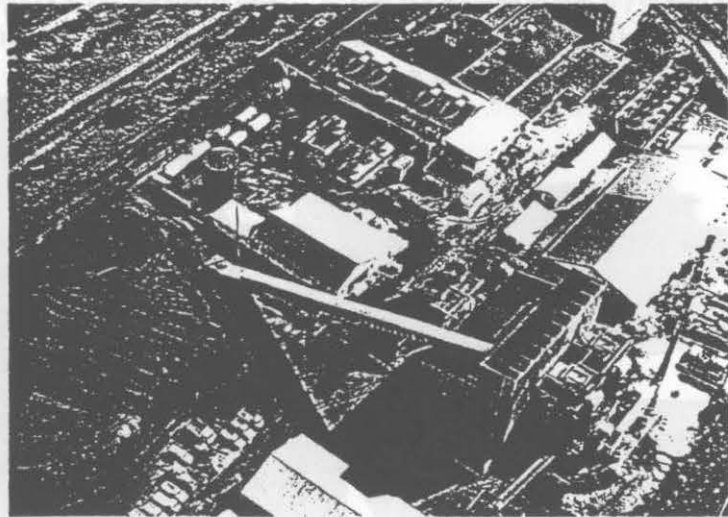
All the details we use are taken from
 Most of them are found combined with
 substances, in rocks called ores, and

Nowadays, the most important fuels are wood, coal, oil and gas. Wood comes from trees, which get their energy from the Sun. In some parts of the world, wood is the main source of fuel for cooking, heating and lighting. But too many trees have been cut down for fuel and not enough new trees have been planted to take their place.



Coal is formed from the remains of plants that grew millions of years ago. When these plants died, they were buried under layers of mud and sand, which eventually became rocks. Over vast periods of time, heat and the pressure of the rocks gradually changed the plants into coal.

When we burn coal, we are using some of the Sun's energy which was stored in the bodies of plants millions of years ago. Coal is a type of "fossil fuel".



RICHES OF THE EARTH

All the metals we use are taken from the Earth. Most of them are found combined with other substances, in rocks called ores, and have to be extracted before they can be used. Some, like gold and copper, may be found as the pure metal.

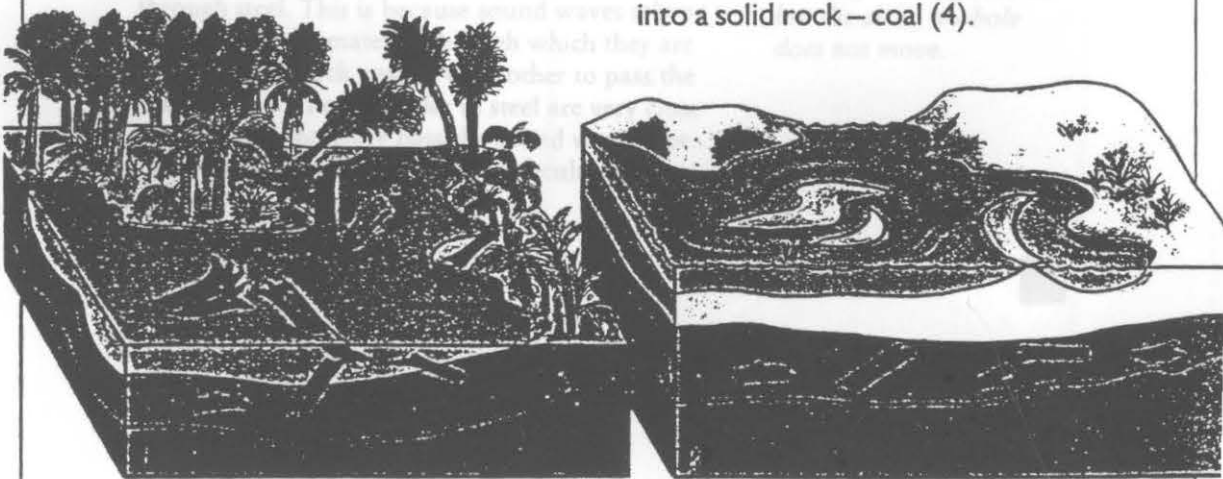
Many of the fuels we use, like coal, gas and oil are also taken from the Earth. These are called "fossil fuels". Coal is usually dug out of the ground. Gas and oil are obtained by drilling deep holes in the Earth, and carrying the gas or oil through a pipe to where it is needed.

Rocks in the Earth's crust can often be used for specialised jobs. For example, one rock called "mica" is found in thin, transparent sheets. It can be used to make windows in high-temperature ovens, where glass would melt.

How coal was formed

Coal has formed over millions of years from the remains of ancient forests growing on swamps (1). As forest trees and plants died, they fell into the swamps

forming layers of dead vegetation. Later, sedimentary rocks formed on top of these layers (2). The pressure caused by the rocks made the layers of vegetation denser and harder (3), and formed them into a solid rock – coal (4).



What is Sound?

Sound is anything that can be heard. The rustling of leaves, the beat of a drum, the bark of a dog—all of these things are sounds.

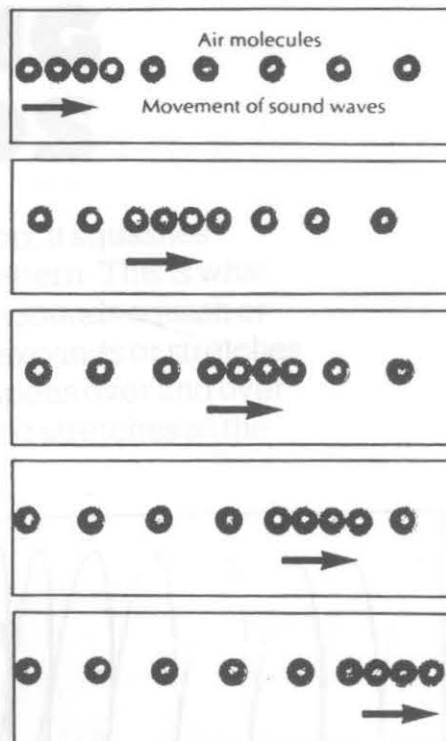
Sound Waves

When we bang two pieces of wood together we make them vibrate. When we hit a drum we make the surface, or skin, of the drum vibrate. If you touch the skin of a drum while it is being hit you will feel the skin vibrating.

If we throw a rock into a pond we can watch the 'waves' that spread outwards from the point at which the rock lands. The bigger the rock, the bigger the waves and the further they travel. A similar thing happens when an object vibrates.

When an object vibrates it causes particles, or molecules, in the air to bounce against each other, thereby causing other molecules to do the same. These waves of moving molecules travel through the air until they no longer have the strength to move the next molecule. They are called *sound waves*. As the sound waves get weaker the sound gets softer until it disappears completely. The strength of the initial vibration affects the distance the sound waves will travel.

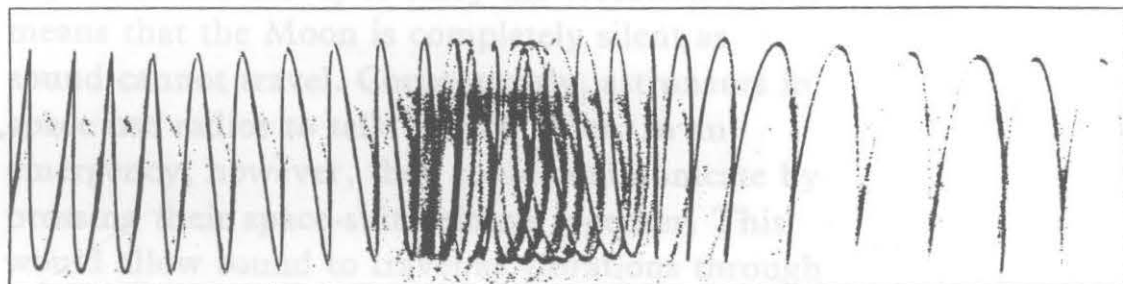
Sound waves travel at different speeds through different materials. Sound travels slowly through air, quickly through water and even more quickly through steel. This is because sound waves rely on molecules in the material through which they are travelling to knock against each other to pass the waves along. The molecules in steel are very close together and therefore pass the sound wave a lot more quickly than air. Air has molecules that are spaced further apart.



Sound waves disturb the molecules as they pass through the air. The molecules knock into each other, vibrating backwards and forwards in a regular manner. The waves go through the air but the air as a whole does not move.

MAKING SOUNDS

If you shake a "slinky" up and down on a table top, it squashes together and stretches out again in a regular pattern. This is what happens to the air when sounds are made. The sounds squash or press together a package of air and when this expands or stretches out again, it squashes the air next to it. This happens over and over again, producing a whole series of squashes and stretches as the sound is passed through the air.



Because sounds have a regular pattern or frequency, like the waves on the sea, they are called sound "waves". But sounds are really very small changes in the pressure of the air.

We cannot see sounds, but we can hear them when our ears pick up the changes in air pressure (see pages 22-25). When you clap, you squash air between your hands and the changes in air pressure make the sounds you hear.



HOW SOUND TRAVELS

Sound travels through the air by spreading out in a series of ripples, like ripples on a pond. These ripples are called "sound waves", and are caused by the air vibrating. In fact, sound can travel through any substance. This means that you can hear sounds underwater. You can even hear a sound travelling through wood if you put your ear to a table-top and tap a spoon on the table.

On the Moon or in space, there is no air (or any other substance) to carry the vibrations. This means that the Moon is completely silent as sound cannot travel. Consequently, astronauts in space use radios to talk to each other. In an emergency, however, they could communicate by pressing their space-suit helmets together. This would allow sound to travel as vibrations through their helmets and through the air inside.



Sound waves

Musical sounds make a series of regular waves. The size of the vibration is called the "amplitude", and the distance between any two waves is called the "wavelength". Noise is like a mixture of lots of different sounds and it has no definite wavelength.

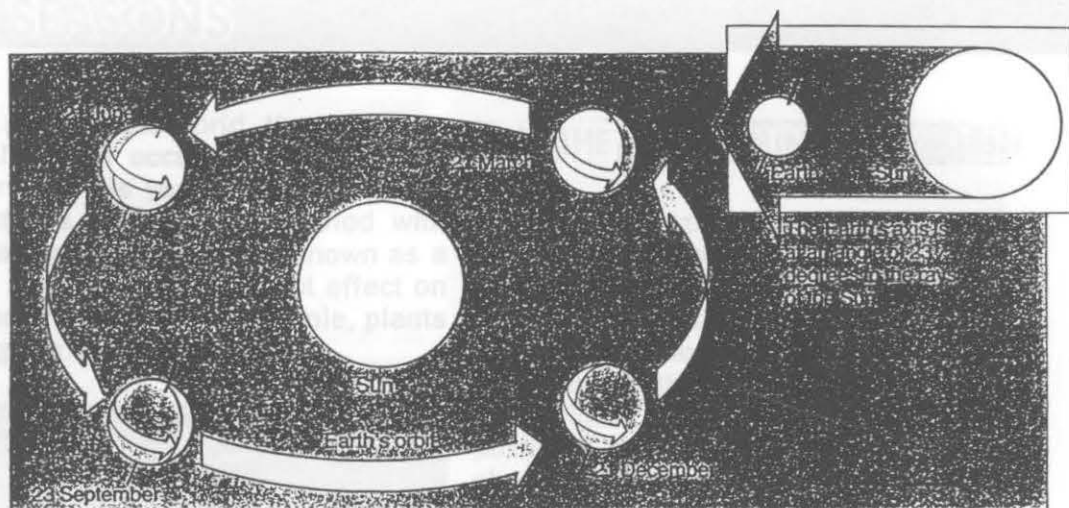
Noise sound wave



Music sound wave



PSEAS1



To discover the cause of the seasons we must look again at the Earth in its orbit around the Sun. The Earth travels once round the Sun each year. It is also spinning on its own axis, once every 24 hours. As it spins, one side of the globe is lit by the Sun and is in daylight; the other side is turned away from the Sun and is in darkness.

If the Earth's axis were upright, compared with its path around the Sun, day and night would be the same length all over the world, and there would be no seasons. But the Earth's axis is not upright. It is tilted over at $23\frac{1}{2}$ degrees so that the globe is unevenly lit. In midsummer, when the Earth is at one end of its annual journey, the northern hemisphere is tilted towards the Sun. The days are long and the nights are short. North of the Arctic Circle the Sun never sets.

In winter, at the opposite end of the journey, the northern regions are tilted away from the Sun. Nights are long, and the days short and cool.

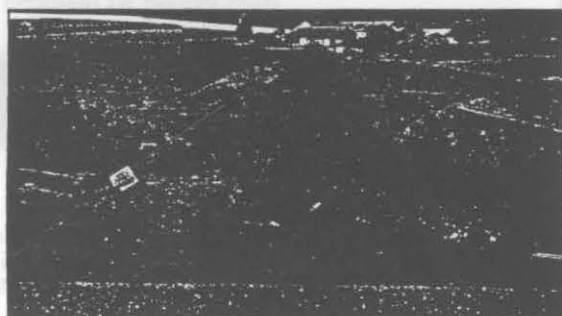
The tropical regions, close to the Equator, are evenly lit at all times of the year and so have hardly any seasonal changes.

△ The small diagram above shows how the tilt of the Earth's axis causes the globe to be lit unevenly by the rays of the Sun.

The larger diagram shows the Earth's annual journey around the Sun. In June it is summer in the northern hemisphere and winter in the southern hemisphere. September is autumn in the north, but spring for those living south of the Equator. By December it is the turn of the southern hemisphere to face the Sun, while the northern regions shiver through their winter. And in March the cycle is completed, with spring in the north and autumn in the south.

4 THE SEASONS

In many parts of the world, the main type of weather that occurs changes during the course of the year (as shown in the four pictures below). Each period with particular type of weather is known as a season. Seasons have a direct effect on plant and animal life; for example, plants start to grow in spring seasons.



ALL THE YEAR-ROUND

Seasons are the result of the tilt of the Earth as it orbits round the Sun. At one end of the Earth's orbit, the North Pole is pointing towards the Sun and the Northern Hemisphere has its hot summer and the Southern Hemisphere has its cold winter. Six months later, the opposite is true. In between, the weather changes during spring and autumn.

These seasons happen because the Sun's rays are spread more thinly in parts of the world tilted away from the Sun (in winter). Also, the length of each day is shorter. The opposite is true when that part of the Earth is tilted towards the Sun in summer. (Compare this to the reason why the poles are cold on page 8.)

Winter in Northern Hemisphere

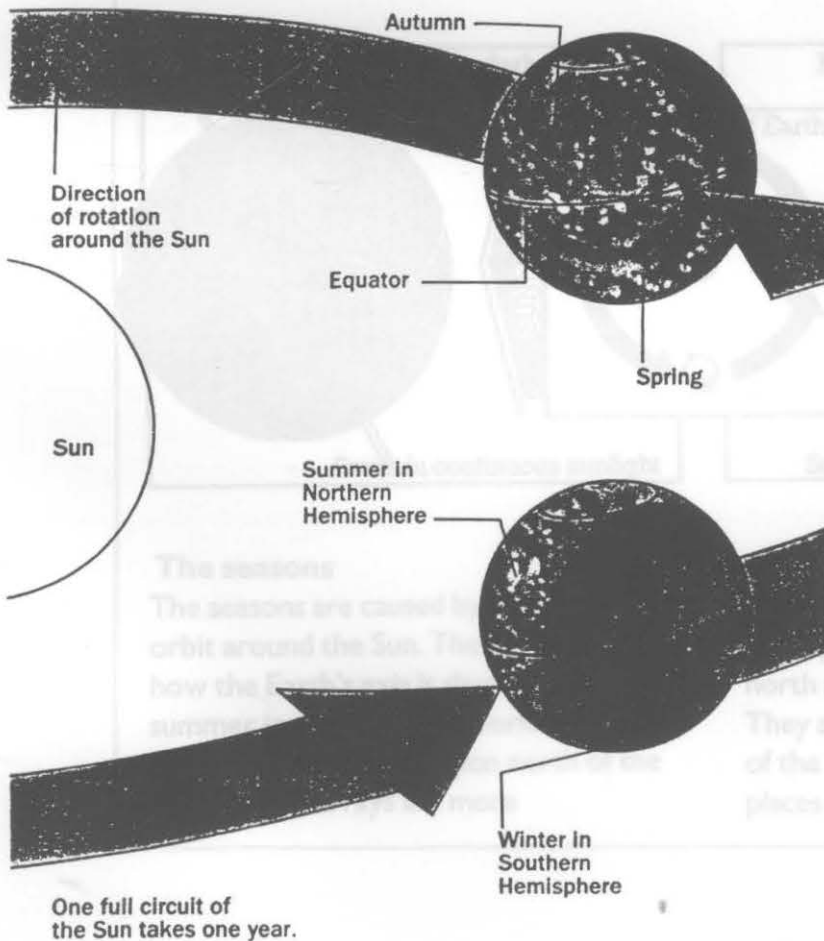
Summer in Southern Hemisphere

Spring

Autumn

DIFFERENT PLACES

The North and South Poles have only two seasons, which are six months of winter followed by six months of summer. Places in between the Equator and the poles usually have spring and autumn as well as summer and winter. Places near the Equator really have only one season, which is like summer. This is because the Sun is always high in the sky. In some places, particularly southern Asia, the seasons change very quickly. The wind blows from the north-east for six months then, within a day, it can turn around and blow from the south-west. These seasonal winds are called monsoons. The monsoon from the south-west brings a season of heavy rain.



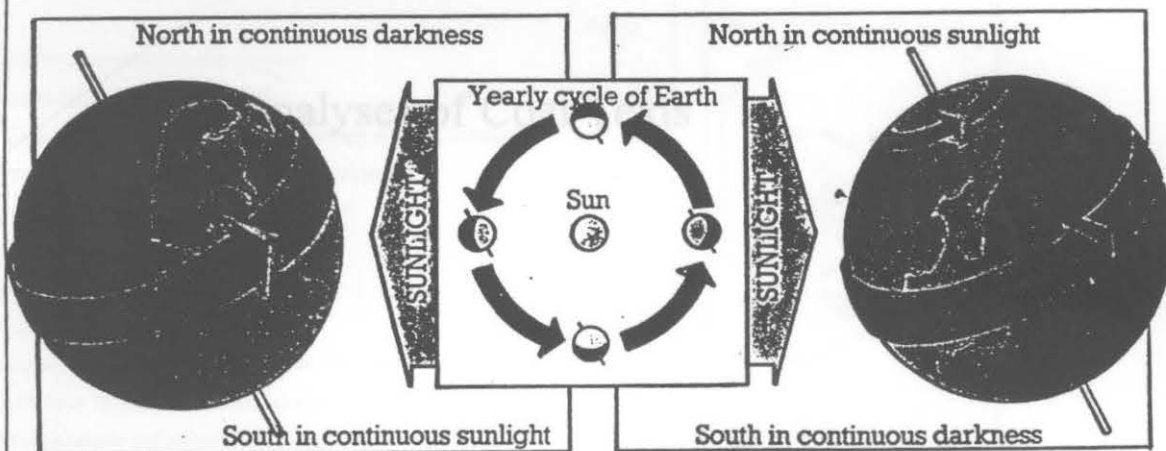
△ The rain brought by the south-westerly monsoon winds in Asia is vital for rice growing. But the rain can also cause rivers to overflow and flood the surrounding land.

The farther away from the Equator you get, the longer the days are in the summer and the shorter they are in the winter. Near to the poles, the Sun never sets at all for nearly six months in the summer. This is why these areas are sometimes called the Land of the Midnight Sun. Also, the Sun does not rise for several months in the middle of winter. At the Arctic and Antarctic Circles, there are only two or three days on which the Sun never sets. At the Equator, there is hardly any variation in the length of days all year.

SPINNING EARTH

The Sun appears to us as if it moves round the Earth. In fact, it is the Earth which spins round on its axis like a top, one turn every day. This movement makes the Sun appear to travel round the Earth. The place where you live points towards the Sun in the day, and away from it at night.

The Earth spins on its axis at a great speed: the surface of the Earth moves at more than 1,500km/h. Gravity provides the force which stops us being thrown off the Earth. Gravity extends a long way from the Earth, and pulls anything within its range towards the Earth. The Moon, and artificial satellites are held in orbit round the Earth by the pull of its gravity.



The seasons

The seasons are caused by the Earth's orbit around the Sun. The diagram shows how the Earth's axis is slanted. During summer in the northern world, the midday Sun is over a region north of the equator, so its rays are more

concentrated and feel hotter. During winter the Sun is over a region south of the equator, and the rays reaching the north spread out over a larger area. They are less concentrated. Places south of the equator have their summer when places north of the equator have winter

Appendix 3

Analyses of Coal Texts

Secondary texts:

Texts	Clauses	CRUs	External Conjunctive relations																					total
			Temporal									Consequential												
												cause												
			simultaneous			successive			consequence			contingency												
												condition			purpose									
i	e	m	i	e	m	i	e	m	i	e	m	e	m	i	e	m								
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 3.1a Comparison of types of external conjunctive relations in secondary coal texts

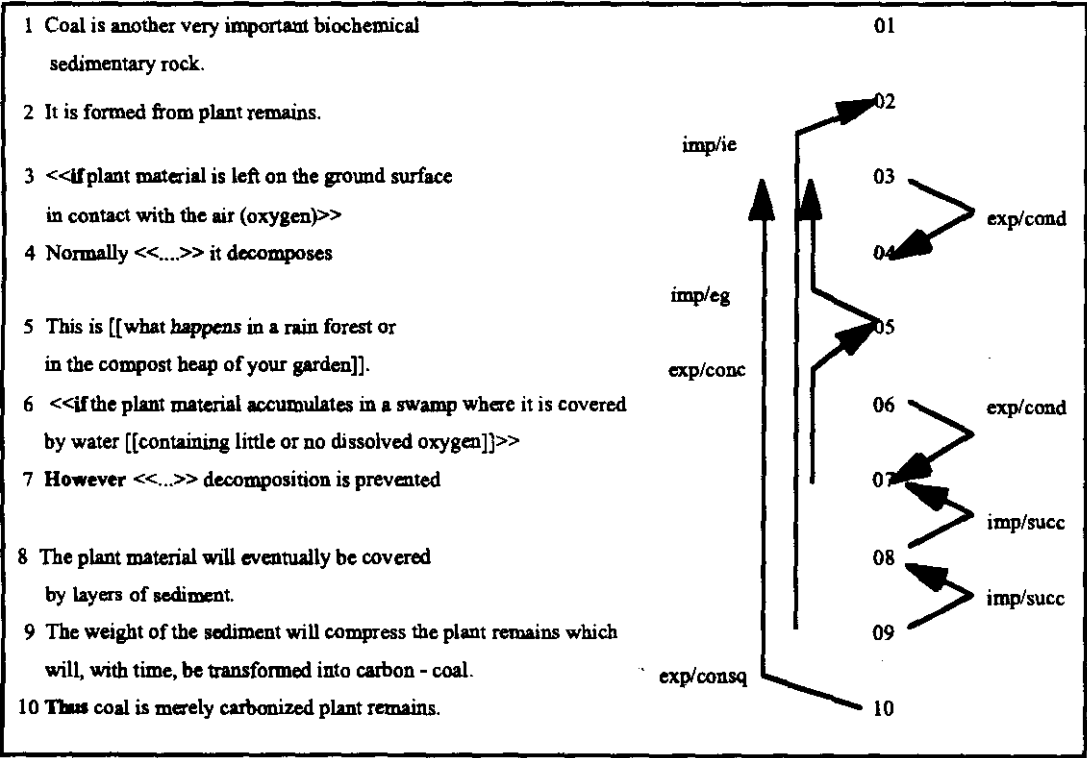


Figure 3.1a Conjunction in SCOAL1

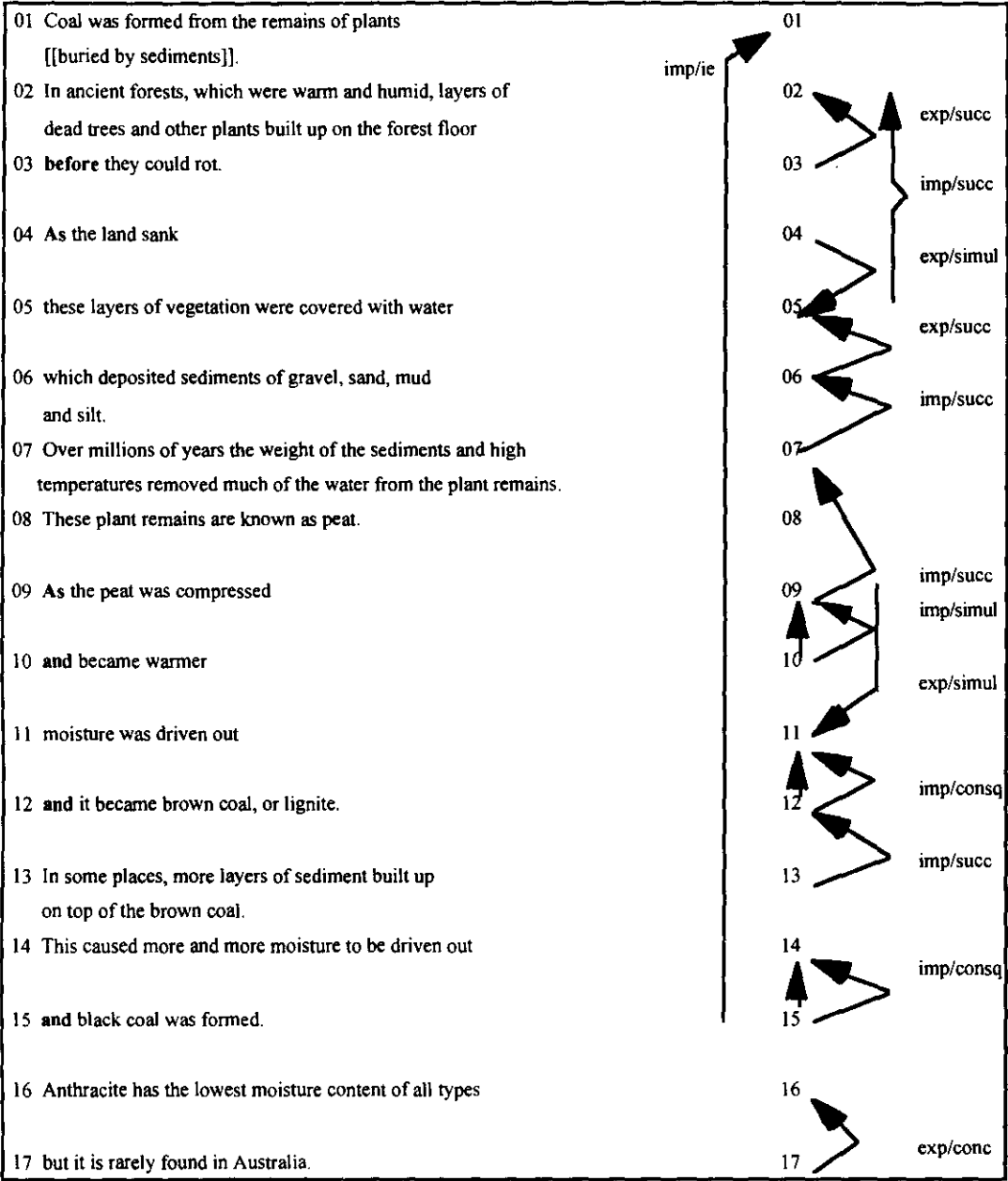


Figure 3.2a Conjunction in SCOAL2

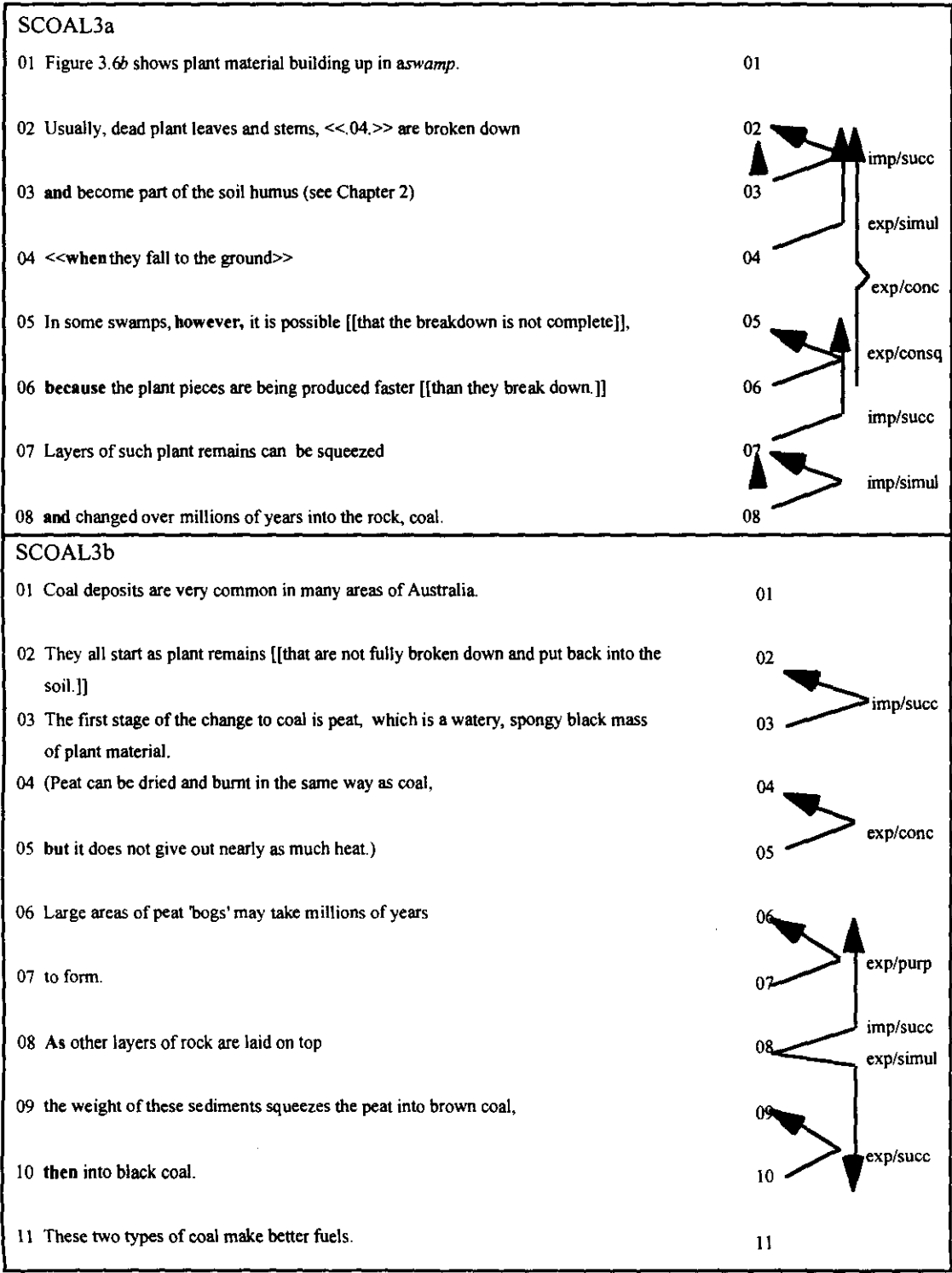


Figure 3.3a Conjunction in SCOAL3

TEXTS - SCOAL	Literal								Inferential															
	Explicit				Implicit				Scriptal				Entailed				Textual							
																	Referential				Ideational			
	1	2	3 a	3 b	1	2	3 a	3 b	1	2	3 a	3 b	1	2	3 a	3 b	1	2	3 a	3 b	1	2	3 a	3 b
CONDITIONS																								
dead		x	x					x														x		
plant material	x	x	x	x																				
accumulates	x	x		0											x									
does not decompose	x	x	x	x																				
TRIGGER																								
water	0	x	-	-																				
deposits	0	x	-	-																				
sediments	x	x	-	-																				
cover	x		-	-										x										
dead			-	-													x				x			
plant material	x	x	-	-																				
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
millions of years	0	x	x	x																				
form	x		x	x										x										
peat		x		x																				
coal	x		x																					
TRANSFORMATION 2																								
weight of sediments	-		-	x																		x		
compress	-	x	-	x																				
peat	-	x	-	x																				
forms	-	x	-					x																
brown coal	-	x	-	x																				
TRANSFORMATION 3																								
weight of sediment	-		-																			x		x
compress	-		-											x										x
brown coal	-	x	-																					x
form	-	x	-					x																
black coal	-	x	-	x																				

Table 3.2a Types of access to nuclear meanings in secondary coal texts

TEXTS - SCOAL	Literal								Inferential															
	Explicit				Implicit				Scriptal				Entailed				Textual							
	1	2	3 _a	3 _b	1	2	3 _a	3 _b	1	2	3 _a		1	2	3 _a	3 _b	Referential				Ideational			
ORIENTATION																								
sediments		x			x																			
bury		x							x															
dead					x	x																		
plant material	x	x																						
forms	x	x																						
coal	x	x		x																				
CONDITIONS																								
water	x	0	0	0																				
contains	x	0	0	0																				
little dissolved O ₂	x	0	0	0																				
covers	x	0	0	0																				
dead		x	x					x													x			
plant material	x	x	x	x																				
contacts	x	0	0	0																				
oxygen	x	0	0	0																				
decomposes	x	x	x	x																				
forms	0	0	x	x																				
soil humus	0	0	x	x																				
swamp	x	0	x	0																				
ancient forest	0	x	0	0																				
warm and humid	0	x	0	0																				
ground surface	x	x	x	0																				
plants	0		x	0						x														
grow	0			0						x						x								
die	0			0						x						x								
rapidly	0		x	0						x														
TRIGGER																								
land	0	x	-	-																				
sinks	0	x	-	-																				
eventually	x	x	-	-																				
TRANSFORMATION ₁																								
high temperatures	0	x	0	0																				
extract	0	x	0	0																				
water	0	x	0	0																				
TRANSFORMATION ₂																								
layers of sediment	-	0	-	x																				
accumulate	-	0	-	x																				
on top of (peat)	-	0	-	x																				
heats up	-	x	-	0																				
extracts	-	x	-	0																				
water	-	x	-	0																				
TRANSFORMATION ₃																								
layers of sediment	-	x	-	0																				
accumulate	-	x	-	0																				
on top of (brown coal)	-	x	-	0																				
in some places	-	x	-	0																				
extracts	-	x	-	0																				
water	-	x	-	0																				
CLOSURE																								
coal	x		-	x																		x		
carbonized	x	0	-	0																				
dead	x	0	-	0																				
plant material	x	0	-	0																				
Anthracite	0	x	-	0																				
lowest	0	x	-	0																				
moisture	0	x	-	0																				
types	0	x	-	x																				

Table 3.3a Types of access to elaborative meanings in secondary coal texts

No	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
1	Coal	is (RELATIONAL: IDENTIFYING)	another very important biochemical sedimentary rock		
2		is formed (MATERIAL)	It		from plant remains (MANNER:MEANS)
3		is left (MATERIAL)	plant material		on the ground surface (SPATIAL:LOCATION) in contact with the air (oxygen) (SPATIAL:LOCATION)
4		decomposes (MATERIAL)	it		
5	This	is (RELATIONAL: IDENTIFYING)	[[what happens in a rain forest or in the compost heap of your garden]].		
		happens (MATERIAL)	what		in a rain forest or in the compost heap of your garden (SPATIAL:LOCATION)
6		accumulates (MATERIAL)	the plant material		in a swamp (SPATIAL:LOCATION)
6.1	water [[containing little or no dissolved oxygen]]	is covered by (RELATIONAL: IDENTIFYING: CIRCUMSTANTIAL)	it		
		containing (RELATIONAL: ATTRIBUTIVE)		little or no oxygen	
7		is prevented (MATERIAL)	decomposition		
8	by layers of sediment	will be covered (MATERIAL)	the plant material		eventually (TEMPORAL:LOCATION)
9	The weight of the sediment	will compress (MATERIAL)	the plant remains		
9.1		will be transformed (MATERIAL)	which		into carbon - coal (ROLE:RESULT) with time (TEMPORAL:EXTENT)
10	coal	is (RELATIONAL: IDENTIFYING)	carbonized plant remains		

Figure 3.4a Transitivity analysis of SCOAL1

No	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01		was formed (MATERIAL)	coal		from the remains of plants buried by sediments (MANNER:MEANS)
	by sediments	buried (MATERIAL)			
02		built up (MATERIAL)	layers of dead trees and other plants		In ancient forests (SPATIAL:LOCATION) on the forest floor (SPATIAL:LOCATION)
2.1		were (RELATIONAL: ATTRIBUTIVE)	which	warm and humid	
03		could rot (MATERIAL)	they		
04		sank (MATERIAL)	the land		
05	with water	were covered (MATERIAL)	these layers of vegetation		
06	which	deposited (MATERIAL)	sediments of gravel, sand, mud and silt.		
07	the weight of the sediments and high temperatures	removed (MATERIAL)	much of the water		from the plant remains (SPATIAL:LOCATION) over millions of years (TEMPORAL: EXTENT)
08	peat	are known as (RELATIONAL: IDENTIFYING)	these plant remains		
09		was compressed (MATERIAL)	the peat		
10		became (RELATIONAL: ATTRIBUTIVE)		warmer	
11		was driven out (MATERIAL)	moisture		
12		became (RELATIONAL: ATTRIBUTIVE)	it	brown coal, or lignite	
13		built up (MATERIAL)	more layers of sediment		in some places (SPATIAL:LOCATION) on top of the brown coal (SPATIAL:LOCATION)
14	This	caused to be driven out (MATERIAL)	more and more moisture		
15		was formed (MATERIAL)	black coal		
16		has (RELATIONAL: POSSESSIVE)	anthracite	the lowest moisture content of all types	
17		is found (MATERIAL)	it		in Australia (SPATIAL:LOCATION)

Figure 3.5a Transitivity analysis of SCOAL2

No	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	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		fall (MATERIAL)	they		to the ground (SPATIAL:LOCATION)
04		become (RELATIONAL: ATTRIBUTIVE)		part of the soil humus	
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 remains		
08		changed (MATERIAL)			into the rock - coal (ROLE:RESULT) over millions of years (TEMPORAL:EXTENT)

Figure 3.6a Transitivity analysis of SCOAL3a

No	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01		are (RELATIONAL: ATTRIBUTIVE)	coal deposits	very common	in many areas of Australia (SPATIAL:LOCATION)
02		start (MATERIAL)	they all		as plant remains [[that are not fully broken down and put back into the soil]] (ROLE:GUISE)
		are broken down (MATERIAL)	that		
		put back (MATERIAL)			into the soil (SPATIAL:LOCATION)
03	Peat	is (RELATIONAL: IDENTIFYING)	the first stage of the change to coal		
3.1		is (RELATIONAL: ATTRIBUTIVE)	which	a watery, spongy black mass of plant material	
04		can be dried and burnt (MATERIAL)	Peat		in the same way as coal (MANNER:COMPARISON)
05	it	does not give out (MATERIAL)	as much heat		
06		may take (RELATIONAL: ATTRIBUTIVE: CIRCUMSTANTIAL)	Large areas of peat 'bogs'	millions of years	
07		to form (MATERIAL)			
08		are laid (MATERIAL)	other layers of rock		on top (SPATIAL:LOCATION)
09	the weight of these sediments	squeezes (MATERIAL)	the peat		into brown coal (ROLE: RESULT)
10					into black coal (ROLE: RESULT)
11		make (RELATIONAL: ATTRIBUTIVE)	These two types of coal	better fuels	

Figure 3.7a Transitivity analysis of SCOAL3b

Cl	Metaphors underlined	Category*
01	Coal is another very important biochemical sedimentary rock.	
02	It is formed from <u>plant remains</u> .	6a, 1a
03	<<if plant material is left on the ground surface in <u>contact</u> with the air (oxygen)>>	1a
04	Normally <<...>> it decomposes	
05	This is [[what happens in a rain forest or in the compost heap of your garden]].	
06	<<if the plant material accumulates in a swamp	
6.1	where it is covered by water [[containing little or no <u>dissolved oxygen</u>]]>>	5a
07	However <<...>> <u>decomposition</u> is prevented	1a
08	The plant material will eventually be covered by layers of sediment.	
09	The weight of the sediment will compress the <u>plant remains</u>	6a, 1a
9.1	which will, with time, be transformed into carbon - coal.	
10	Thus coal is merely <u>carbonized plant remains</u> .	5a, 6a, 1a

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 3.4a Grammatical metaphor in SCOAL1

Cl	Metaphors underlined	Category*
01	Coal was formed from <u>the remains</u> of plants [[buried by sediments]].	1a
02	In ancient forests, <<...>> layers of dead trees and other plants built up on the forest floor	
2.1	<<which were warm and humid>>	
03	before they could rot.	
04	As the land sank	
05	these layers of vegetation were covered with water	
06	which deposited sediments of <u>gravel, sand, mud and silt</u> .	
07	Over millions of years the weight of the sediments and high temperatures removed much of the water from the <u>plant remains</u> .	6a, 1a
08	These <u>plant remains</u> are known as peat.	6a, 1a
09	As the peat was compressed	
10	and became warmer	
11	moisture was driven out	
12	and it became brown coal, or lignite.	
13	In some places, more layers of sediment built up on top of the brown coal.	
14	This <u>caused</u> more and more moisture to be driven out	12b
15	and black coal was formed.	
16	Anthracite has the lowest <u>moisture content</u> of all types	6a, 1c
17	but it is rarely found in Australia.	

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 3.5a Grammatical metaphor in SCOAL2

Cl	Metaphors underlined	Category*
01	Figure 3.6 <i>b</i> shows plant material building up in a <i>swamp</i> .	
02	Usually, dead plant leaves and stems, <<.....>> are broken down	
03	<<when they fall to the ground>>	
04	and become part of the soil humus (see Chapter 2)	
05	In some swamps, however, it is possible [[that the <u>breakdown</u> is not complete]],	1a
06	because the plant pieces are being produced faster [[than they break down.]]	
07	Layers of such <u>plant remains</u> can be squeezed	6a, 1a
08	and changed over millions of years into the rock, coal.	

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 3.6a Grammatical metaphor in SCOAL3a

Cl	Metaphors underlined	Category*
01	<u>Coal deposits</u> are very common in many areas of Australia.	6a, 1a
02	They all start as <u>plant remains</u> [[that are not fully broken down and put back into the soil.]]	6a, 1a
03	<u>The first stage of the change</u> to coal is peat,	12a, 1c
3.1	which is a watery, spongy black mass of plant material.	
04	(Peat can be dried and burnt in <u>the same way</u> as coal,	12d
05	but it does not give out nearly as much <u>heat</u> .)	2a
06	Large areas of peat 'bogs' may take millions of years	
07	to form.	
08	As other layers of rock are laid on top	
09	the weight of these sediments squeezes the peat into brown coal,	
10	then into black coal.	
11	These two types of coal make better fuels.	

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 3.7a Grammatical metaphor in SCOAL3b

Primary texts:

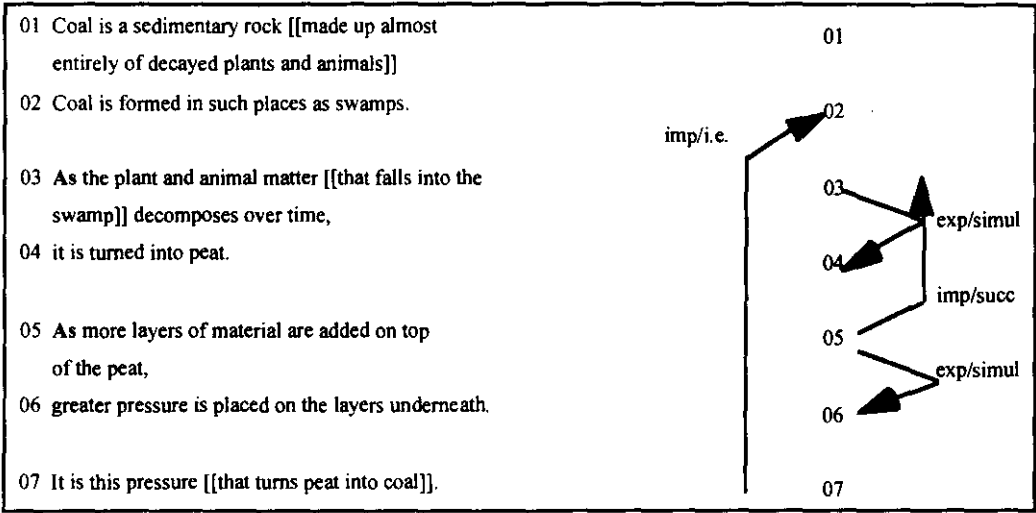


Figure 3.8a Conjunction in PCOAL1

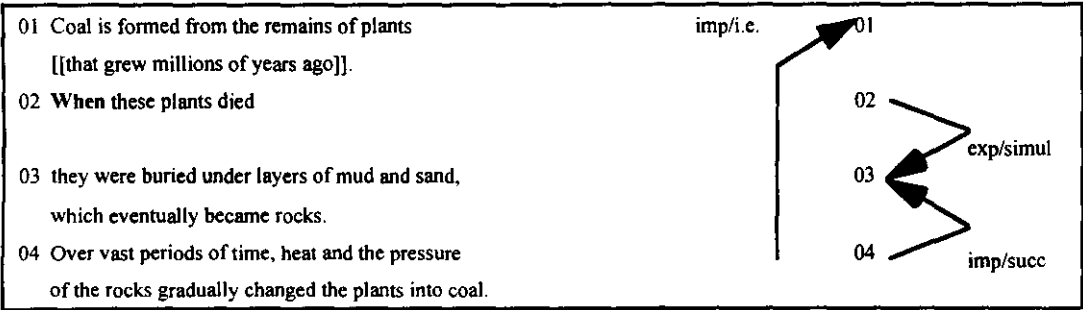


Figure 3.9a Conjunction in PCOAL2

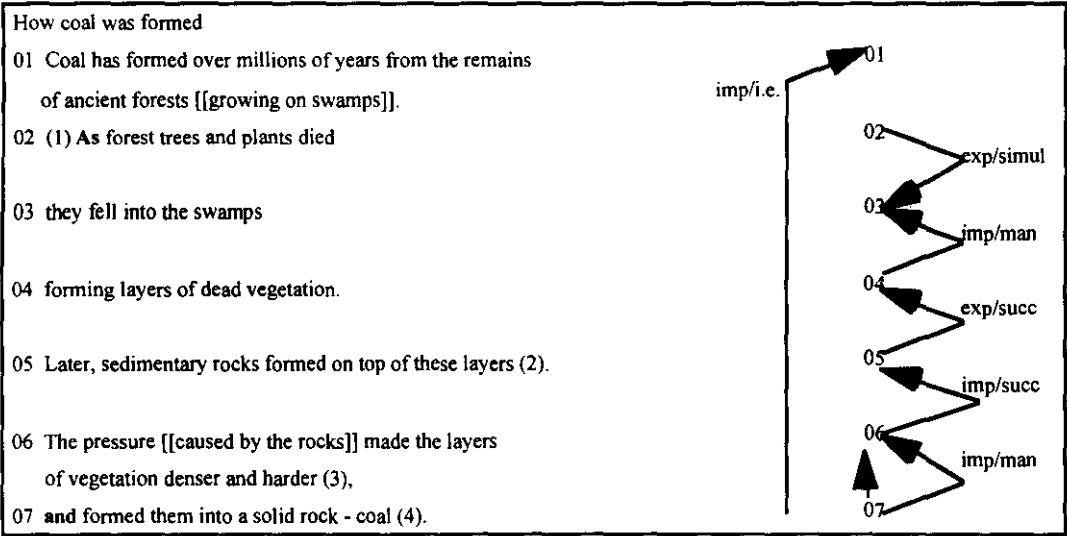


Figure 3.10a Conjunction in PCOAL3

	Literal						Inferential											
	Explicit			Implicit			Scriptal			Entailed			Textual					
													Referential			Ideational		
TEXTS - PCOAL	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CONDITIONS																		
dead	-	x	x															
plant material	-	x	x															
accumulates	-	0	x															
does not decompose	-	0	0															
TRIGGER																		
water	-	0	0															
deposits	-	0	0															
sediments	-	x	x															
cover	-	x	x															
dead	-													x	x			
plant material		x	x															
TRANSFORMATION 1																		
weight of sediments	0	x	x															
compress	0							x	x									
dead										x				x	x			
plant material	x	x	x															
millions of years					x			x										x
form	x	x	x															
peat	x	-	-															
coal	-	x	x															
TRANSFORMATION 2																		
weight of sediments		-	-					x										
compress		-	-					x										
peat	x	-	-															
forms	x	-	-															
brown coal		-	-															
TRANSFORMATION 3																		
weight of sediment	-	-	-															
compress	-	-	-															
brown coal	-	-	-															
form	-	-	-															
black coal	x	-	-															

Table 3.8a Types of access to nuclear meanings in primary coal texts

No	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01	Coal	is (RELATIONAL: IDENTIFYING)	a sedimentary rock [[made up almost entirely of decayed plants and animals]]		
		made up of (RELATIONAL: ATTRIBUTIVE)		decayed plants and animals	
02		is formed (MATERIAL)	Coal		in such places as swamps (SPATIAL:LOCATION)
03		decomposes (MATERIAL)	the plant and animal matter [[that falls into the swamp]]		over time (TEMPORAL: EXTENT)
		falls (MATERIAL)	that		into the swamp (SPAT/LOC)
04		is turned into (RELATIONAL: ATTRIBUTIVE)	it	peat	
05		are added (MATERIAL)	more and more layers		on top of the peat (SPATIAL:LOCATION)
06		is placed (MATERIAL)	greater and greater pressure		on the layers underneath (SPATIAL:LOCATION)
07	this pressure	is (RELATIONAL: IDENTIFYING)	It[[that turns peat into coal]]		
	that	turns into (RELATIONAL: ATTRIBUTIVE)	peat	coal	

Figure 3.11a Transitivity analysis of PCOAL1

No	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01		is formed (MATERIAL)	Coal		from the remains of plants [[that grew millions of years ago]] (MANNER: MEANS)
		grew (MATERIAL)	that		millions of years ago (TEMPORAL:LOCATION)
02		died (MATERIAL)	these plants		
03		were buried (MATERIAL)	they		under layers of mud and sand (SPATIAL:LOCATION)
04		became (RELATIONAL: ATTRIBUTIVE)	which	rocks	eventually (TEMPORAL: LOCATION)
05	heat and the pressure of the rocks	changed (MATERIAL)	the plants		Over vast periods of time (TEMPORAL:EXTENT) gradually (MANNER: QUALITY) into coal (ROLE: RESULT)

Figure 3.12a Transitivity analysis of PCOAL2

No	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01		has formed (MATERIAL)	Coal		over millions of years (TEMPORAL:EXTENT) from the remains of ancient forests [[growing on swamps]] (MANNER:MEANS)
		growing (MATERIAL)			on swamps (SPATIAL: LOCATION)
02		died (MATERIAL)	forest trees and plants		
03		fell (MATERIAL)	they		into the swamps (SPATIAL:LOCATION)
04		forming (MATERIAL)	layers of dead vegetation		
05		formed (MATERIAL)	sedimentary rocks		Later (TEMPORAL:LOCATION) on top of these layers (SPATIAL:LOCATION)
06	The pressure [[caused by the rocks]]	made (RELATIONAL: ATTRIBUTIVE)	the layers of vegetation	denser and harder	
	by the rocks	caused (RELATIONAL: IDENTIFYING)			
07		formed (MATERIAL)	them		into a solid rock - coal (ROLE:RESULT)

Figure 3.13a Transitivity analysis of PCOAL3

CI	Metaphors underlined	Category*
01	Coal is a sedimentary rock [[made up almost entirely of <u>decayed</u> plants and animals]]	5a
02	Coal is formed in such places as swamps.	
03	As the plant and animal matter [[that falls into the swamp]] decomposes over time,	
04	it is turned into peat.	
05	As more layers of material are added on top of the peat,	
06	greater pressure is placed on the layers underneath.	
07	It is this pressure [[that turns peat into coal]].	

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 3.9a Categories of grammatical metaphor in PCOAL1

CI	Metaphors underlined	Category*
01	Coal is formed from <u>the remains</u> of plants [[that grew millions of years ago]].	1a
02	When these plants died	
03	they were buried under layers of mud and sand,	
04	which eventually became rocks.	
05	Over vast periods of time, heat and the pressure of the rocks gradually changed the plants into coal.	

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 3.10a Categories of grammatical metaphor in PCOAL2

CI	Metaphors underlined	Category*
01	Coal has formed over millions of years from <u>the remains</u> of ancient forests [[growing on swamps]].	1a
02	(1) As forest trees and plants died	
03	they fell into the swamps	
04	forming layers of dead vegetation.	
05	Later, sedimentary rocks formed on top of these layers (2).	
06	The pressure [[caused by the rocks]] made the layers of vegetation denser and harder (3).	12b
07	and formed them into a solid rock - coal (4).	

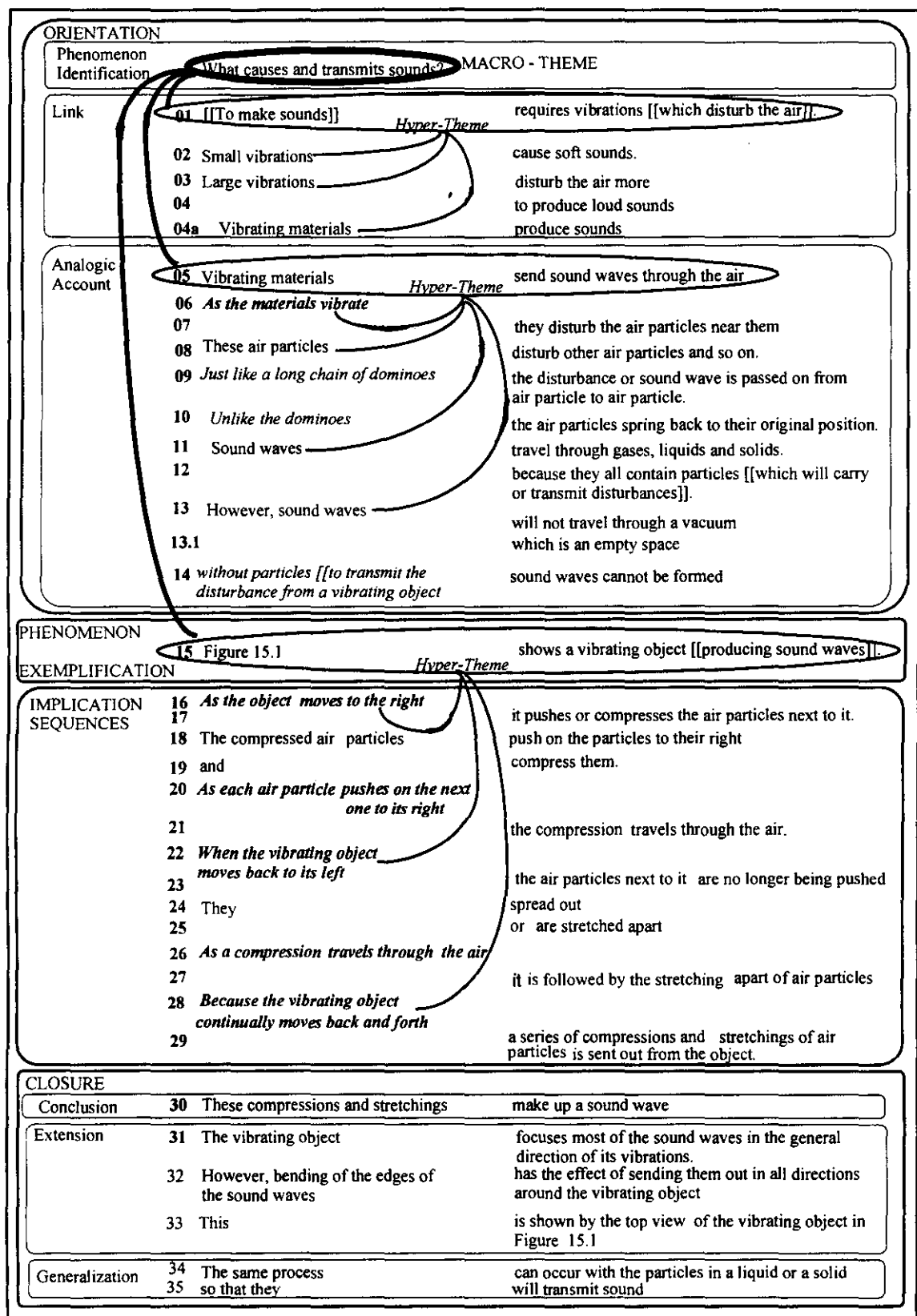
*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 3.11a Categories of grammatical metaphor in PCOAL3

Appendix 4

Analyses of Sound Texts

Secondary texts:



The text is divided into two columns showing Theme on the left and Rheme on the right. Marked Themes are in italics and β clauses as marked Themes are in bold italics.

Figure 4.1a Theme and schematic structure in SSND1

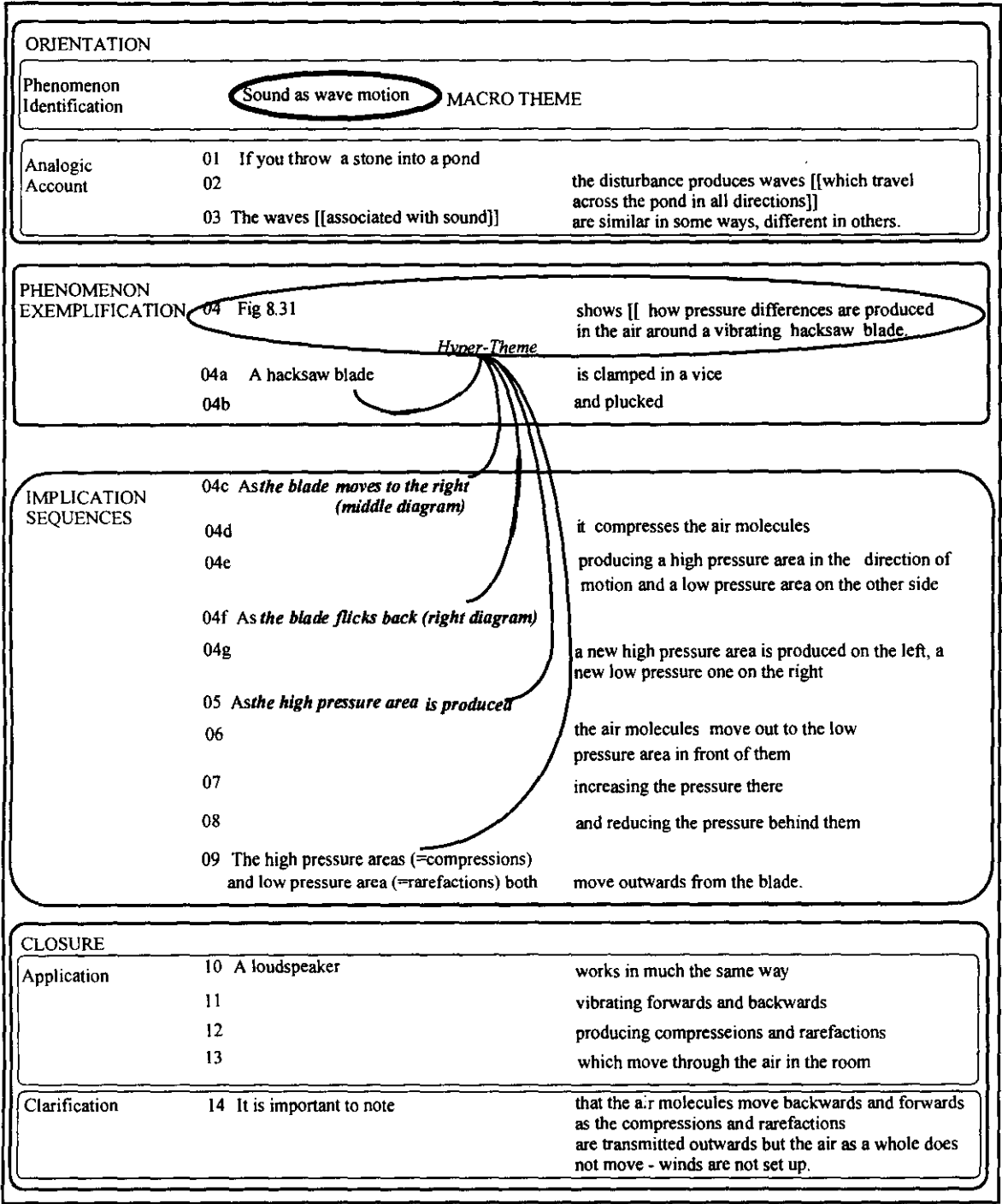


Figure 4.2a Theme and schematic structure in SSND2

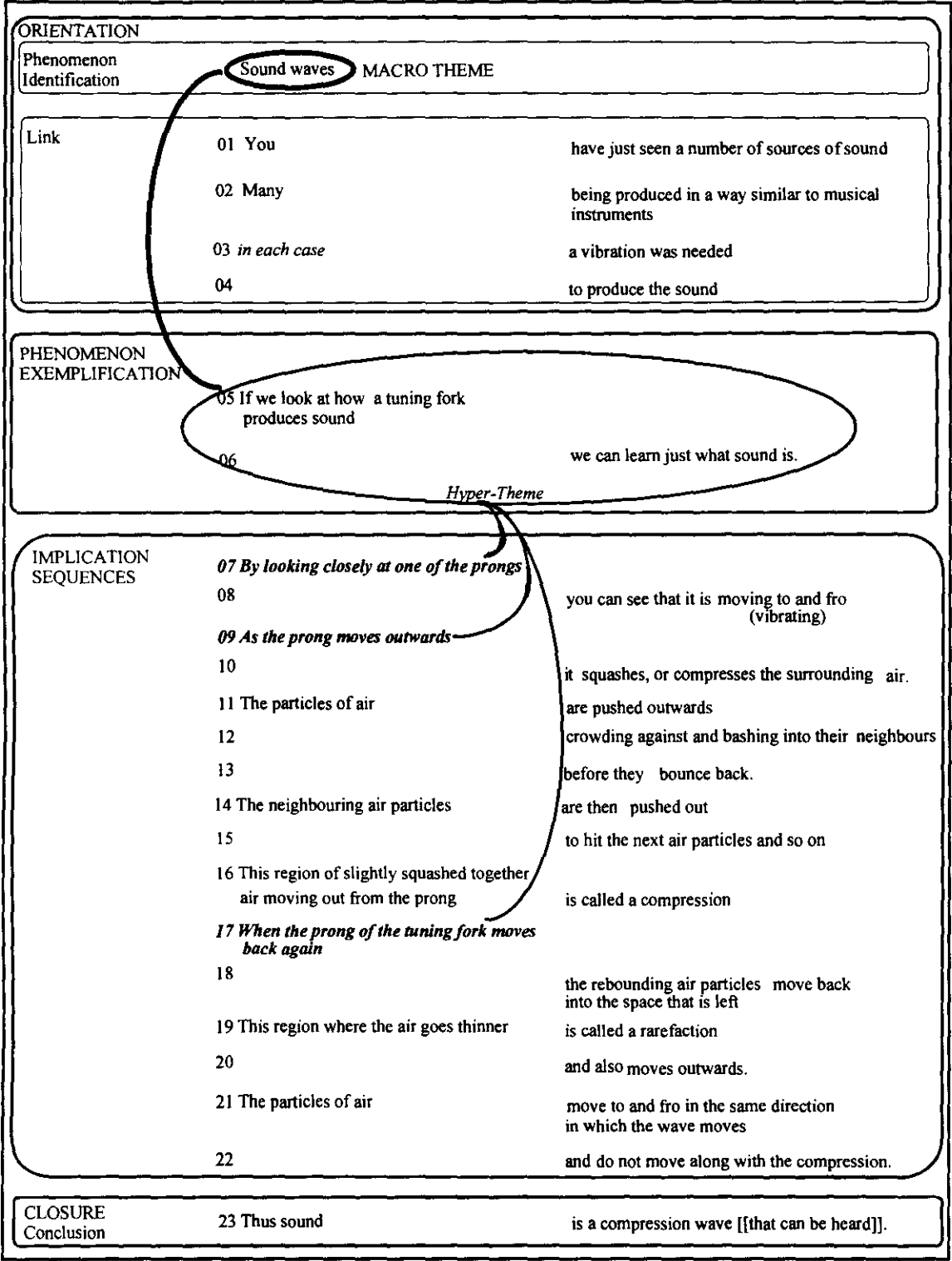


Figure 4.3a Theme and schematic structure in SSND3

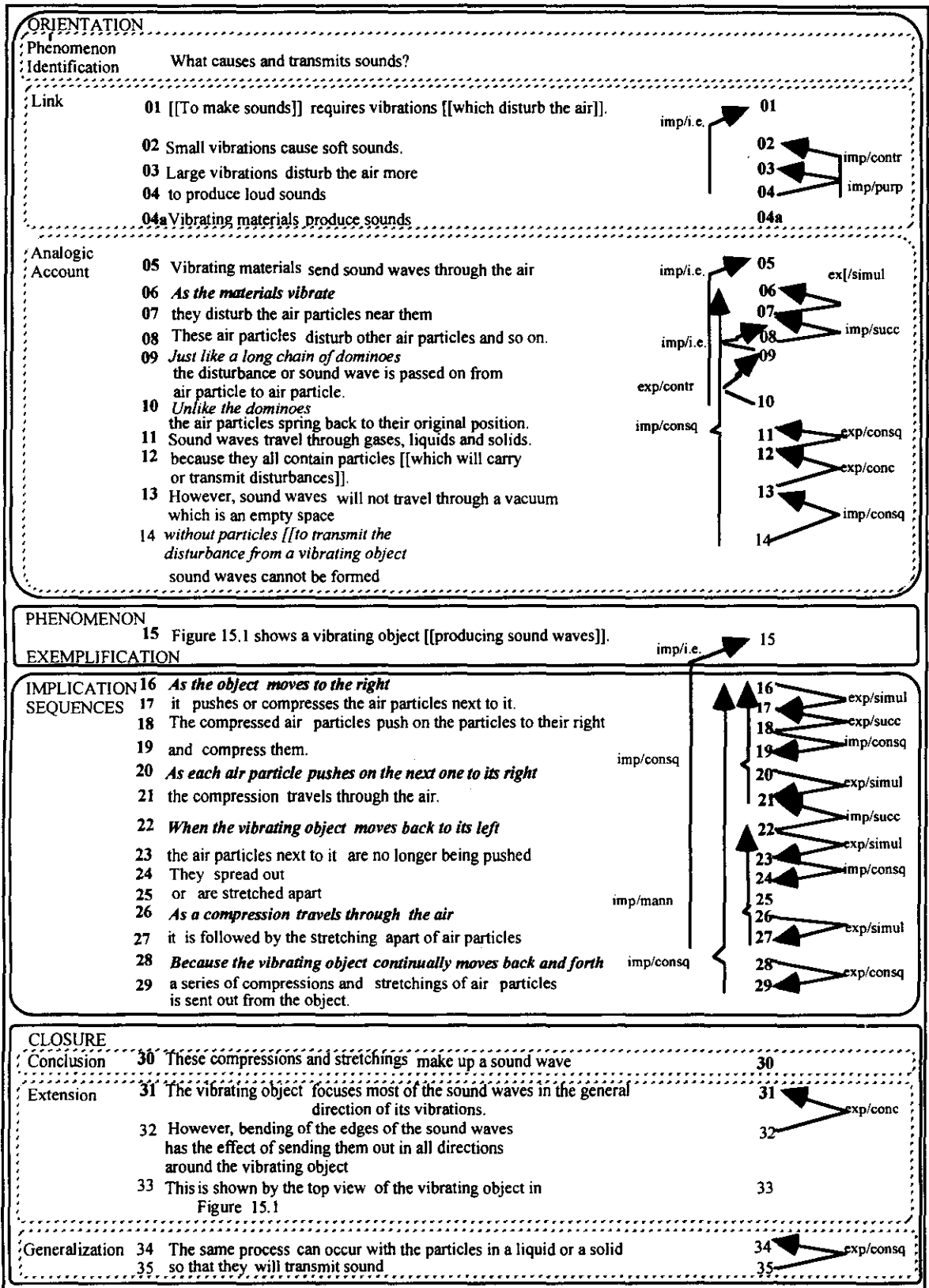


Figure 4.4a Conjunctive relations and schematic structure in SSND1

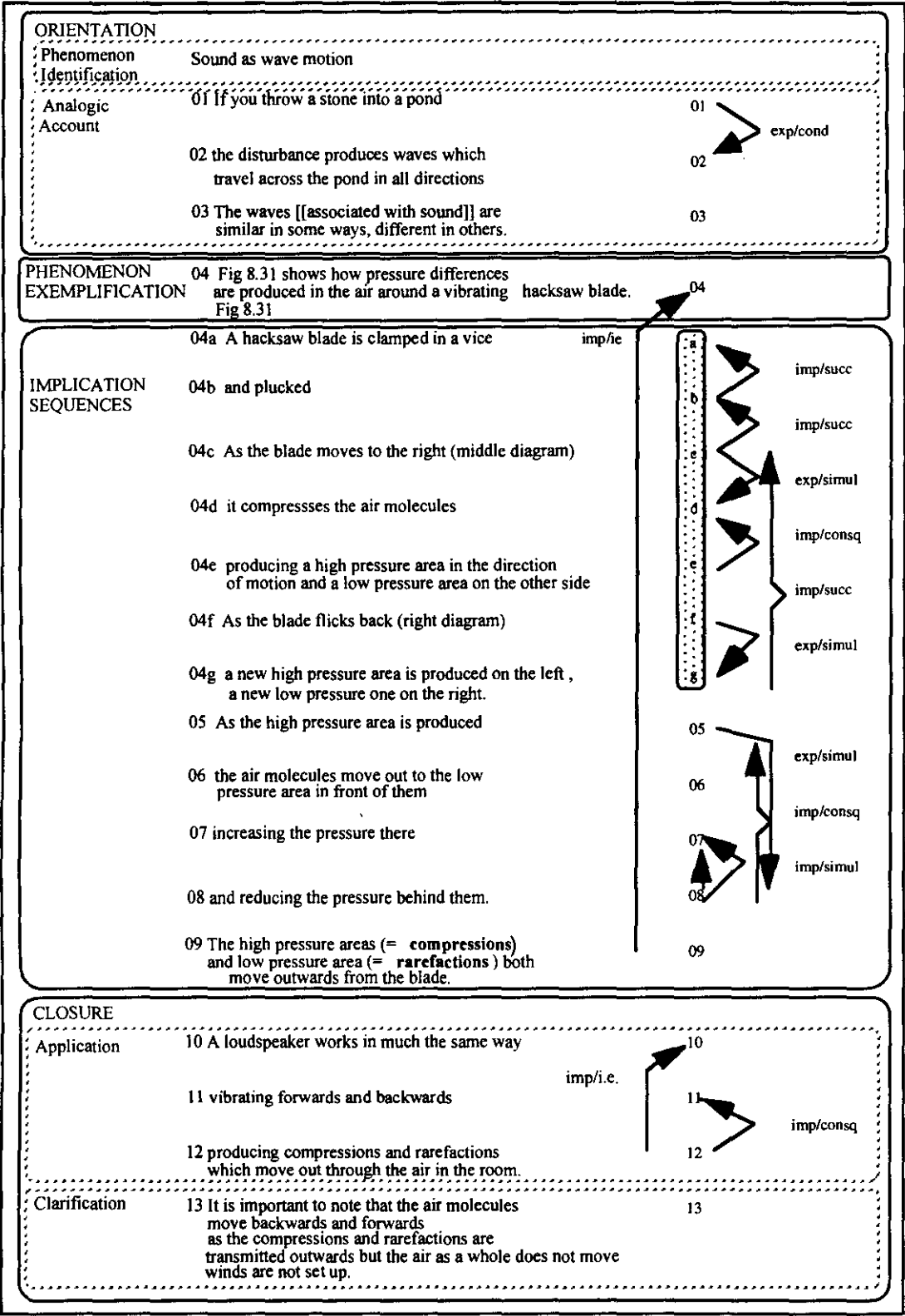


Figure 4.5a Conjunctive relations and schematic structure in SSND2

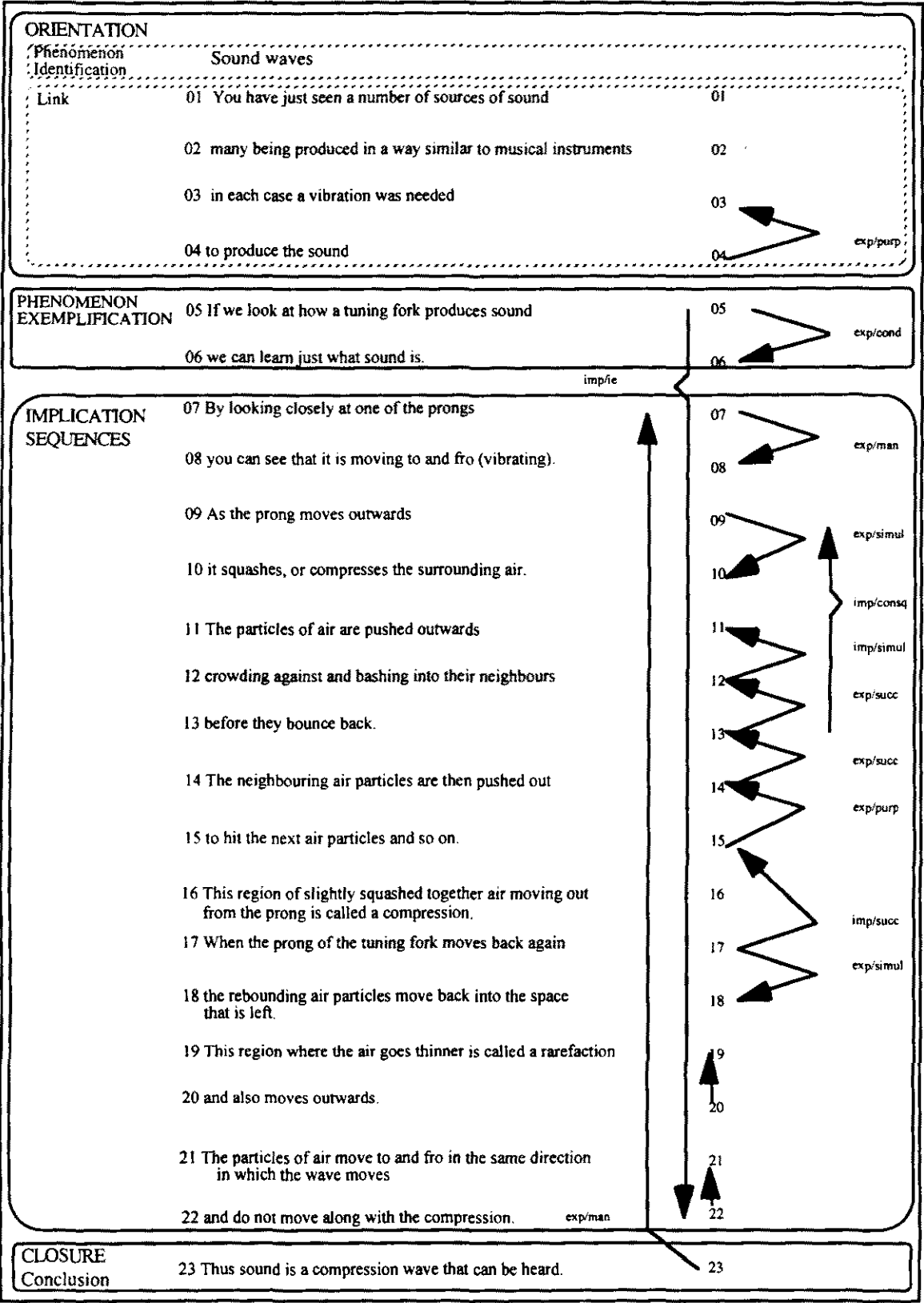


Figure 4.6a Conjunctive relations and schematic structure in SSND3

	Literal						Inferential											
	Explicit			Implicit			Scriptal			Textual								
										Entailed			Retrieved					
													Referential			Ideational		
TEXTS - SSND	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
IMPLICATION SEQUENCES																		
moves	x	x	x															
object	x	x	x															
right	x	x				x												
compresses	x	x	x															
air	x	x	x															
molecules		x		x		x												
compressed	x														x		x	
air molecules		x		x		x												
push	x					x					x							
compress	x								x		x							
air molecules to right				x		x					x							
RECURSION	x	0	x															
compression	x	x	x															
travels	x	x																
through the air	x				x													
object	x	x	x															
moves	x	x	x															
left	x	x	x															
creates		x	0								x							
low pressure area		x	0								x							
right		x	0	x														
compressed			0													x		x
air molecules to right			0			x							x					
spread out	x	0				x												
into low pressure area	0	0							x									
rarefaction		x	x	x														
travels		x	x	x														
through the air					x	x										x		
object	x																	
sends	x																	
series	x																	
compressions	x																	
rarefactions					x													
through the air					x													

Table 4.1a Types of reader access to nuclear meanings in IMPLICATION SEQUENCES in secondary sound texts

TEXTS - SSND	Literal						Inferential											
	Explicit			Implicit			Scriptal			Textual								
										Entailed			Retrieved					
													Referential			Ideational		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
IMPLICATION SEQUENCES																		
creates	0	x	0															
object	0	x	0															
low pressure area	0	x	0															
left of object	0	x	0															
air molecules	0		0									x						
to left	0		0		x													
become	0		0		x													
low pressure area	0	x	0															
(compressed air molecules)																		
move		x				x					x							
low pressure area	0	x	0															
in front of them		x		x		x												
(object)																		
compresses	0	x	0															
air molecules	0	x	0															
left	0	x	0															

Table 4.2a Types of reader access to elaborative meanings in IMPLICATION SEQUENCES in secondary sound texts

No	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01	[[To make sounds]]	requires (RELATIONAL: IDENTIFYING)	vibrations[[which disturb the air]]		
		to make (MATERIAL)	sounds		
	which	disturb (MATERIAL)	the air		
02	small vibrations	cause (RELATIONAL: IDENTIFYING)	soft sounds		
03	Large vibrations	disturb (MATERIAL)	the air		more (MANNER:COMPARISON)
04		to produce (MATERIAL)	loud sounds		
05	Vibrating materials	send (MATERIAL)	sound waves		through the air (SPATIAL:LOCATION)
06		vibrate (MATERIAL)	the materials		
07	they	disturb (MATERIAL)	the air particles near them		
08	These air particles	disturb (MATERIAL)	other air particles		and so on (MANNER: DEGREE)
09		is passed on (MATERIAL)	the disturbance or sound wave		like a long chain of dominoes (MANNER:COMPARISON) from air particle to air particle (SPATIAL: LOCATION)
10		spring back (MATERIAL)	the air particles		Unlike the dominoes (MANNER:COMPARISON) to their original position (SPATIAL:LOCATION)
11		travel (MATERIAL)	sound waves		through gases, liquids and solids (SPATIAL:LOCATION)
12	they all	contain (RELATIONAL: IDENTIFYING: POSSESSIVE)	particles which will carry or transmit disturbances		
	which	will carry or transmit (Material)	disturbances		
13		will not travel (MATERIAL)	sound waves		through a vacuum (SPATIAL:LOCATION)
14	which	is (RELATIONAL: IDENTIFYING)	an empty space		
15		cannot be formed (MATERIAL)	sound waves		without particles [[to transmit the disturbance from a vibrating object]] (MANNER:MEANS)
		to transmit (MATERIAL)	disturbances		from a vibrating object (SPATIAL:LOCATION)
16	Figure 15.1	shows (RELATIONAL: IDENTIFYING)	a vibrating object producing sound waves		
	a vibrating object	producing (MATERIAL)	sound waves		
17		moves (MATERIAL)	the object		to the right (SPATIAL:LOCATION)
18	it	pushes or compresses (MATERIAL)	the air particles next to it		
19	the compressed air particles	push on (MATERIAL)	the particles to their right		
20		compress (MATERIAL)	them		
21	each air particle	pushes on (MATERIAL)	the next one to its right		
22		travels (MATERIAL)	the compression wave		through the air (SPATIAL:LOCATION)
23		moves back (MATERIAL)	the vibrating object		to its left (SPATIAL:LOCATION)

24		are being pushed (MATERIAL)	the air particles next to it		
25		spread out (MATERIAL)	they		
26		are stretched apart (MATERIAL)			
27		travels (MATERIAL)	a compression wave		through the air (SPATIAL:LOCATION)
28	the stretching apart of air particles	is followed by (RELATIONAL: IDENTIFYING)	it		
29		moves back and forth (MATERIAL)	the vibrating object		continuously (TEMPORAL:EXTENT)
30		is sent out (MATERIAL)	a series of compressions and stretchings of air particles		from the object (SPATIAL:LOCATION)
31	these compressions and stretchings	make up (RELATIONAL: IDENTIFYING)	a sound wave		
32	The vibrating object	focuses (MATERIAL)	most of the sound waves		in the general direction of its vibrations (SPATIAL:LOCATION)
33		has (RELATIONAL: ATTRIBUTIVE: POSSESSIVE)	bending of the edges of sound waves	the effect of sending them out in all directions around the vibrating object	
		sending out (MATERIAL)	them		in all directions around the vibrating object (SPATIAL:LOCATION)
34	by the top view of the vibrating object in figure 15.1	is shown (RELATIONAL: IDENTIFYING)	this		
35		can occur (MATERIAL)	the same process		with particles in a liquid or a solid (MANNER:MEANS)
36	they	will transmit (MATERIAL)	sound		

Figure 4.7a Transitivity analysis of SSND1

No	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01	you	throw (MATERIAL)	a stone		into a pond (SPATIAL:LOCATION)
02	the disturbance	produces (MATERIAL)	waves [[which travel across the pond in all directions]]		
		travel (MATERIAL)	which		across the pond (SPATIAL:LOCATION) in all directions (SPATIAL:LOCATION)
03		are (RELATIONAL: ATTRIBUTIVE)	the waves [[associated with sound]]	similar in some ways, different in others	
04		shows (VERBAL)	Fig 8.3]	[[how pressure differences are produced in the air around a vibrating hacksaw blade]]	
		are produced (MATERIAL)	pressure differences		in the air around a vibrating hacksaw blade (SPATIAL:LOCATION)
04a		is clamped (MATERIAL)	a hacksaw blade		in a vice (SPATIAL:LOCATION)
04b		plucked (MATERIAL)			
04c		moves (MATERIAL)	the blade		to the right (SPATIAL:LOCATION)
04d	it	compresses (MATERIAL)	the air molecules		
04e		producing (MATERIAL)	a high pressure area in the direction of motion and a low pressure area on the other side		
04f		flicks (MATERIAL)	the blade		back (SPATIAL:LOCATION) (right diagram) (SPATIAL:LOCATION)
04g		is produced (MATERIAL)	a new high pressure area a new low pressure area		on the left (SPATIAL: LOCATION) on the right (SPATIAL:LOCATION)
05		is produced (MATERIAL)	the high pressure area		
06		move (MATERIAL)	the air molecules		out (SPATIAL:LOCATION) to the low pressure area in front of them (SPATIAL:LOCATION)
07		increasing (MATERIAL)	the pressure there		
08		reducing (MATERIAL)	the pressure behind them		
09		move (MATERIAL)	the high pressure areas (=compressions) and the low pressure areas (=rarefactions) both		outwards from the blade (SPATIAL:LOCATION)
10		works (MATERIAL)	a loudspeaker		in much the same way (MANNER:COMPARISON)
11		vibrating (MATERIAL)			forwards and backwards (SPATIAL:LOCATION)
12		producing (MATERIAL)	compressions and rarefactions		
13		move (MATERIAL)	which		out (SPATIAL:LOCATION) through the air in the room (SPATIAL:LOCATION)

14		is (RELATIONAL: ATTRIBUTIVE)	It [[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]]	important	
		move (MATERIAL)	the air molecules		backwards and forwards (SPATIAL:LOCATION)
		are transmitted (MATERIAL)	the compressions and rarefactions		outwards (SPATIAL:LOCATION)
		does not move (MATERIAL)	the air as a whole		
15		are not set up (MATERIAL)	winds		

Figure 4.8a Transitivity analysis of SSND2

No	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01		have just seen (MENTAL)	you	a number of sources of sound	
02		being produced (MATERIAL)	many		in a way similar to musical instruments (MANNER: COMPARISON)
03		was needed (RELATIONAL: ATTRIBUTIVE)	a vibration		in every case (MATTER)
04		to produce (MATERIAL)	the sound		
05		look at (BEHAVIOURAL)	we	how a tuning fork produces sound	
	a tuning fork	produces (MATERIAL)	sound		
06		can learn MENTAL	we	what sound is.	
	what	is (RELATIONAL: IDENTIFYING)	sound		
07		looking at (BEHAVIOURAL)		one of the prongs	
08		can see (MENTAL)	you	that it is moving to and fro (vibrating)	
		is moving (MATERIAL)	it		to and fro (SPATIAL:LOCATION)
09		moves (MATERIAL)	the prong		outwards (SPATIAL:LOCATION)
10	it	squashes, or compresses (MATERIAL)	the surrounding air		
11		are pushed (MATERIAL)	the particles of air		outwards (SPATIAL:LOCATION)
12		crowding against and bashing into (MATERIAL)	their neighbours		
13		bounce (MATERIAL)	they		back (SPATIAL:LOCATION)
14		are pushed (MATERIAL)	The neighbouring air particles		out (SPATIAL:LOCATION)
15		to hit (MATERIAL)		the next air particles	
16	a compression	is called (RELATIONAL: IDENTIFYING)	This region of slightly squashed together air moving out from the prong		
		moving (MATERIAL)			out from the prong (SPATIAL:LOCATION)
17		moves (MATERIAL)	the prong of the tuning fork		back (SPATIAL:LOCATION) again (TEMPORAL: FREQUENCY)
18		move (MATERIAL)	the rebounding air particles		back (SPATIAL:LOCATION) into the space that is left (SPATIAL:LOCATION)

19	a rarefaction	is called (RELATIONAL: IDENTIFYING)	This region where the air goes thinner		
		goes (RELATIONAL: ATTRIBUTIVE)	the air	thinner	
20		moves (MATERIAL)			outwards (SPATIAL: LOCATION).
21		move to and fro (MATERIAL)	the particles of air		in the same direction in which the wave moves (SPATIAL:LOCATION)
		moves (MATERIAL)	the wave		
22		do not move (MATERIAL)			along (SPATIAL: LOCATION) with the compression (ACCOMPANIMENT)
23	sound	is (RELATIONAL: IDENTIFYING)	a compression wave that can be heard.		
		can be heard (MENTAL)	that		

Figure 4.9a Transitivity analysis of SSND3

CI	Metaphors underlined	Category*
	What causes and transmits sounds?	
01	[[To make sounds]] <u>requires vibrations</u> [[which disturb the air]].	12b, 1a
02	Small <u>vibrations</u> <u>cause</u> soft sounds.	1a, 12b
03	Large <u>vibrations</u> disturb the air more	1a
04	<u>to produce</u> loud sounds.	12b
	<u>Vibrating</u> materials <u>produce</u> sound	5a, 12b
05	<u>Vibrating</u> materials send sound waves through the air.	5a
06	As the materials <u>vibrate</u>	
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, <u>the disturbance</u> or sound wave is passed on from air particle to air particle.	1a
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 <u>disturbances</u>]].	1a
13	However, sound waves will not travel through a vacuum	
14	which is an empty space:	
15	without particles [[to transmit the <u>disturbance</u> from a <u>vibrating</u> object]], sound waves cannot be formed.	1a, 5a
16	Figure 15.1 shows a <u>vibrating</u> object [[producing sound waves]].	5a, 12b
17	As the object moves to the right	
18	it pushes or compresses the air particles next to it.	
19	The <u>compressed</u> air particles then push on the particles to their right	5a
20	and compress them.	
21	As each air particle pushes on the next one to its right	
22	<u>the compression</u> travels through the air.	1a
23	When the <u>vibrating</u> object moves back to its left	5a
24	the air particles next to it are no longer being pushed.	
25	They spread out	
26	or are stretched apart.	
27	As a <u>compression</u> travels through the air	1a
28	it is <u>followed</u> by the <u>stretching apart</u> of air particles.	12b, 1a
29	Because the <u>vibrating</u> object continually moves back and forth	5a
30	a series of <u>compressions</u> and <u>stretchings</u> of air particles is sent out from the object.	12a, 1a, 1a
31	These <u>compressions</u> and <u>stretchings</u> make up a sound wave.	1a, 1a
32	The <u>vibrating</u> object focuses most of the sound waves in the general direction of its <u>vibrations</u> .	5a, 6
33	However, <u>bending</u> of the edges of the sound waves has <u>the effect</u> of sending them out in all directions around the <u>vibrating</u> object.	1a 12a, 5a
34	This is shown by the top <u>view</u> of the <u>vibrating</u> object in figure 15.1.	1a, 5a
35	The same <u>process</u> can occur with the particles in a liquid or a solid	1a
36	so that they will also transmit sound.	

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 4.3a Grammatical metaphor in SSND1

CI	Metaphors underlined	Category*
	Sound as <u>wave motion</u>	6, 1a
01	if you throw a stone into a pond	
02	<u>the disturbance produces waves</u> [[which travel across the pond in all directions]]	1a, 12b
03	The waves [[associated with sound]] are similar in some ways different in others.	
04	Fig 8.31 shows how <u>pressure differences are produced</u> in the air around a <u>vibrating hacksaw blade</u> .	6, 2b, 12b, 5a,
05	As the high pressure area is <u>produced</u>	12b
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 (= <u>compressions</u>) and low pressure area (= <u>rarefactions</u>) both move outwards from the blade.	1a, 1a
10	A loudspeaker works <u>in much the same way</u>	12c
11	<u>vibrating forwards and backwards</u>	
12	<u>producing compressions and rarefactions</u>	12b, 1a, 1a
13	which move out through the air in the room.	
14	It is important to note [[that the air molecules move backwards and forwards as the <u>compressions</u> and <u>rarefactions</u> are transmitted outwards but the air as a whole does not move]]	1a, 1a
15	winds are not set up.	
	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	<u>producing</u> a high pressure area in the direction of <u>motion</u> and a low pressure area on the other side	12b, 1a
04f	As the blade flicks back (right diagram)	
04g	a new high pressure area <u>is produced</u> on the left , a new low pressure one on the right.	12b

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 4.4a Grammatical metaphor in SSND2

CI	Metaphors underlined	Category*
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 <u>a vibration</u> was needed	1a
04	to <u>produce</u> the sound	12b
05	If we look at [[how a tuning fork <u>produces</u> sound]]	12b
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)]].	
09	As the prong moves outwards	
10	it squashes, or compresses the <u>surrounding</u> air.	5d
11	The particles of air are pushed outwards	
12	crowding against and bashing into their neighbours	
13	before they bounce back.	
14	The <u>neighbouring</u> air particles are then pushed out	6
15	to hit the next air particles and so on.	
16	This region of slightly <u>squashed together</u> air [[moving out from the prong]] is called <u>a compression</u> .	5a, 1a
17	When the prong of the tuning fork moves back again	
18	the <u>rebounding</u> air particles move back into the space [[that is left]].	5a
19	This region [[where the air goes thinner]] is called [[<u>a rarefaction</u>]]	1a
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 <u>the compression</u> .	1a
23	Thus sound is a <u>compression</u> wave [[that can be heard]].	1a

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 4.5a Grammatical metaphor in SSND3

Primary texts:

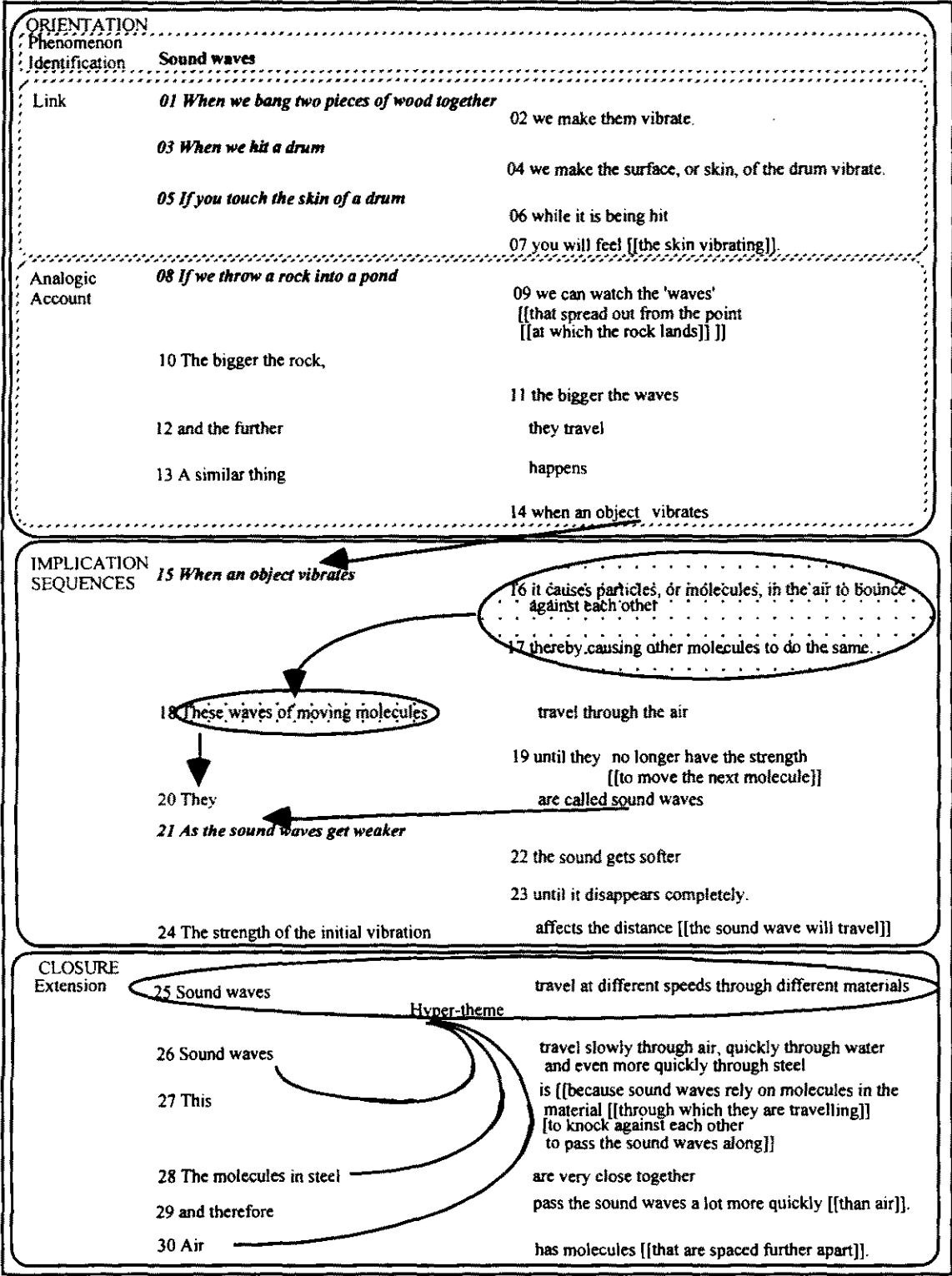


Figure 4.10a Theme and schematic structure in PSND1

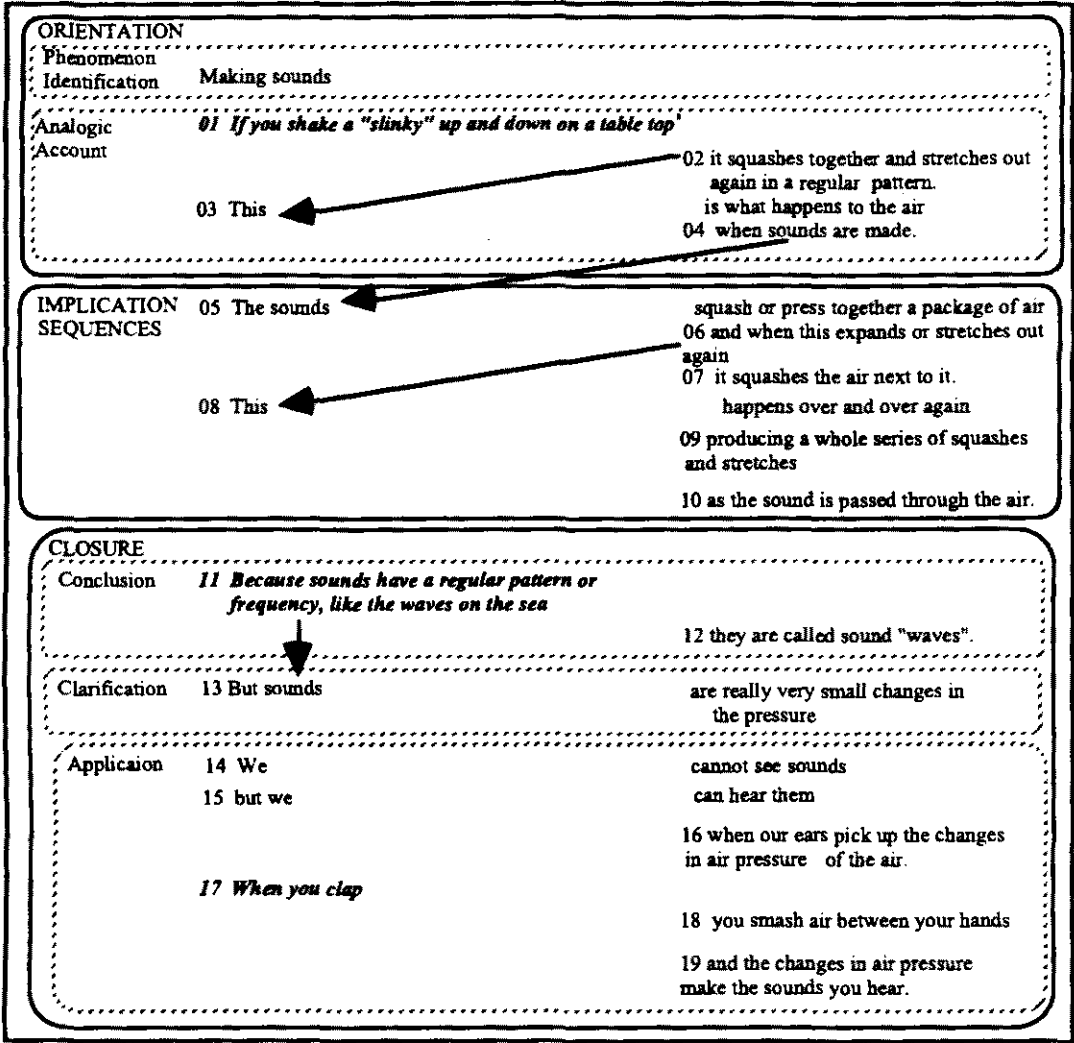


Figure 4.11a Theme and schematic structure in PSND2

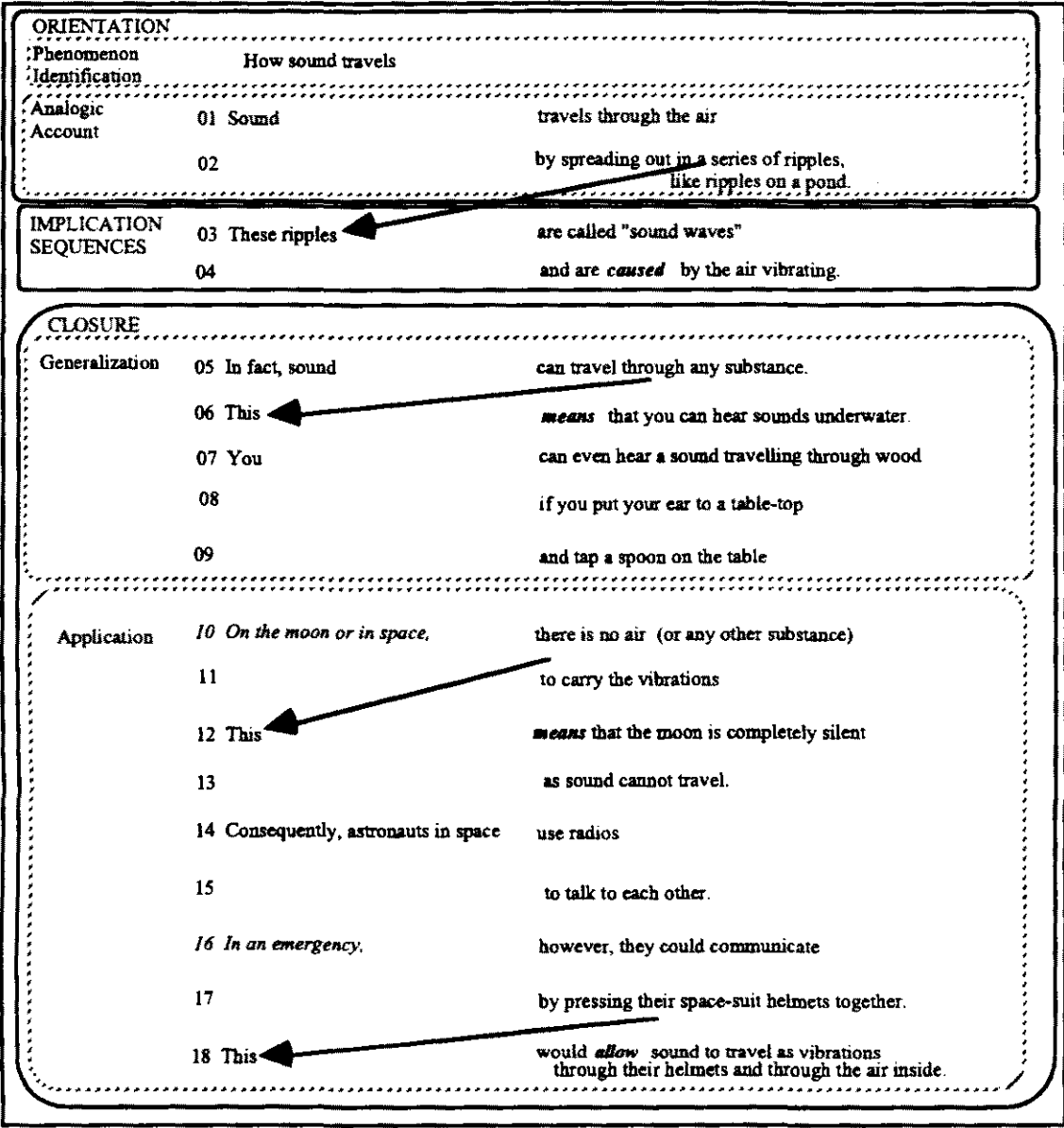


Figure 4.12a Theme and schematic structure in PSND3

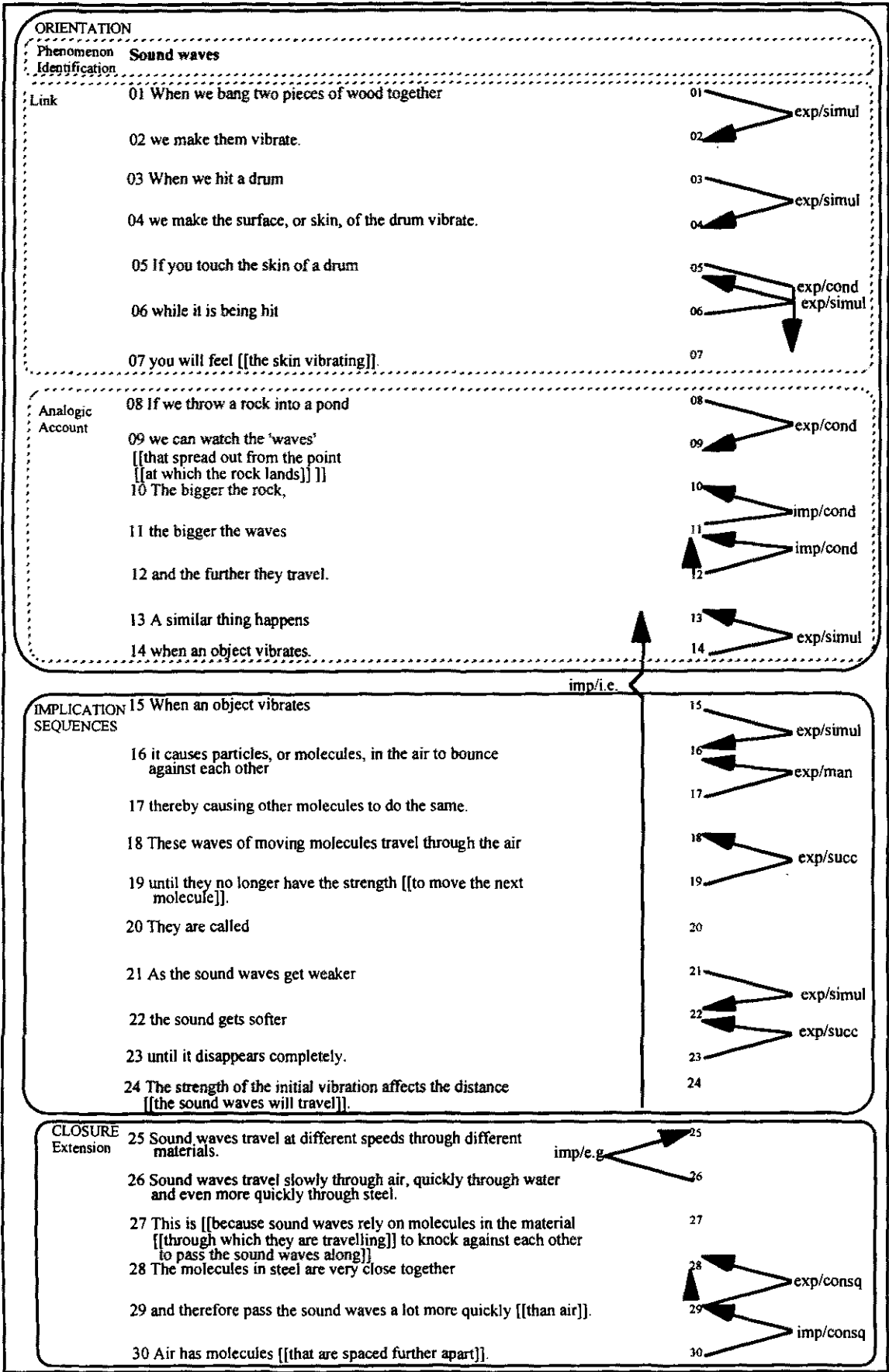


Figure 4.13a Conjunction and schematic structure in PSND1

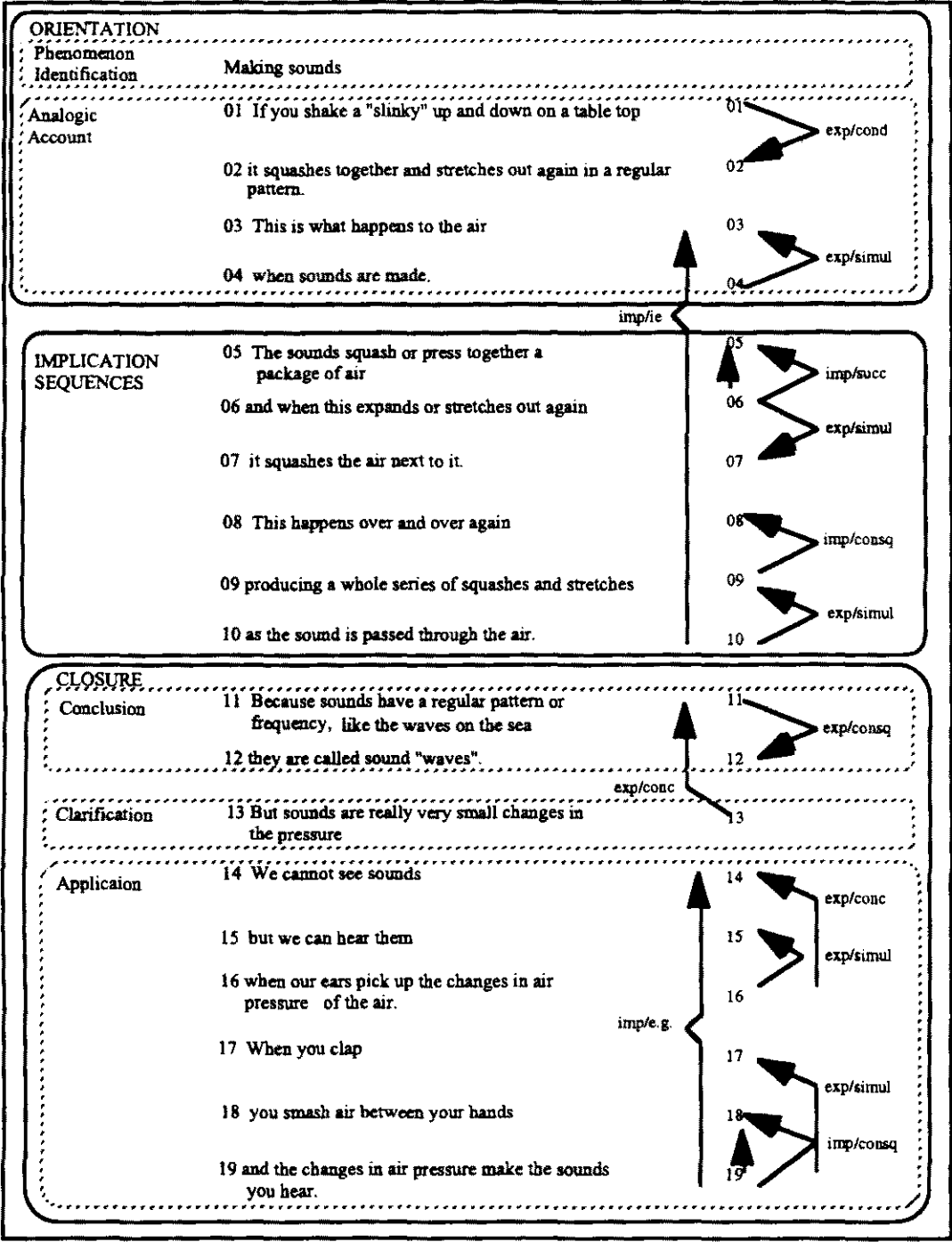


Figure 4.14a Conjunction and schematic structure in PSND2

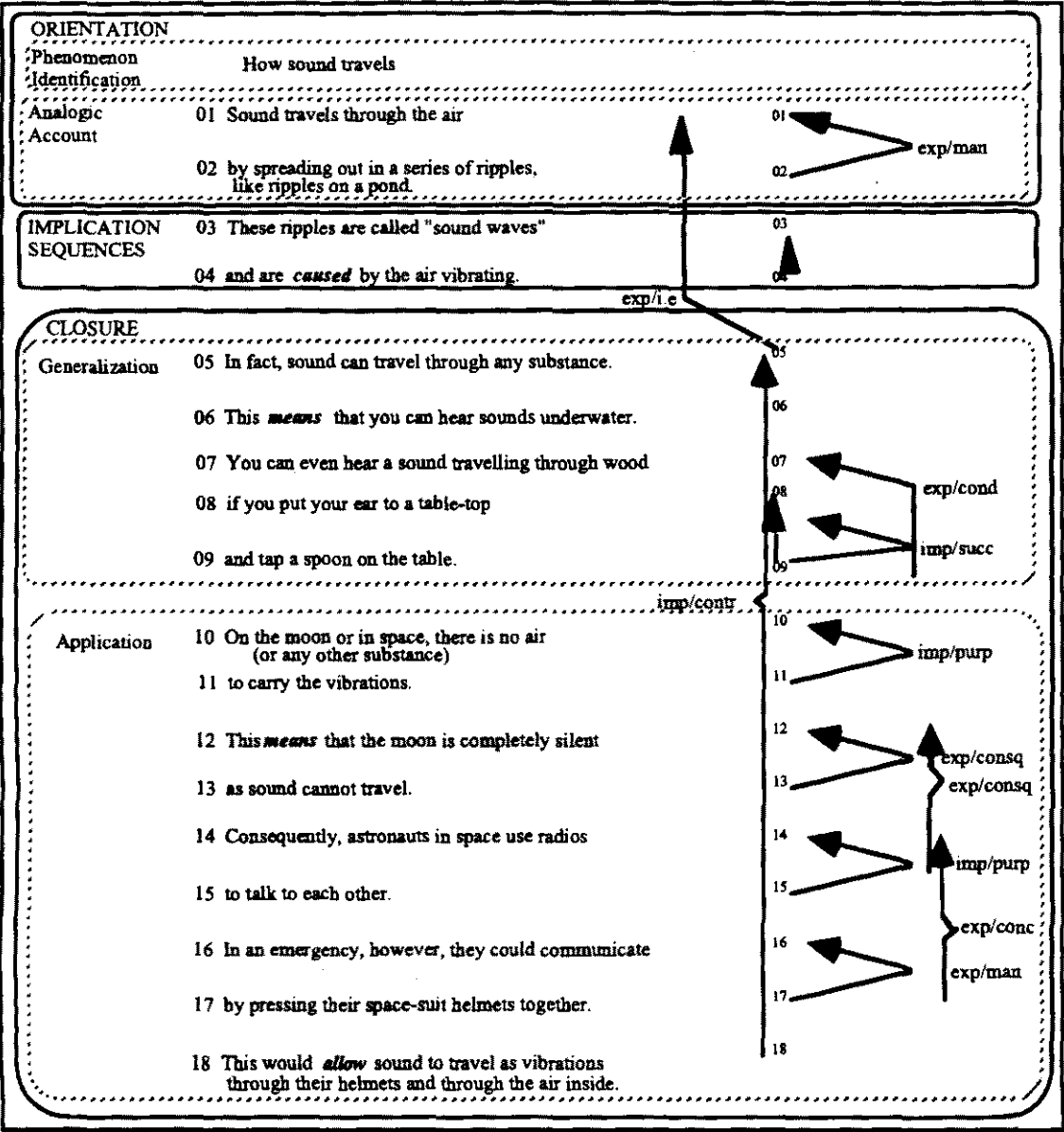


Figure 4.15a Conjunction and schematic structure in PSND3

	Literal									Inferential											
	Explicit			Implicit			Scriptal			Textual											
										Entailed						Retrieved					
													Referential			Ideational					
TEXTS - PSND	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
IMPLICATION SEQUENCES																					
moves		0									x										
object	x	0																			
right		0									x										
compresses	0				x																
air	x	x																			
molecules	x	0																			
compressed	0																				x
air molecules	0													x							
push	x										x										
compress	0				x																
air molecules to right				x	x																
RECURSION	x	x																			
compression	0	0																			
travels	0	0																			
through the air	0	0																			
object	x	0																			
moves		0									x										
left		0									x										
creates	0	0																			
low pressure area	0	0																			
right	0	0																			
compressed	0																				
air molecules to right	x																				x
spread out		x									x										
into low pressure area	0	0																			
rarefaction	0	0																			
travels	x	0																			
through the air	0	0																			
object	0	0																			
sends	0	0																			
series		x		x																	
compressions	0				x																
rarefactions	0				x																
through the air	x	x																			

Table 4.6a Types of reader access to nuclear meanings in primary sound texts

No	AGENT	PROCESS	MEDIUM	BENEF/RNG	CIRCUMSTANCE
01	we	bang (MATERIAL)	two pieces of wood	together (ATTRIBUTE)	
02	we	make vibrate (MATERIAL)	them		
03	we	hit (MATERIAL)	a drum		
04	we	make vibrate (MATERIAL)	the surface, or skin of the drum		
05		touch (BEHAVIOURAL)	you	the skin of a drum	
06		is being hit (MATERIAL)	it		
07		will feel (MENTAL)	you	[[the skin vibrating]]	
		vibrating (MATERIAL)	the skin		
08	we	throw (MATERIAL)	a rock		into a pond (SPATIAL:LOCATION)
09		can watch (BEHAVIOURAL)	we	the 'waves' [[that spread out from the point [[at which the rock lands]]	
		spread out (MATERIAL)	that		from the point [[at which the rock lands]] (SPATIAL:LOCATION)
		lands (MATERIAL)	the rock		
10		(RELATIONAL: ATTRIBUTIVE)	the rock	the bigger	
11		(RELATIONAL: ATTRIBUTIVE)	the waves	the bigger	
12		travel (MATERIAL)	they		the further (SPATIAL:EXTENT)
13		happens (MATERIAL)	a similar thing		
14		vibrates (MATERIAL)	object		
15		vibrates (MATERIAL)	object		
16	it	causes to bounce (MATERIAL)	particles, or molecules, in the air		against each other (SPATIAL:LOCATION)
17		causing to do (MATERIAL)	other molecules	the same	
18		travel (MATERIAL)	these waves of moving molecules		through the air (SPATIAL:LOCATION)
19		have (RELATIONAL: POSSESSIVE: ATTRIBUTIVE)	they	the strength [[to move the next molecule]]	no longer (TEMPORAL:EXTENT)
		to move (MATERIAL)	the next molecule		
20	sound waves	are called (RELATIONAL: IDENTIFYING)	they		
21		gets (RELATIONAL: ATTRIBUTIVE)	the sound waves	weaker	
22		gets (RELATIONAL: ATTRIBUTIVE)	the sound	softer	
23		disappears (MATERIAL)	it		
24	The strength of the initial vibration	affects (RELATIONAL: IDENTIFYING)	the distance [[the sound waves will travel]]		
		will travel (MATERIAL)	the sound waves		

25		travel (MATERIAL)	sound waves		at different speeds (MANNER:QUALITY) through different materials (SPATIAL:LOCATION)
26		travel (MATERIAL)	sound waves		slowly (MANNER:QUALITY) through air (SPATIAL:LOCATION) quickly (MANNER:QUALITY) through water (SPATIAL:LOCATION) more quickly (MANNER:COMPARISON) through steel (SPATIAL:LOCATION)
27	[[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]]]]	is (RELATIONAL: IDENTIFYING)	this		
	sound waves	rely on (RELATIONAL: IDENTIFYING)	molecules in the material [[through which they are travelling]] to knock against each other to pass the sound waves along]]		
		are travelling (MATERIAL)	they		through which (SPATIAL:LOCATION)
		to knock (MATERIAL)	molecules in the material		against each other (SPATIAL:LOCATION)
		to pass (MATERIAL)	the sound		along (SPATIAL:LOCATION)
28		are (RELATIONAL: ATTRIBUTIVE)	the molecules in steel	very close together	
29		pass (MATERIAL)	the sound waves		a lot more quickly [[than air]] (MANNER:COMPARISON)
30		has (RELATIONAL: POSSESSIVE: ATTRIBUTIVE)	air	molecules [[that are spaced further apart]]	
		are spaced (RELATIONAL: ATTRIBUTIVE)	that	further apart	

Figure 4.16a Transitivity analysis of PSND1

No	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01	you	shake (MATERIAL)	a slinky		up and down (MANNER:QUALITY) on a tabletop (SPATIAL:LOCATION)
02		squashes together and stretches out (MATERIAL)	it		again in a regular pattern (MANNER:QUALITY)
03	This	is (RELATIONAL: IDENTIFYING)	what happens to the air		
		happens to (MATERIAL)	what	the air	
04		are made (MATERIAL)	sounds		
05	The sounds	squash or press together (MATERIAL)	a package of air		
06		expands or stretches out (MATERIAL)	this		again
07	it	squashes (MATERIAL)	the air next to it		
08		happens (MATERIAL)	this		over and over again
09		producing (MATERIAL)	a whole series of squashes and stretches		
10		is passed (MATERIAL)	the sound		through the air (SPATIAL:LOCATION)
11		have (RELATIONAL: POSSESSIVE: ATTRIBUTIVE)	sounds	a regular pattern or frequency	like the waves on the sea (MANNER:COMPARISON)
12	sound "waves"	are called (RELATIONAL: IDENTIFYING)	they		
13	sounds	are (RELATIONAL: IDENTIFYING)	very small changes in the pressure of the air		
14		cannot see (MENTAL)	we	sounds	
15		can hear (MENTAL)	we	them	
16		pick up (MENTAL)	our ears	the changes in air pressure	
16a		see (BEHAVIOURAL)		pages 22-25	
17		clap (MATERIAL)	you		
18	you	smash (MATERIAL)	air		between your hands (SPATIAL:LOCATION)
19	the changes in air pressure	make (RELATIONAL: IDENTIFYING)	the sounds [[you hear]]		
		hear (MENTAL)	you		

Figure 4.17a Transitivity analysis of PSND2

No	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01		travels (MATERIAL)	sound		through the air (SPATIAL:LOCATION)
02		spreading out (MATERIAL)			in a series of ripples (MANNER:MEANS) like ripples in a pond (MANNER:COMPARISON)
03	sound waves (TOKEN)	are called (RELATIONAL: IDENTIFYING)	these ripples (VALUE)		
04	the air vibrating (TOKEN)	are caused by (RELATIONAL: IDENTIFYING)	(.....)		
05		can travel (MATERIAL)	sound		through any substance (SPATIAL:LOCATION)
06	This	means (RELATIONAL: IDENTIFYING)	that you can hear sounds underwater		
		can hear (MENTAL)	you	sounds	underwater (SPATIAL:LOCATION)
07		can hear (MENTAL)	you	a sound travelling through wood	
		travelling (MATERIAL)	a sound		through wood (SPATIAL:LOCATION)
08	you	put (MATERIAL)	your ear		to a table top (SPATIAL:LOCATION)
09		tap (MATERIAL)	a spoon		on the table (SPATIAL:LOCATION)
10		is (EXISTENTIAL)	no air (or any other substance)		on the moon or in space (SPATIAL:LOCATION)
11		to carry (MATERIAL)	the vibrations		
12	This	means (RELATIONAL: IDENTIFYING)	that the moon is completely silent		
		is (RELATIONAL: ATTRIBUTIVE)	the moon	silent	
13		cannot travel (MATERIAL)	sound		
14	astronauts	use (MATERIAL)	radios		
15		to talk (VERBAL)		to each other	
16		could communicate (VERBAL)	they		in an emergency (TEMPORAL:LOCATION)
17		pressing (MATERIAL)	their space suit helmets	together (ATTRIBUTE)	
18	This	would allow to travel (MATERIAL)	sound		as vibrations (ROLE) through their helmets (SPAT:LOCATION) and through the air inside (SPATIAL:LOCATION)

Figure 4.18a Transitivity analysis of PSND3

CI	Metaphors underlined	Category*
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]].	
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	12a
14	when an object vibrates.	
15	When an object vibrates	
16	it <u>causes</u> particles, or molecules, in the air to bounce against each other	12b
17	thereby <u>causing</u> other molecules to do the same.	12b
18	These waves of <u>moving</u> molecules travel through the air	5a
19	until they no longer have <u>the strength</u> [[to move the next molecule]].	2b
20	They are called <u>sound waves</u> .	
21	As the sound waves <u>get weaker</u>	
22	the sound gets softer	
23	until it disappears completely.	
24	<u>The strength</u> of the initial <u>vibration</u> affects the distance [[the sound waves will travel]].	2b, 1a, 12b
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 <u>rely on</u> [[molecules in the material [[through which they are travelling]] to knock against each other to pass the sound waves along]]]].	12b
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]].	

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 4.7a Grammatical metaphor in PSND1

Cl	Metaphors underlined	Category*
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.	
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 <u>squashes</u> and <u>stretches</u>	12b, 12a, 1a, 1a
10	as the sound is passed through the air.	
11	Because sounds have a regular pattern or frequency, like the waves on the sea	
12	they are called sound "waves".	
13	But sounds are really very small <u>changes</u> in the pressure of the air.	1a
14	We cannot see sounds	
15	but we can hear them	
16	when our ears pick up the <u>changes</u> in air pressure	1a
16a	(see pages 22-25)	
17	When you clap	
18	you smash air between your hands	
19	and the <u>changes</u> in air pressure make the sounds [[you hear]].	1a

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 4.8a Grammatical metaphor in PSND2

Cl	Metaphors underlined	Category*
01	Sound travels through the air	
02	by spreading out in a <u>series</u> of ripples, like ripples on a pond.	12a
03	These ripples are called "sound waves"	
04	and are <u>caused</u> by [[the air vibrating]].	12b
05	In fact, sound can travel through any substance.	
06	This <u>means</u> that you can hear sounds underwater.	12b
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.	
10	On the moon or in space, there is no air (or any other substance)	
11	to carry the <u>vibrations</u> .	1a
12	This <u>means</u> that the moon is completely silent	12b
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 <u>allow</u> sound to travel as <u>vibrations</u> through their helmets and through the air inside.	12b, 1a

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 4.9a Grammatical metaphor in PSND3

Appendix 5

Analyses of Seasons Texts

Secondary texts:

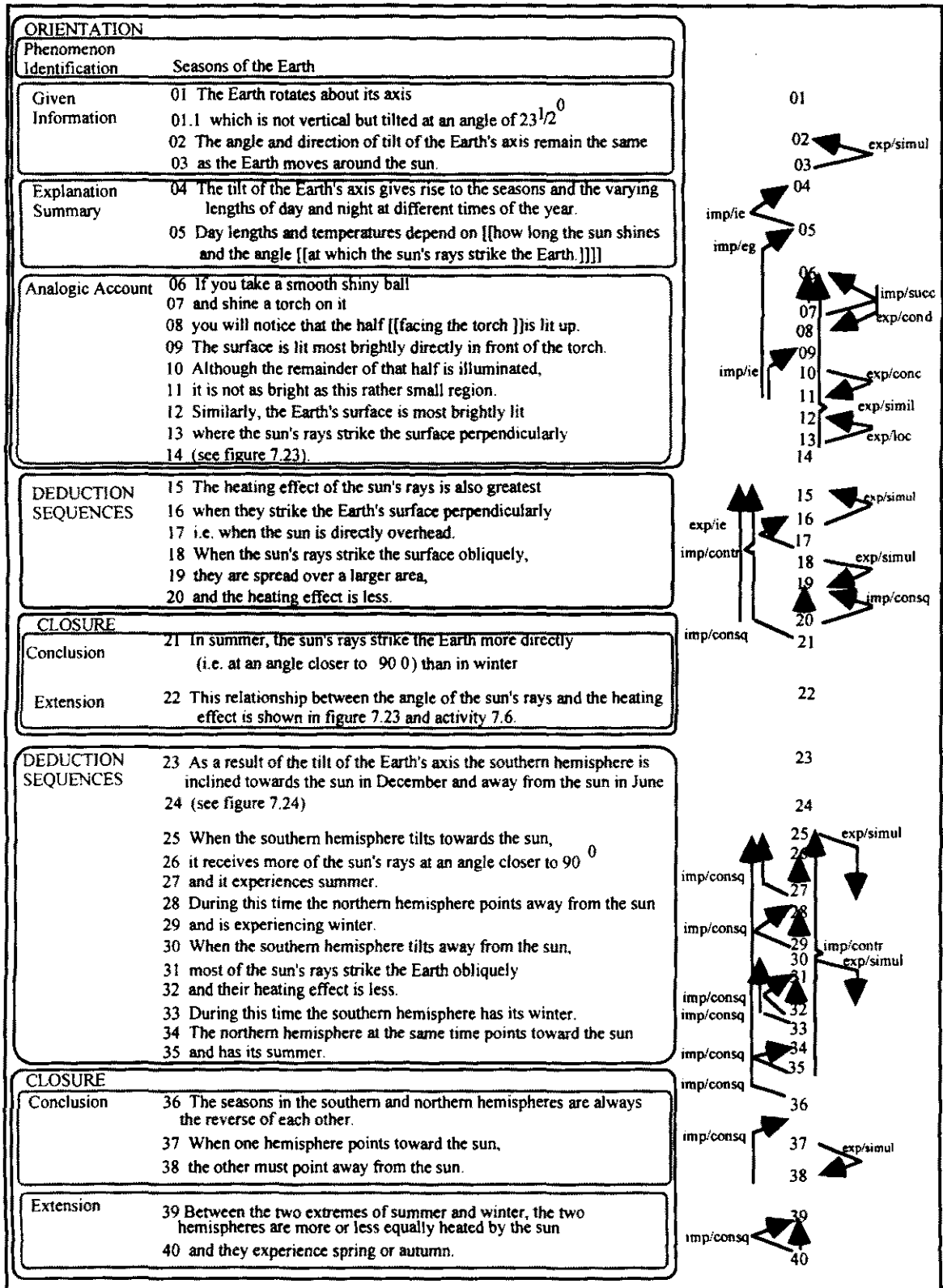
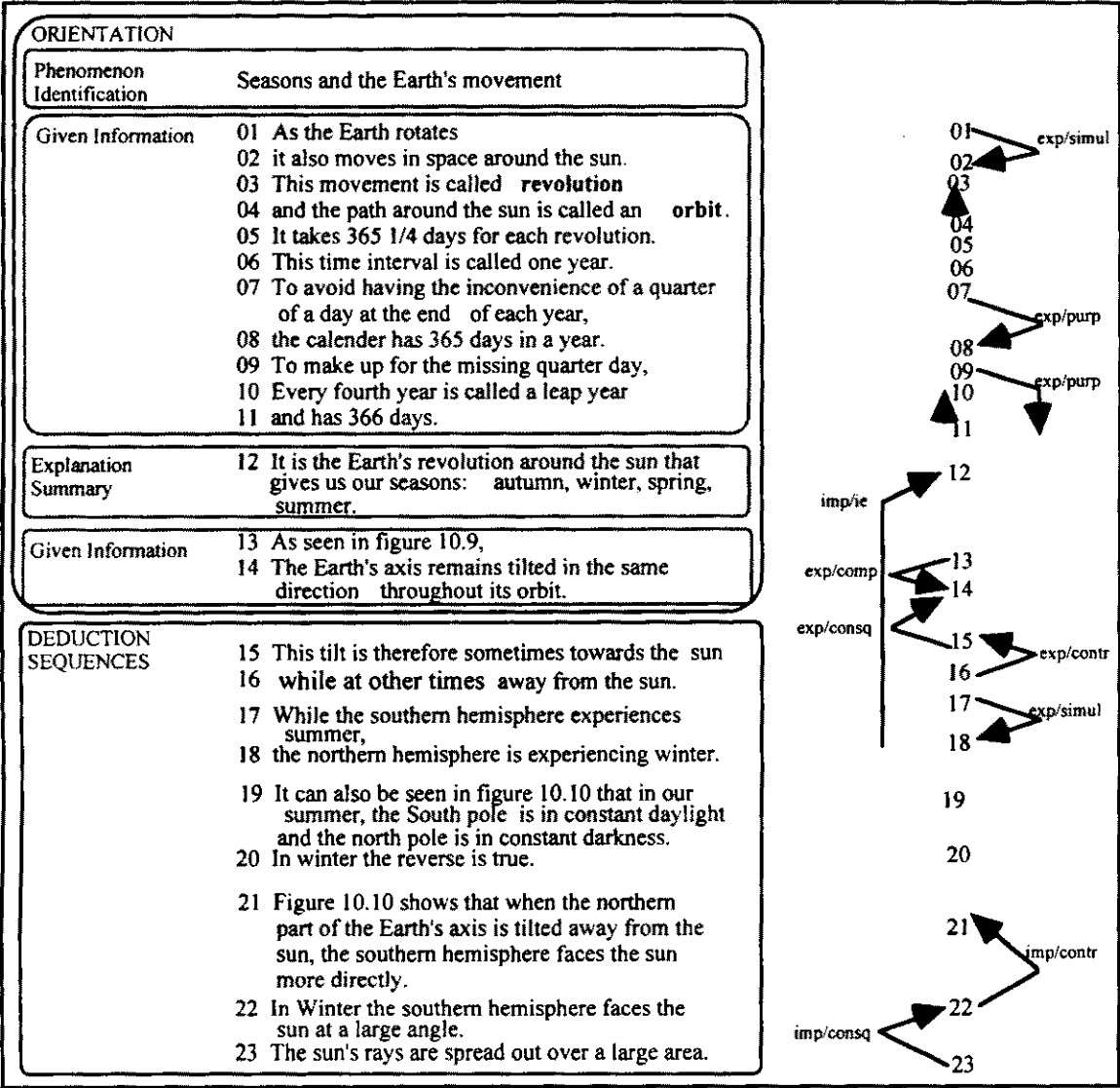


Figure 5.1a Conjunction and schematic structure in SSEAS1



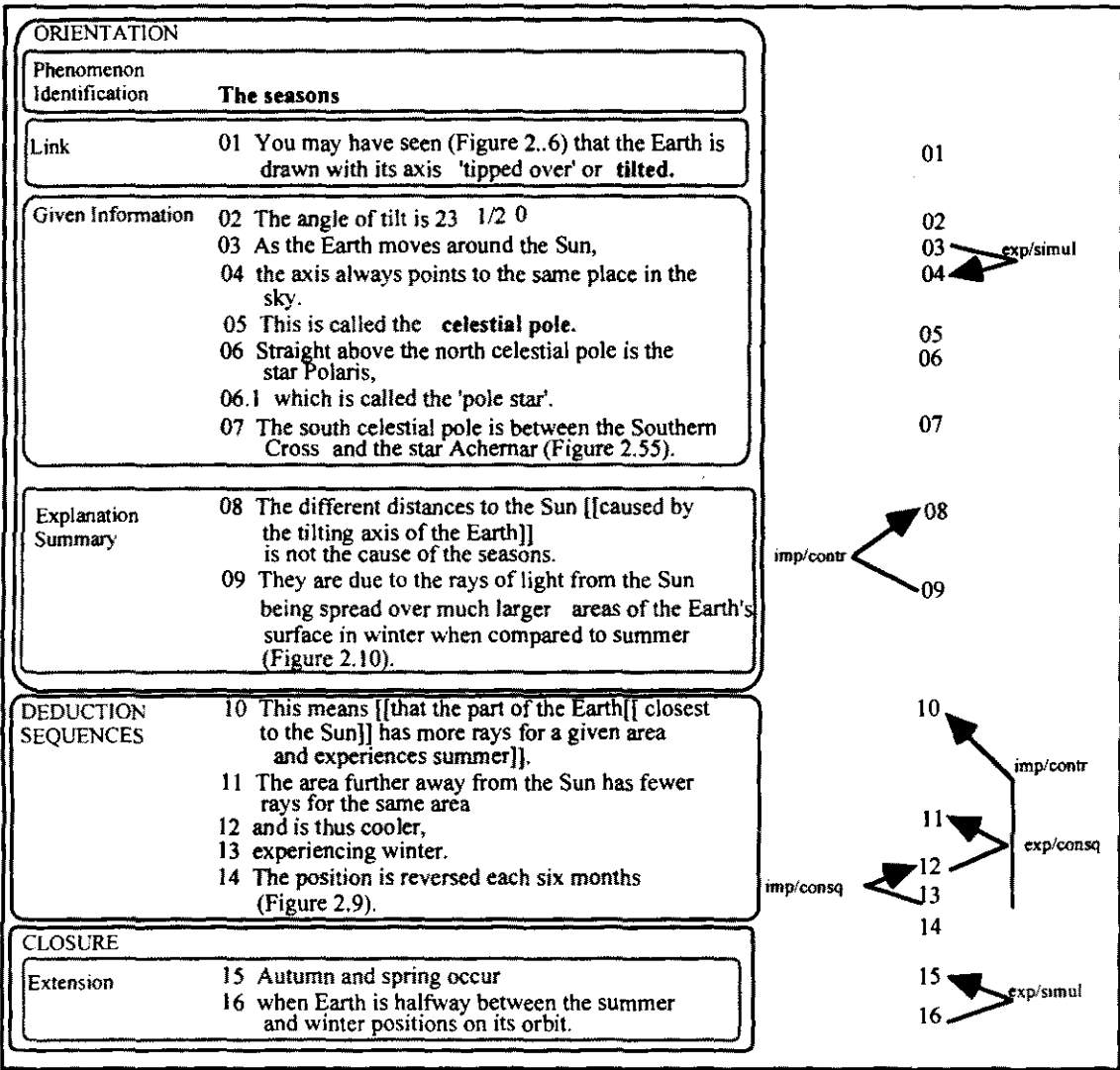


Figure 5.3a Conjunction and schematic structure in SSEAS3

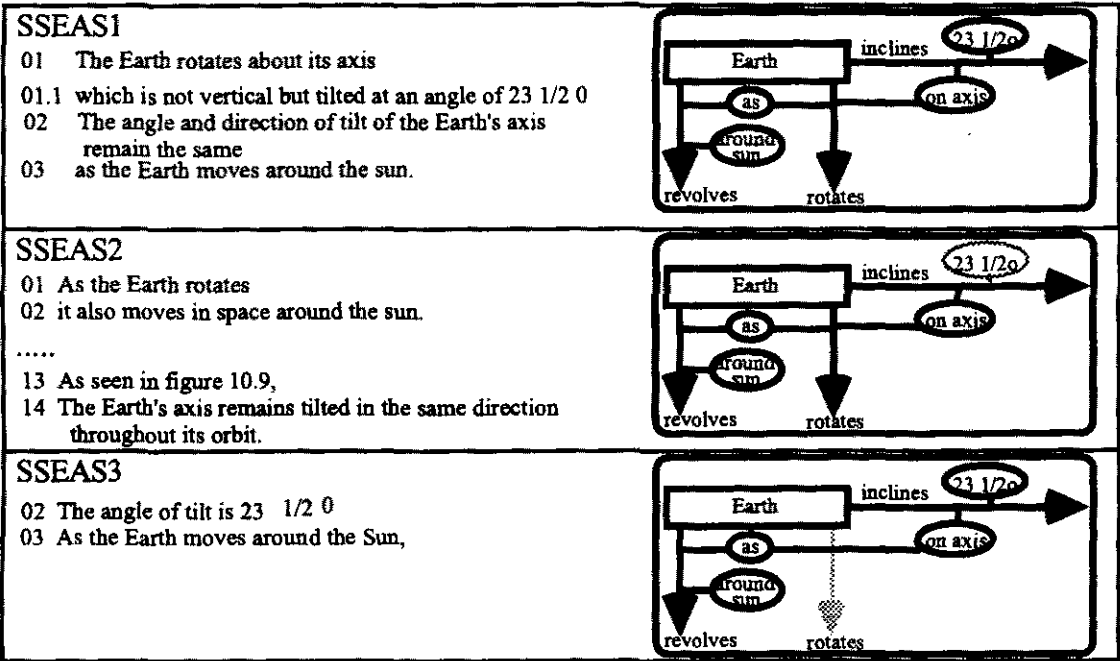
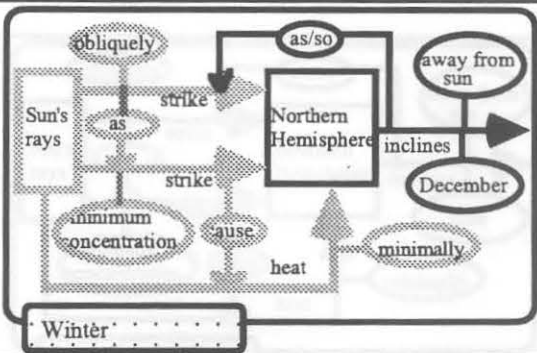


Figure 5.4a Semantic map for the Given Information element in secondary seasons texts

There is substantial commonality of ideational meanings across texts in this element. The numerical value of the angle of the Earth's inclination on its axis is omitted from SSEAS2 and SSEAS3 does not indicate that the Earth rotates on its axis. Apart from the scriptally inferred meaning of *on axis* in SSEAS2, reader access to the selected meanings is literal and explicit.

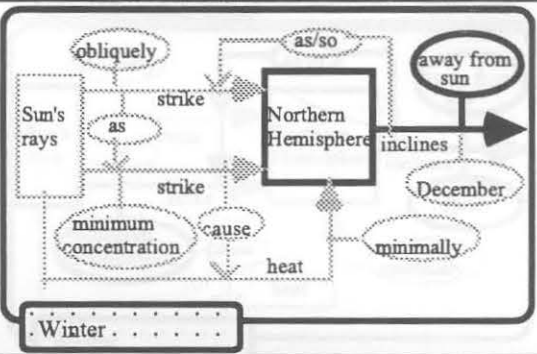
SSEAS1

- 28 During this time the northern hemisphere
points away from the sun
29 and is experiencing winter.



SSEAS2

- 15 This tilt is therefore sometimes towards the sun
16 while at other times away from the sun.
17 While the southern hemisphere experiences summer,
18 the northern hemisphere is experiencing winter.
.....
21 Figure 10.10 shows that when the northern part
of the Earth's axis is tilted away from the sun,
the southern hemisphere faces the sun more directly.



SSEAS3

- 11 The area further away from the Sun has fewer
rays for the same area
12 and is thus cooler,
13 experiencing winter.

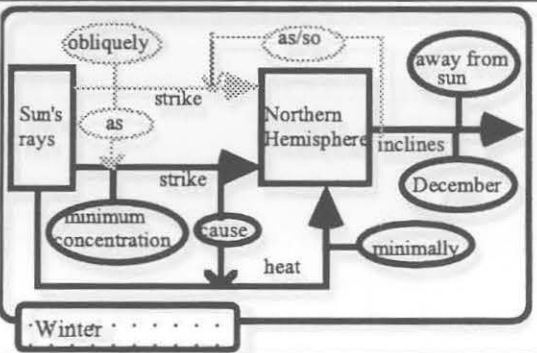


Figure 5.5a Semantic map for second phase of DEDUCTION SEQUENCES in secondary seasons texts

The additional thin, solid relation lines in the maps for SSEAS2 and SSEAS3 show the relationship of the main verb striking the earth with minimal concentration is minimally concentrated in the way in which the northern hemisphere is inclined to the sun, and an intermediate connecting idea for obliquely rays is a ray for rays rays as for the way they are included.

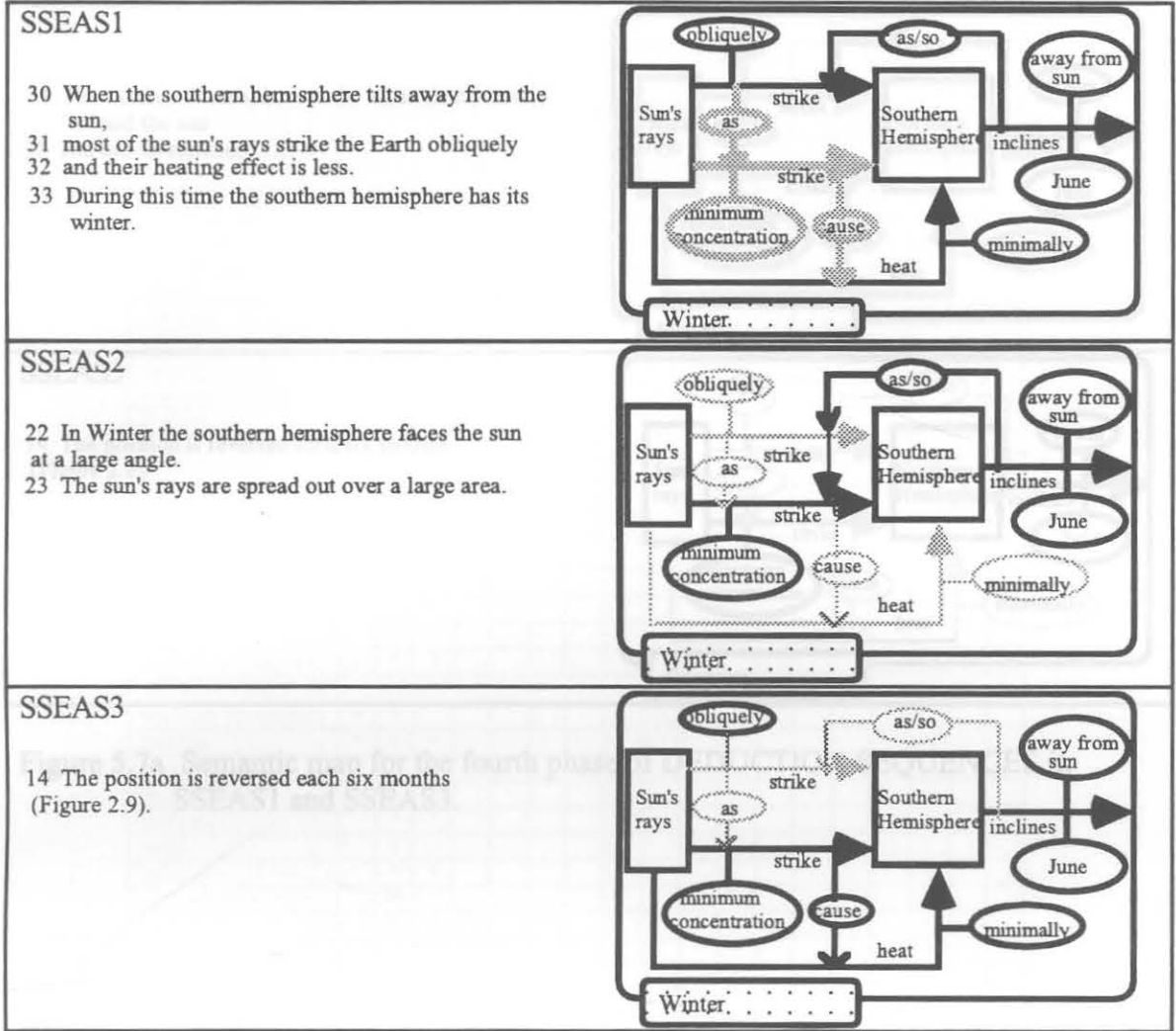


Figure 5.6a Semantic map for third phase of DEDUCTION SEQUENCES in secondary seasons texts

The additional thin, solid relation line in the map for SSEAS2 indicates that the cause of the sun's rays striking the earth with minimal concentration is directly attributed to the angle at which the southern hemisphere is inclined to the sun, and no intermediate reasoning about the oblique angle at which the sun's rays strike the surface is included.

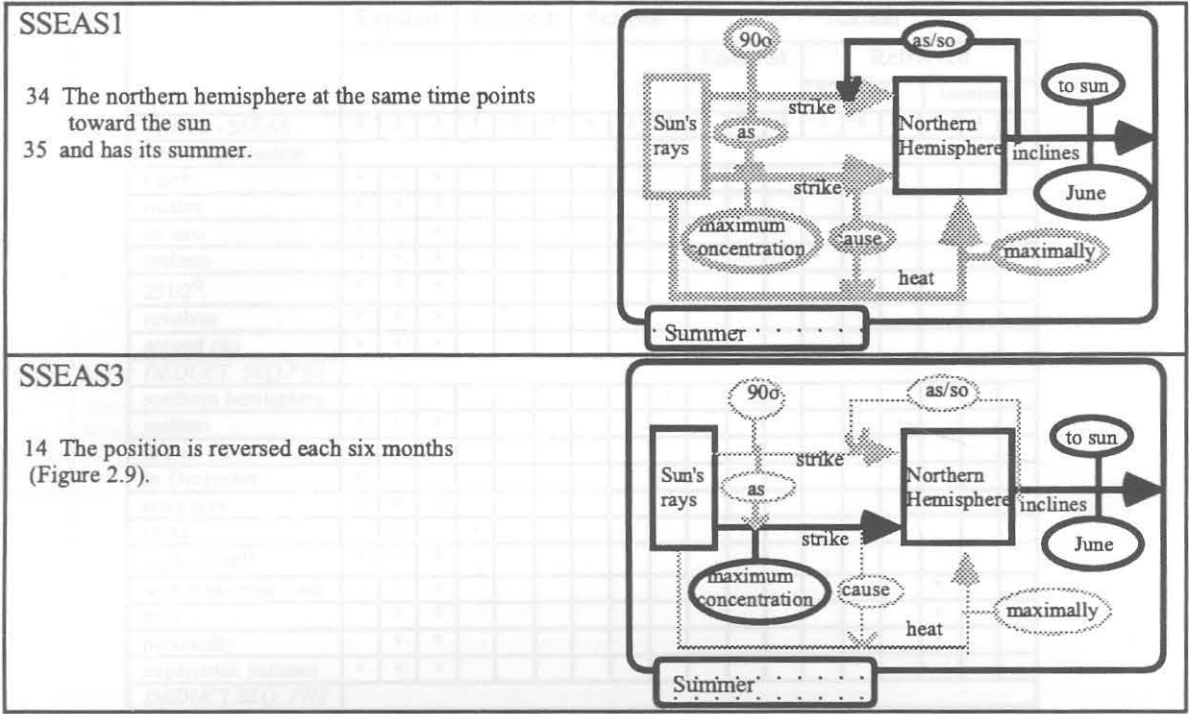


Figure 5.7a Semantic map for the fourth phase of DEDUCTION SEQUENCES in SSEAS1 and SSEAS3.

Table 5.1a Types of reader access to nuclear meanings in secondary seasons texts

	Literal									Inferential											
	Explicit			Implicit			Scriptal			Textual											
										Entailed						Retrieved					
																Referential			Ideational		
TEXTS - SSEAS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
<i>Given Information</i>																					
Earth	x	x	x																		
rotates	x	x	0																		
on axis	x		x						x												
inclines	x	x	x																		
231/2 ⁰	x	0	x																		
revolves	x	x	x																		
around sun	x	x	x																		
<i>DEDUCT. SEQ. PH1</i>																					
southern hemisphere	x	x							x												
inclines	x	x	x																		
to sun	x	x	x																		
in December	x								x	x											
sun's rays	x	0	x																		
strike		0		x										x							
angle of 90 ⁰	x	0	0																		
with maximum conc		0	x																x		
heat		0	0																x		
maximally		0	0																x		
experience summer	x	x	x																		
<i>DEDUCT. SEQ. PH2</i>																					
northern hemisphere	x	x							x												
inclines	x	x	x																		
away from sun	x	x	x																		
in December		0							x					x							
sun's rays		0	x																x		
strike		0												x					x		
obliquely		0	0																x		
with minimum conc		0	x																x		
heat		0	x																x		
minimally		0	x																x		
experience winter	x	x	x																		
<i>DEDUCT. SEQ. PH3</i>																					
southern hemisphere	x	x																			x
inclines	x					x															x
away from sun	x					x															x
in June	x								x	x											
sun's rays	x	x																			x
strike	x													x	x						
obliquely	x	0	0																		
with minimum conc		x																	x		x
heat	x	0																			x
minimally	x	0																			x
experience winter	x	x																			x
<i>DEDUCT. SEQ. PH 4</i>																					
northern hemisphere	x	0																			x
inclines	x	0																			x
to sun	x	0				x															x
in June		0							x					x							
sun's rays		0																	x		x
strike		0												x					x		
angle of 90 ⁰		0	0																x		
with maximum conc		0																	x		x
heat		0	0																x		
maximally		0	0																x		
experience summer	x	0																			x

Table 5.1a Types of reader access to nuclear meanings in secondary seasons texts

	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01		rotates (MATERIAL)	the Earth		about its axis (SPATIAL:LOCATION)
01.1		is (RELATIONAL: ATTRIBUTIVE)	which	not vertical but tilted at an angle of $23\frac{1}{2}^{\circ}$	
02		remain (RELATIONAL: ATTRIBUTIVE)	The angle and direction of tilt of the Earth's axis	the same	
03		moves (MATERIAL)	the Earth		around the sun (SPATIAL:LOCATION)
04	The tilt of the Earth's axis	gives rise to (RELATIONAL: CIRCUMSTANTIAL: IDENTIFYING)	the seasons and the varying lengths of day and night at different times of the year		
05	Day lengths and temperatures	depend on (RELATIONAL: CIRCUMSTANTIAL: IDENTIFYING)	[[how long the sun shines and the angle [[at which the sun's rays strike the Earth]]		
		shines (MATERIAL)	the sun		how long (TEMPORAL:EXTENT)
	the sun's rays	strike (MATERIAL)	the Earth		at which (angle) (MANNER:QUALITY)
06	you	take (MATERIAL)	a smooth shiny ball		
07		shine (MATERIAL)	a torch		on it (SPATIAL:LOCATION)
08		will notice (MENTAL)	you	that the half [[facing the torch]] is lit up	
		facing (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)		the torch	
09		is lit (MATERIAL)	the surface		most brightly (MANNER:QUALITY) directly in front of the torch (SPATIAL:LOCATION)
10		is illuminated (MATERIAL)	the remainder of that half		
11		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	it	not as bright as this rather small region	
12		is lit (MATERIAL)	the Earth's surface		most brightly (MANNER:QUALITY)
13	the sun's rays	strike (MATERIAL)	the Earth		perpendicularly (MANNER:QUALITY)
14		see (BEHAVIOURAL)	Figure 7.23		
15		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the heating effect of the sun's rays	greatest	
16	they	strike (MATERIAL)	the earth's surface		perpendicularly (MANNER:QUALITY)
17		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the sun	directly overhead (SPATIAL:LOCATION)	
18	the sun's rays	strike (MATERIAL)	the surface		obliquely (MANNER:QUALITY)
19		are (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	they	spread over a larger area (SPATIAL; LOCATION)	
20		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the heating effect	less	

21	the sun's rays	strike (MATERIAL)	the Earth		In summer (TEMPORAL: LOCATION) more directly, i.e. at an angle closer to 90° , than in winter (MANNER:QUALITY)
22		is shown (VERBAL)	The relationship between the angle of the sun's rays and the heating effect		in figure 7.23 and activity 7.6 (SPATIAL:LOCATION)
23		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the southern hemisphere	inclined towards the sun (SPATIAL: LOCATION)	in December (TEMPORAL: LOCATION)
			away from the sun (SPATIAL:LOCATION)		in June (TEMPORAL: LOCATION)
24		see (BEHAVIOURAL)	figure 7.24		
25		tilts (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	the southern hemisphere	towards the sun (SPATIAL:LOCATION)	
26	it	receives (MATERIAL)	more of the sun's rays at an angle closer to 90°		
27		experiences (BEHAVIOURAL)	it	summer	
28		points (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	the northern hemisphere	away from the sun (SPATIAL:LOCATION)	During this time (TEMPORAL: LOCATION)
29		is experiencing (BEHAVIOURAL)		winter	
30		tilts (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	the southern hemisphere	away from the sun (SPATIAL:LOCATION)	
31	most of the sun's rays	strike (MATERIAL)	the Earth		obliquely (MANNER:QUALITY)
32		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	their heating effect	less	
33		has (BEHAVIOURAL)	the southern hemisphere	its winter	during this time (TEMPORAL: LOCATION)
34		points (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	the northern hemisphere	towards the sun (SPATIAL:LOCATION)	at the same time (TEMPORAL: LOCATION)
35		has (BEHAVIOURAL)		its summer	
36	The seasons in the southern and northern hemisphere	are (RELATIONAL: INTENSIVE: IDENTIFYING)	the reverse of each other		
37		points (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	one hemisphere	towards the sun (SPATIAL:LOCATION)	
38		must point (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	the other	away from the sun (SPATIAL: LOCATION)	
39	by the sun	are heated (MATERIAL)	the two hemispheres		more or less equally MANNER:QUALITY) between the extremes of summer and winter(TEMPORAL:LOCATION)
40		experience (BEHAVIOURAL)	they	spring or autumn	

Figure 5.8a Transitivity analysis of SSEAS1

	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01		rotates (MATERIAL)	the Earth		
02		moves (MATERIAL)	it		in space (SPATIAL :LOCATION) around the sun (SPATIAL:LOCATION)
03	revolution	is called (RELATIONAL: INTENSIVE IDENTIFYING)	this movement		
04	an orbit	is called (RELATIONAL: INTENSIVE; IDENTIFYING)	the path around the sun		
05		takes (RELATIONAL: CIRCUMSTANTIAL; ATTRIBUTIVE)	It [for each revolution]	365 ¹ /4days	
06	one year	is called (RELATIONAL: INTENSIVE: IDENTIFYING)	this time interval		
07		avoid having (BEHAVIOURAL)	the inconvenience of a quarter of a day at the end of each year		
08		has (RELATIONAL: POSSESSIVE; ATTRIBUTIVE)	the calendar	365 days in a year	
09		make up for (RELATIONAL: POSSESSIVE; IDENTIFYING)	the missing quarter day		
10	a leap year	is called (RELATIONAL: INTENSIVE: IDENTIFYING)	every fourth year		
11		has (RELATIONAL: POSSESSIVE; ATTRIBUTIVE)	366 days		
12	the Earth's revolution around the sun	is (RELATIONAL: INTENSIVE: IDENTIFYING)	it [[that gives us our seasons: autumn, winter, spring and summer]]		
	that	gives (MATERIAL)	our seasons: autumn, winter, spring and summer	us	
13		seen (MENTAL)			in Figure 10.9 (SPATIAL:LOCATION)
14		remains (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the Earth's axis	tilted in the same direction	throughout its orbit (TEMPORAL: EXTENT)
15		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	this tilt	towards the sun (SPATIAL : LOCATION)	
16				away from the sun (SPATIAL:LOCATION)	at other times (TEMPORAL: LOCATION)
17		experiences (BEHAVIOURAL)	the southern hemisphere	summer	
18		is experiencing (BEHAVIOURAL)	the northern hemisphere	its winter	
19		can be seen (MENTAL)		it [[that in our summer, the south pole is in constant daylight and the north pole is in constant darkness]]	in Figure 10.10 (SPATIAL:LOCATION)

		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the south pole	in constant daylight (SPATIAL: LOCATION)	
		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the north pole	in constant darkness (SPATIAL: LOCATION)	
20		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the reverse	true	in winter (TEMPORAL: LOCATION)
21		shows (VERBAL)	Figure 10.10		
		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the northern part of the earth's axis	tilted away from the sun (SPATIAL:LOCATION)	
		faces (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	the southern hemisphere	the sun	more directly (MANNER:QUALITY)
22		faces (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	the southern hemisphere	the sun	at a large angle (MANNER:QUALITY) in winter (TEMPORAL: LOCATION)
23		are (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	the sun's rays	spread out over a large area (SPATIAL:LOCATION)	

Figure 5.9a Transitivity analysis of SSEAS2

	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
01		may have seen (MENTAL)	you	that the Earth is drawn with its axis "tipped over" or tilted.	(Figure 2.6)
		is drawn (MATERIAL)		the Earth	with its axis tipped over or tilted (MANNER:QUALITY)
02	23 ¹ / ₂ °	is (RELATIONAL: INTENSIVE: IDENTIFYING)	the angle of tilt		
03		moves (MATERIAL)	the earth		around the sun (SPATIAL:LOCATION)
04	the axis	points to (RELATIONAL: INTENSIVE: IDENTIFYING)	the same place in the sky		
05	the celestial pole	is called (RELATIONAL: INTENSIVE: IDENTIFYING)	this		
06		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the star Polaris	straight above the north celestial pole (SPATIAL:LOCATION)	
06.1	the "pole star"	is called (RELATIONAL: INTENSIVE: IDENTIFYING)	which		
07		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the south celestial pole	between the Southern Cross and the star Achernar (SPATIAL:LOCATION)	(Figure 2.55)
08	The different distances to the Sun [[caused by the tilting axis of the Earth]]	is not (RELATIONAL: INTENSIVE: IDENTIFYING)	the cause of the seasons		
	by the tilting axis of the Earth	caused (RELATIONAL: CIRCUMSTANTIAL: IDENTIFYING)			
09		are (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	They	due to the rays of light from the sun being spread over much larger areas of the Earth's surface in winter when compared with summer	(Figure 2.10)
		being (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	the rays of light from the sun	spread over much larger areas of the Earth's surface (SPATIAL: LOCATION)	in winter (TEMPORAL:LOCATION)
		compared (RELATIONAL: CIRCUMSTANTIAL: IDENTIFYING)	with summer		
10	This	means (RELATIONAL: INTENSIVE: IDENTIFYING)	[[that the part of the Earth closest to the sun has more rays for a given area and experiences summer]]		
		has (RELATIONAL: POSSESSIVE: ATTRIBUTIVE)	that part of the Earth closest to the sun	more rays for a given area	
		(RELATIONAL: INTENSIVE: ATTRIBUTIVE)		closest to the Earth	

		experiences (BEHAVIOURAL)		summer	
11		has (RELATIONAL: POSSESSIVE: ATTRIBUTIVE)	The area further away from the sun	fewer rays for the same area	
		(RELATIONAL: INTENSIVE: ATTRIBUTIVE)		further away from the sun	
12		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)		cooler	
13		experiencing (BEHAVIOURAL)		Winter	
14		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the position	reversed	every six months (TEMPORAL:LOCATION)
15		occur (MATERIAL)	Autumn and Spring		
16		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the earth	halfway between the summer and winter positions on its orbit (SPATIAL:LOCATION)	

Figure 5.10a Transitivity analysis of SSEAS3

Clause	Metaphors underlined	Category*
01	The Earth rotates about its axis	
01.1	which is not vertical but tilted at an angle of $23\frac{1}{2}^0$.	
02	The angle and direction of <u>tilt</u> of the Earth's axis remain the same	2b
03	as the Earth moves around the sun.	
04	The <u>tilt</u> of the Earth's axis <u>gives rise to</u> the seasons and the <u>varying lengths</u> of day and night at different times of the year.	2b, 12b, 5d, 2b
05	<u>Day lengths</u> and temperatures <u>depend on</u> [[how long the sun shines and the angle [[at which the sun's rays strike the Earth.]]]]	6a, 2b, 12b,
06	If you take a smooth shiny ball	
07	and shine a torch on it	
08	you will notice that the half [[facing the torch]] is lit up.	
09	The surface is lit most brightly directly in front of the torch.	
10	Although the remainder of that half is illuminated,	
11	it is not as bright as this rather small region.	
12	Similarly, the Earth's surface is most brightly lit	
13	where the sun's rays strike the surface perpendicularly	
14	(see figure 7.23).	
15	The <u>heating effect</u> of the sun's rays is also greatest	5a, 12a
16	when they strike the Earth's surface perpendicularly	
17	i.e. when the sun is directly overhead.	
18	When the sun's rays strike the surface obliquely,	
19	they are spread over a larger area,	
20	and the <u>heating effect</u> is less.	5a, 12a
21	In summer, the sun's rays strike the Earth more directly (i.e. at an angle closer to 90^0) than in winter	
22	This <u>relationship</u> between the angle of the sun's rays and the <u>heating effect</u> is shown in figure 7.23 and activity 7.6.	1c, 5a, 12a
23	<u>As a result</u> of the <u>tilt</u> of the Earth's axis the southern hemisphere is inclined towards the sun in December and away from the sun in June	12d, 2b
24	(see figure 7.24)	
25	When the southern hemisphere tilts towards the sun,	
26	it receives more of the sun's rays at an angle closer to 90^0	
27	and it experiences summer.	
28	<u>During this time</u> the northern hemisphere points away from the sun	12d
29	and is experiencing winter.	
30	When the southern hemisphere tilts away from the sun,	
31	most of the sun's rays strike the Earth obliquely	
32	and their <u>heating effect</u> is less.	5a, 12a
33	<u>During this time</u> the southern hemisphere has its winter.	12d
34	The northern hemisphere <u>at the same time</u> points toward the sun	12d
35	and has its summer.	
36	The seasons in the southern and northern hemispheres are always <u>the reverse</u> of each other.	12a
37	When one hemisphere points toward the sun,	
38	the other must point away from the sun.	
39	Between the two extremes of summer and winter, the two hemispheres are more or less equally heated by the sun	
40	and they experience spring or autumn.	

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 5.2a Grammatical metaphor in SSEAS1

Clause	Metaphors underlined	Category*
01	As the Earth rotates	
02	it also moves in space around the sun.	
03	This <u>movement</u> is called <u>revolution</u>	1a, 1a
04	and the path around the sun is called an orbit.	
05	It takes $365\frac{1}{4}$ days for each <u>revolution</u> .	1a
06	This time interval is called one year.	
07	To avoid having <u>the inconvenience</u> of a quarter of a day at the end of each year,	2b
08	The calendar has 365 days in a year.	
09	To make up for the missing quarter day,	
10	every fourth year is called a leap year	
11	and has 366 days.	
12	It is the Earth's <u>revolution</u> around the sun that <u>gives us</u> our seasons: autumn, winter, spring, summer.	1a, 12b
13	As seen in figure 10.9,	
14	The Earth's axis remains tilted in the same direction throughout its orbit.	
15	This <u>tilt</u> is therefore sometimes towards the sun	2b
16	while at other times away from the sun.	
17	While the southern hemisphere experiences summer,	
18	the northern hemisphere is experiencing winter.	
19	It can also be seen in figure 10.10 [[that in our summer, the South pole is in <u>constant daylight</u> and the north pole is in <u>constant darkness</u> .]]	5h, 5h
20	In winter <u>the reverse</u> is true.	12a
21	Figure 10.10 shows that	
	when <u>the northern part of the Earth's axis</u> is tilted away from the sun,	
	the southern hemisphere faces the sun more directly.	
22	In Winter the southern hemisphere faces the sun at a large angle.	
23	The sun's rays are spread out over a large area.	

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 5.3a Grammatical metaphor in SSEAS2

Clause	Metaphors underlined	Category*
01	You may have seen (Figure 2.6) [[that the Earth is drawn with its axis 'tipped over' or <u>tilted</u> .]]	
02	The angle of <u>tilt</u> is 23^0 .	2b
03	As the Earth moves around the Sun,	
04	the axis always points to the same place in the sky.	
05	This is called the <u>celestial pole</u> .	
06	Straight above the north celestial pole is the star Polaris,	
06.1	which is called the 'pole star'.	
07	The south celestial pole is between the Southern Cross and the star Achernar (Figure 2.55).	
08	The different distances to the Sun [[<u>caused</u> by the <u>tilting</u> axis of the Earth]] is not <u>the cause</u> of the seasons.	12b, 12a
09	They are [[<u>due to</u> the rays of light from the Sun being spread over much larger areas of the Earth's surface in winter when <u>compared to</u> summer (Figure 2.10).]]	12c, 12b
10	This <u>means</u> [[that the part of the Earth closest to the Sun has more rays for a given area and experiences summer]].	12b
11	The area further away from the Sun has fewer rays for the same area	
12	and is thus cooler,	
13	experiencing winter.	
14	The position is <u>reversed</u> each six months (Figure 2.9).	12b
15	Autumn and spring occur	
16	when Earth is halfway between the summer and winter positions on its orbit.	

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 5.4a Grammatical metaphor in SSEAS3

Primary texts:

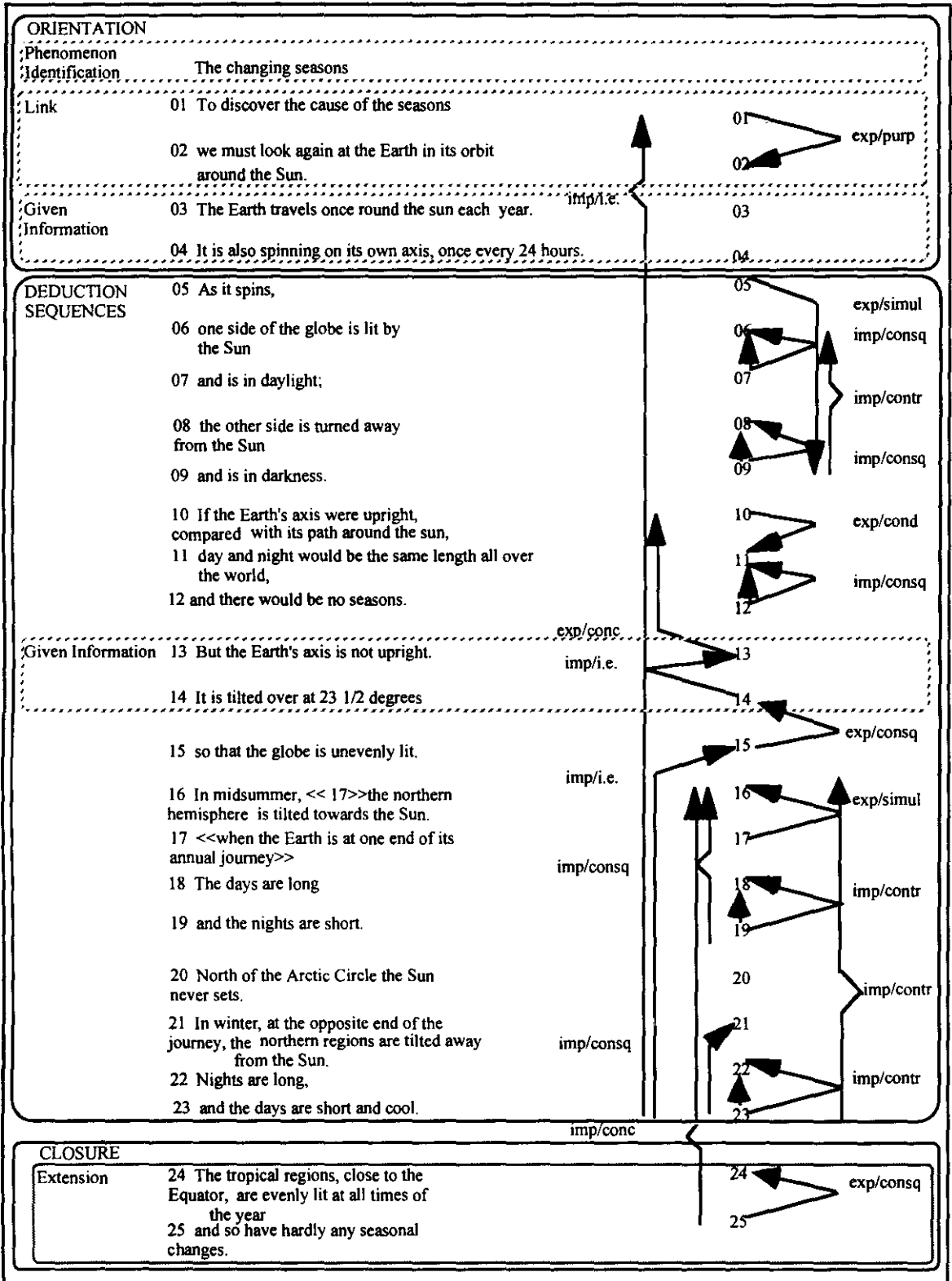


Figure 5.11a Conjunction and schematic structure in PSEAS1

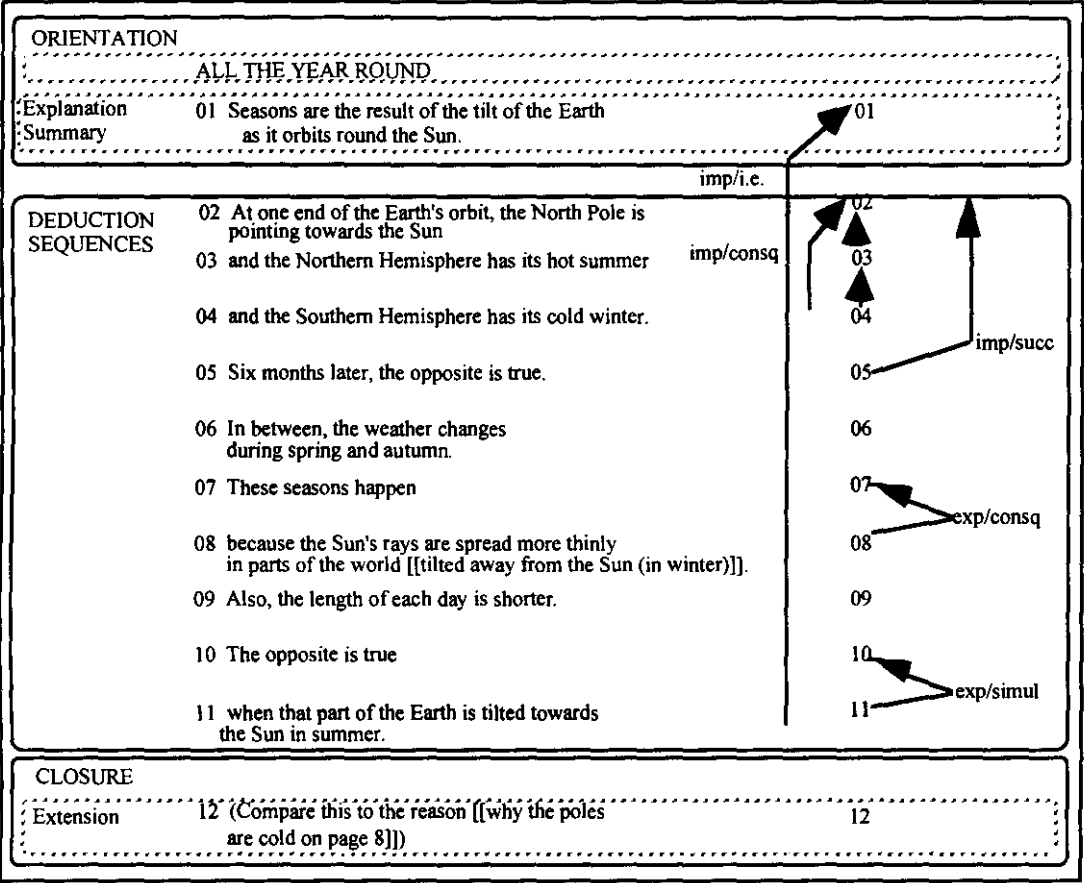


Figure 5.12a Conjunction and schematic structure in PSEAS2

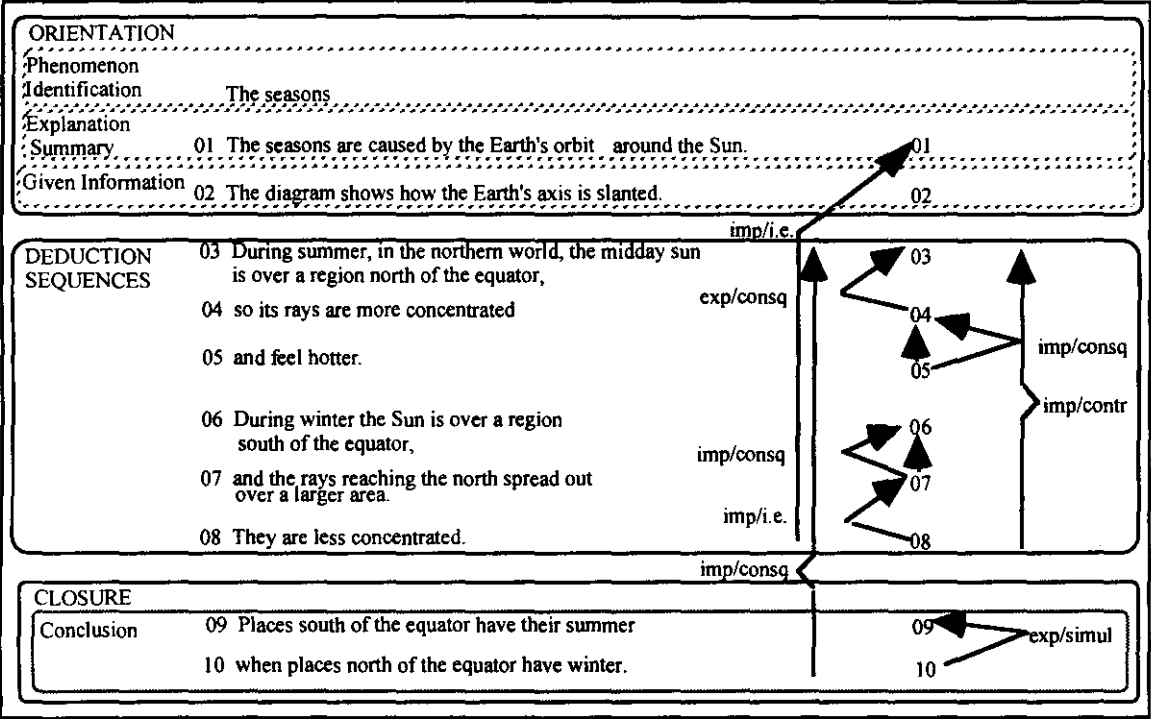


Figure 5.13a Conjunction and schematic structure in PSEAS3

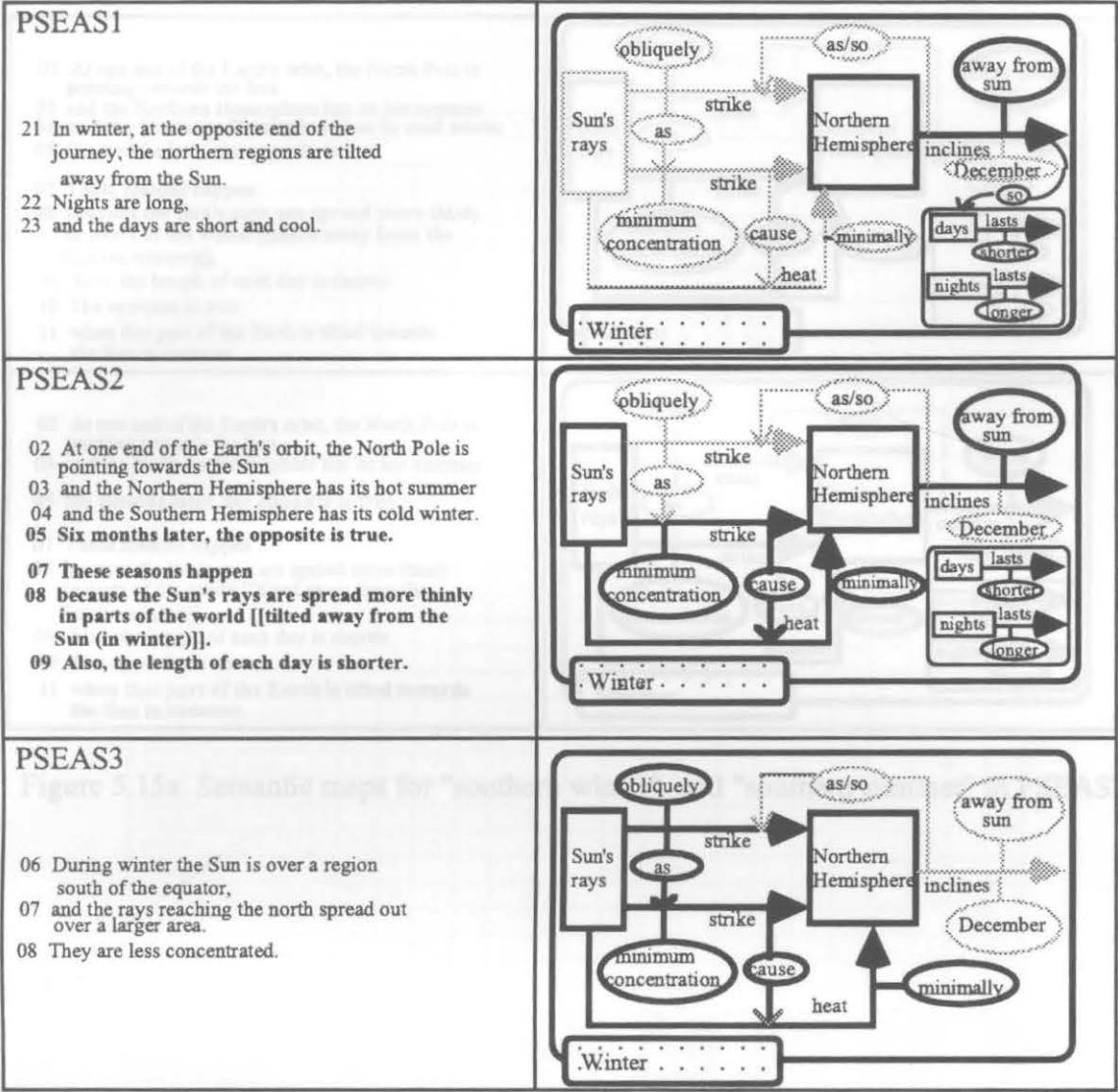


Figure 5.14a Semantic maps for "northern winter" phase of DEDUCTION SEQUENCES in primary seasons texts

An appropriate semantic mapping of the location in time realised in clause 05 in PSEAS2 as "Six months later" is problematic. Here it can be considered an implicit realisation of the specific location in time of the northern winter "in December".

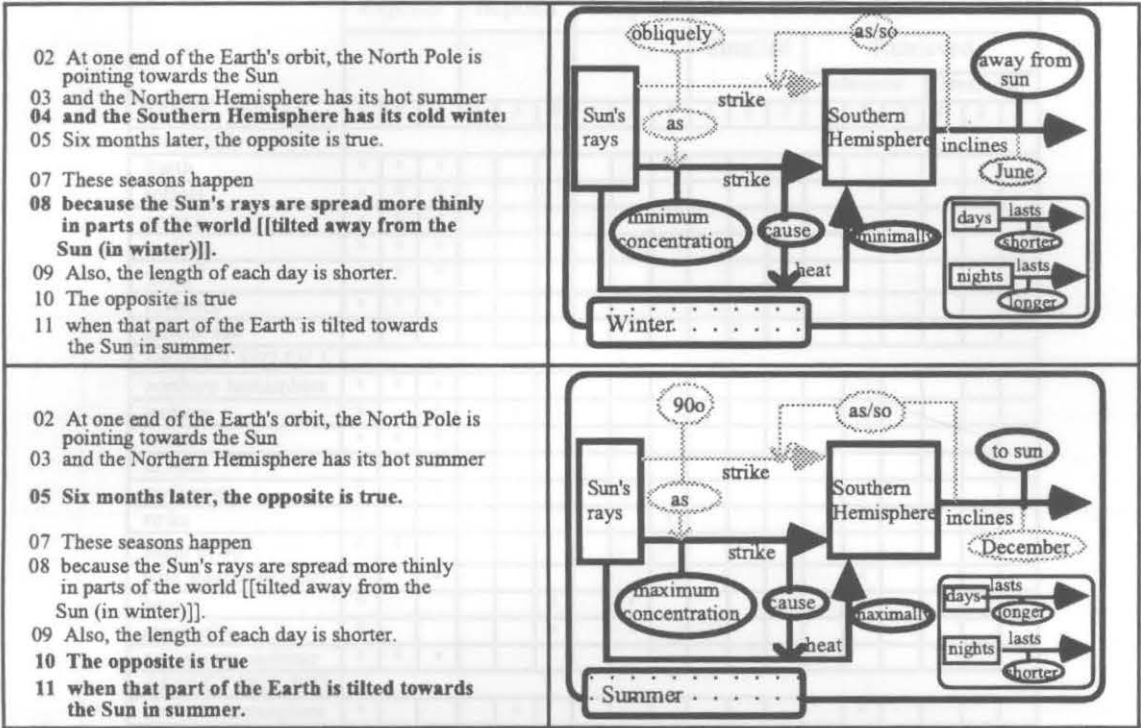


Figure 5.15a Semantic maps for "southern winter" and "southern summer" in PSEAS2

Table 5.3a Types of reader access to nuclear meanings in primary school texts

	Literal						Inferential											
	Explicit			Implicit			Scriptal			Textual								
										Entailed			Retrieved					
													Referential			Ideational		
TEXTS - PSEAS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
<i>Given Information</i>																		
Earth	x	x	x															
rotates	x	0	0															
on axis	x	0	x															
inclines	x	x	x															
231/2 ⁰	x	0	0															
revolves	x	x	x															
around sun	x	x	x															
<i>DEDUCT.SEQ.PH 1</i>																		
northern hemisphere	x	x	x															
inclines	x		0		x													
to sun	x	x	0															
in June	0	0	0															
sun's rays	0		x												x			
strike	0									x					x			
angle of 90 ⁰	0	0								x								
with maximum conc	0		x												x			
heat	0				x			x										
maximally	0				x			x										
experience summer	x	x	x															
<i>DEDUCT.SEQ. PH2</i>																		
northern hemisphere	x				x										x			
inclines	x		0												x			
away from sun	x		0												x			
in December	0		0						x									
sun's rays	0	x	x															
strike	0	0	x															
obliquely	0	0								x								
with minimum conc	0	x	x															
heat	0	0	0															
minimally	0	0	0															
experience winter	x		x												x			
<i>DEDUCT.SEQ. PH3</i>																		
southern hemisphere		x																
inclines		x																
away from sun		x																
in June		0																
sun's rays		x																
strike		x																
obliquely		0																
with minimum conc		x																
heat					x													
minimally					x													
experience winter		x																
<i>DEDUCT. SEQ. PH1</i>																		
southern hemisphere					x													
inclines		x																
to sun		x																
in December		0																
sun's rays															x			
strike															x			
angle of 90 ⁰		0																
with maximum conc															x			
heat		0																
maximally		0																
experience summer															x			

Table 5.5a Types of reader access to nuclear meanings in primary seasons texts

	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
1		to discover (BEHAVIOURAL)		the cause of the seasons	
2		must look at (BEHAVIOURAL)	we	the Earth in its orbit around the Sun	again (TEMPORAL: FREQUENCY)
3		travels (MATERIAL)	the Earth		round the Sun (SPATIAL:LOCATION) once each year (TEMPORAL: FREQUENCY)
4		is spinning (MATERIAL)	it		on its own axis (SPATIAL:LOCATION) once, every 24 hours (TEMPORAL: FREQUENCY)
5		spins (MATERIAL)	it		
6	by the sun	is lit (MATERIAL)	one side of the globe		
7		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)		in daylight (SPATIAL:LOCATION)	
8		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the other side	turned away from the sun (SPATIAL:LOCATION)	
9		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)		in darkness (SPATIAL:LOCATION)	
10		were (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the Earth's axis	upright compared with its path around the sun (MANNER:QUALITY)	
11		would be (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	day and night	the same length	all over the world (SPATIAL:LOCATION)
12		would be (EXISTENTIAL)	no seasons		
13		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the Earth's axis	not upright	
14		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	it	tilted over at $23\frac{1}{2}$ degrees	
15		is lit (MATERIAL)	the globe		unevenly (MANNER: QUALITY)
16		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the northern hemisphere	tilted toward the sun (SPATIAL:LOCATION)	in midsummer (TEMPORAL: LOCATION)
17		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the Earth	at one end of its annual journey (SPATIAL:LOCATION)	
18		are (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the days	long	
19		are (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the nights	short	
20		sets (MATERIAL)	the sun		north of the Arctic (SPATIAL:LOCATION)
21		are (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the northern regions	tilted away from the Sun	In winter (TEMPORAL:LOCATION) at the opposite end of the journey (TEMPORAL:LOCATION)

22		are (RELATIONAL; INTENSIVE; ATTRIBUTIVE)	nights	long	
23		are (RELATIONAL; INTENSIVE; ATTRIBUTIVE)	the days	short and cool	
24		are lit (MATERIAL)	the tropical regions		close to the equator (SPATIAL:LOCATION) evenly (MANNER:QUALITY) at all times of the year (TEMPORAL:LOCATION)
25		have (BEHAVIOURAL)		any seasonal changes	

Figure 5.16a Transitivity analysis of PSEAS1

	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
1	Seasons	are (RELATIONAL: INTENSIVE: IDENTIFYING)	the result of the tilt of the Earth as it orbits around the Sun		
		orbits (MATERIAL)	it		around the sun (SPATIAL: LOCATION)
2		is pointing (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	the North Pole	towards the Sun	At one end of the Earth's orbit (SPATIAL: LOCATION)
3		has (BEHAVIOURAL)	the northern hemisphere	its hot summer	
4		has (BEHAVIOURAL)	the southern hemisphere	its cold winter	
5		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the opposite	true	six months later (TEMPORAL: LOCATION)
6		changes (MATERIAL)	the weather		during spring and autumn (TEMPORAL: LOCATION)
7		happen (MATERIAL)	these seasons		
8		are (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the Sun's rays	spread more thinly	in parts of the world [[tilted away from the Sun (in winter)]] (TEMPORAL: LOCATION)
		(.....) (RELATIONAL: INTENSIVE: ATTRIBUTIVE)		tilted away from the Sun	in winter (TEMPORAL: LOCATION)
9		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the length of each day	shorter	
10		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the opposite	true	
11		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	that part of the Earth	tilted towards the Sun	in summer (TEMPORAL: LOCATION)
12		compare (BEHAVIOURAL)	this		to the reason [[why the poles are cold]] on page 8
		are (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the poles	cold	

Figure 5.17a Transitivity analysis of PSEAS2

	AGENT	PROCESS	MEDIUM	BENEFIC/RNG	CIRCUMSTANCE
1	by the Earth's orbit around the sun	are caused (RELATIONAL: CIRCUMSTANTIAL: IDENTIFYING)	the seasons		
2		shows (VERBAL)	the diagram	[[how the Earth's axis is slanted]]	
		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the Earth's axis	slanted	how
3		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the midday sun	over a region north of the equator (SPATIAL: LOCATION)	During summer (TEMPORAL: LOCATION) in the northern world (SPATIAL: LOCATION)
4		are (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	its rays	more concentrated	
5		feel (RELATIONAL: INTENSIVE: ATTRIBUTIVE)		hotter	
6		is (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	the sun	over a region south of the equator (SPATIAL: LOCATION)	During winter (TEMPORAL: LOCATION)
7		spread out (RELATIONAL: CIRCUMSTANTIAL: ATTRIBUTIVE)	the rays [[reaching the north]]	over a larger area (SPATIAL: LOCATION)	
		reaching (MATERIAL)		the north	
8		are (RELATIONAL: INTENSIVE: ATTRIBUTIVE)	they	less concentrated	
9		have (BEHAVIOURAL)	places south of the equator	their summer	
10		have (BEHAVIOURAL)	places north of the equator	winter	

Figure 5.18a Transitivity analysis of PSEAS3

C1	Metaphors underlined	Category*
01	To discover <u>the cause</u> of the seasons	12a
02	we must look again at the Earth in its orbit around the Sun.	
03	The Earth travels once round the sun each year.	
04	It is also spinning on its own axis, once every 24 hours.	
05	As it spins,	
06	one side of the globe is lit by the Sun	
07	and is in <u>daylight</u> ;	2b
08	the other side is turned away from the Sun	
09	and is in <u>darkness</u> .	2b
10	If the Earth's axis were upright compared with its path around the sun,	
11	day and night would be the same <u>length</u> all over the world,	2b
12	and there would be no seasons.	
13	But the Earth's axis is not upright.	
14	It is tilted over at 23 ¹ / ₂ degrees	
15	so that the globe is unevenly lit.	
16	In midsummer, <<....>>the northern hemisphere is tilted towards the Sun.	
17	<<when the Earth is at one end of its annual journey>>	
18	The days are long	
19	and the nights are short.	
20	North of the Arctic Circle the Sun never sets.	
21	In winter, at the opposite end of the journey, the northern regions are tilted away from the Sun.	
22	Nights are long,	
23	and the days are short and cool.	
24	The tropical regions, close to the Equator, are evenly lit at all times of the year	
25	and so have hardly any <u>seasonal changes</u> .	1a, 6a

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 5.6a Grammatical metaphor in PSEAS1

CI	Metaphors underlined	Category*
01	Seasons are <u>the result of the tilt</u> of the Earth as it orbits round the Sun.	12a, 2b
02	At one end of the Earth's orbit, the North Pole is pointing towards the Sun	
03	and the Northern Hemisphere has its hot summer	
04	and the Southern Hemisphere has its cold winter.	
05	Six months later, <u>the opposite</u> is true.	12a
06	In between, the weather changes during spring and autumn.	
07	These seasons happen	
08	because the Sun's rays are spread more thinly in parts of the world [[tilted away from the Sun (in winter)]].	
09	Also, <u>the length</u> of each day is shorter.	2b
10	<u>The opposite</u> is true	12a
11	when that part of the Earth is tilted towards the Sun in summer.	
12	(Compare this to <u>the reason</u> [[why the poles are cold on page 8]])	12a

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 5.7a Grammatical metaphor in PSEAS2

CI	Metaphors underlined	Category*
01	The seasons are <u>caused</u> by the Earth's orbit around the Sun.	12b
02	The diagram shows [[how the Earth's axis is slanted]].	
03	During summer, in the northern world, the midday sun is over a region north of the equator,	
04	so its rays are more concentrated	
05	and feel hotter.	
06	During winter the Sun is over a region south of the equator,	
07	and the rays [[reaching the north]]spread out over a larger area.	
08	They are less concentrated.	
09	Places south of the equator have their summer	
10	when places north of the equator have winter.	

*Categories of grammatical metaphor are detailed in Tables 2.12 and 2.13 in Chapter 2

Table 5.8a Grammatical metaphor in PSEAS3

Appendix 6

**Analyses of Field effects on variation in explanatory texts
within and across primary and secondary school levels**

COAL					SOUND				SEASONS			
Secondary Texts	1	2	3	3		1	2	3		1	2	3
			a	b								
ORIENTATION	✓	✓		✓	ORIENTATION	✓	✓	✓	ORIENTATION	✓	✓	✓
Phenomenon Identification	✓	✓		✓	Phenomenon Identification	✓	✓	✓	Phenomenon Identification	✓	✓	✓
^ (Link)	✓				^ (Link)	✓		✓	^ (Link)			✓
									^ Given Information	✓	✓	✓
(Phenomenon Contextualization)	✓			✓								
(Explanation Summary)	✓	✓							^ Explanation Summary	✓	✓	✓
					^ (Analogic Account)	✓	✓		^ (Analogic Account)	✓		
					^ PHENOMENON EXEMPLIFICATION	✓	✓	✓				
^ IMPLICATION SEQUENCES	✓	✓	✓	✓	^ IMPLICATION SEQUENCES	✓	✓	✓	^ DEDUCTION SEQUENCES	✓	✓	✓
Conditions	✓	✓	✓	✓	Compression	✓	✓	✓	Orientations Summary	✓	✓	
^ Trigger	✓	✓			^ Rarefaction	✓	✓	✓	^ [Southern Summer	✓	✓	✓
^ Transformation	✓	✓	✓	✓	^ Seriation	✓			^ Northern Winter	✓	✓	✓
^ Transformation ⁿ		✓		✓					^ Southern Winter	✓	✓	✓
									Northern Summer]	✓		✓
^ (CLOSURE)	✓	✓		✓	^ CLOSURE	✓	✓	✓	^ (CLOSURE)	✓		✓
(Conclusion)	✓				Conclusion	✓		✓	(Conclusion)	✓		
					^ [(Extension)	✓			^ (Extension)	✓		✓
					(Generalisation/Application)	✓	✓					
					(Clarification))		✓					
^ (Comment)		✓		✓								

Table 6.1a Variation of schematic structure with Field within secondary texts

(This display does not show the iteration of the DEDUCTION SEQUENCES and CLOSURE elements in the first seasons text).

COAL				SOUND				SEASONS			
Primary Texts	1	2	3		1	2	3		1	2	3
ORIENTATION	✓	✓	✓	ORIENTATION	✓	✓	✓	ORIENTATION	✓	✓	✓
Phenomenon Identification	✓		✓	Phenomenon Identification	✓	✓	✓	Phenomenon Identification	✓	✓	✓
^ (Link)				^ (Link)	✓			^ (Link)	✓		
								^ Given Information	✓		✓
^ (Phenomenon Contextualization)											
^ (Explanation Summary)	✓	✓	✓					^ Explanation Summary		✓	✓
				^ (Analogic Account)	✓	✓	✓	^ (Analogic Account)			
				^ PHENOMENON EXEMPLIFICATION							
^ IMPLICATION SEQUENCES	✓	✓	✓	^ IMPLICATION SEQUENCES	✓	✓	✓	^ DEDUCTION SEQUENCES	✓	✓	✓
Conditions		✓	✓	Compression	✓	✓	✓	Orientations Summary			
^ Trigger		✓	✓	^ Rarefaction	✓			^ [Southern Summer		✓	
^ Transformation	✓	✓	✓	^ Seriation		✓		^ Northern Winter	✓	✓	✓
^ Transformation ⁿ	✓							^ Southern Winter		✓	
								Northern Summer]	✓	✓	✓
^ (CLOSURE)				^ CLOSURE	✓	✓	✓	^ (CLOSURE)	✓	✓	✓
(Conclusion)				Conclusion		✓		(Conclusion)			✓
				^ [(Extension)	✓			^ (Extension)	✓	✓	
				(Generalisation/Application)		✓	✓				
				(Clarification)]		✓					
^ (Comment)											

Table 6.2a Variation of schematic structure with Field within primary texts

Elements of schematic structure which occurred in the secondary texts but not in the primary texts are indicated by the light shading.

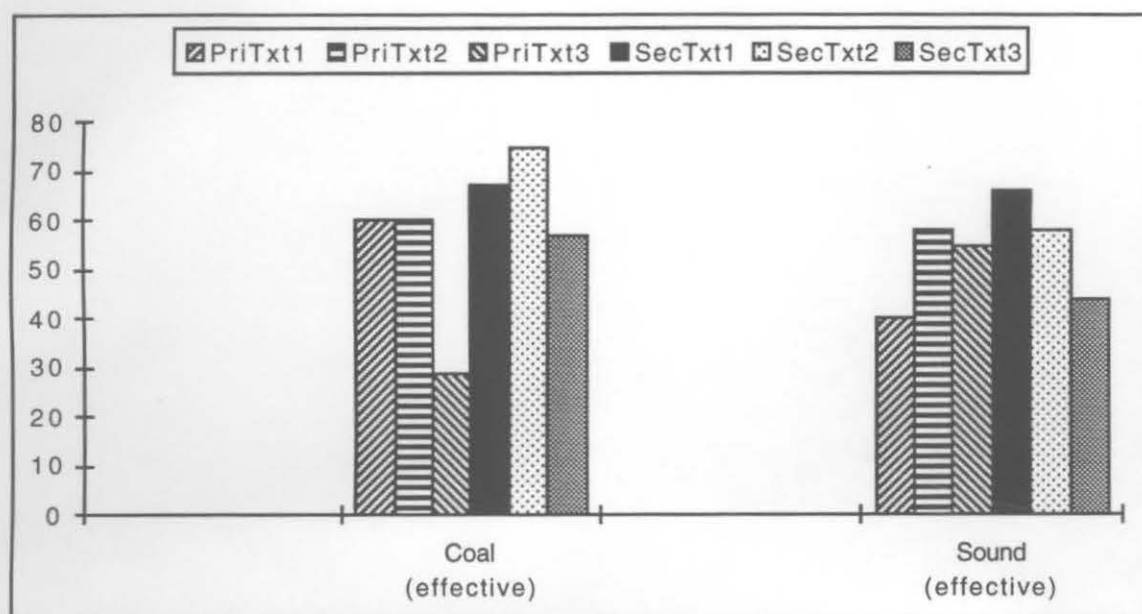


Figure 6.1a Proportion of effective Material processes in total number of Material processes in each text

	COAL						SOUND						SEASONS					
	Primary			Secondary			Primary			Secondary			Primary			Secondary		
TEXTS	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Category																		
GROUP RANK																		
1 Nominal group parataxis				2	1		1	1		1	2					1		1
1.1 Thing ^ Qualifier					1													
2 Verbal group parataxis							1			1		2						
3 Embedded clauses																		
CLAUSE RANK																		
4 Relational: intensive identifying clause	1			2	1	1	1	2	1	2		3					2	
5 Relational possessive attributive clause					1													
CLAUSE COMPLEX																		
6 Projection																		
7 Paratactic elaborating clause																		
DISCOURSE SEMANTICS																		
8 Reference						1				1								
DISCOURSE SEMANTICS AND LEXICOGRAMMAR																		
9 Reference and Relational: identifying clause				1													2	2
TOTAL	1	0	0	5	4	1	2	4	1	4	2	5	0	0	0	1	4	3
UNDEFINED TECHNICAL TERMS	5	1	3	3	0	1	0	1	0	0	2	0	7	3	3	5	5	4

Table 6.3a Comparison of use of resources for naming and defining technical terms

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