A COMPARISON OF SELECTED SYLLISTIC FEATURES
IN TECHNICAL AND NON-TECHNICAL WRITING

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Richard D. Vick
November 1985
A COMPARISON OF SELECTED STYLISTIC FEATURES
IN TECHNICAL AND NON-TECHNICAL WRITING

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An Abstract of a Dissertation by
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November 1985
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The problem. Most technical writing texts say something about technical writing style, and some devote an entire chapter to it. This study attempted to determine whether there are quantifiable stylistic differences between technical and non-technical writing affecting readability, conciseness, precision, and vigor.

Procedure. Ten 15-sentence samples from journals in science and engineering were compared with ten 15-sentence samples from journals in the humanities. Readability was measured by average sentence length, average T-unit length, percentage of sentences using subject-verb-object or subject-verb-complement order, number of syntactic chunks per major closure, and ratio of propositions to arguments. Conciseness was measured by the number of words per proposition. Precision was measured by the ratio of nouns and verbs to adjectives and adverbs. Vigor was measured by the percentage of passive verbs, the percentage of nouns that are nominalized verbs, a comparison of the Noun-Word Quotient with the Verb-Word Quotient, and the ratio of nouns and verbs to adjectives and adverbs.

Findings. The samples were compared at the .05 level of significance. It was found that the technical writing samples had shorter sentences, shorter T-units, a higher percentage of sentences using subject-verb-object or subject-verb-complement order, and fewer syntactic chunks per major closure. It did not have a higher ratio of propositions to arguments. It was found that technical writing did not have a significantly lower number of words per proposition nor a significantly higher ratio of nouns and verbs to adjectives and adverbs. It was found that technical writing did not have a lower percentage of nominalizations, a lower ratio of NWQ to VWQ, or a lower percentage of passives.

Conclusions. It was concluded that the most significant stylistic differences between technical and
non-technical writing were in readability. No evidence was found to indicate that technical writing was significantly more concise, precise, or vigorous than non-technical writing.

Recommendations. It was recommended that information such as that contained in this study be used in technical writing texts.
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CHAPTER ONE
Introduction

Statement of the Problem

Most technical writing texts say something about technical writing style, and many devote an entire chapter to the subject. Houp and Pearsall, Andrews and Blickle, Fielden, Eisenberg, Weisman, Sherlock, Markel, and Alvarez are authors of well known technical writing texts who offer stylistic advice to the technical writing student. While these texts take a variety of approaches to style, there are certain qualities that appear again and again. Prominent among these are readability (or clarity), conciseness, precision, and vigor (power, vitality). However, Houp and Pearsall’s Reporting Technical Information is the only one of the best known texts that gives any specific statistical information on style. This text cites Christenson’s study showing that professional writers use subject-verb-object or subject-verb-complement order seventy-five percent of the time.

Since many, if not most, teachers of technical writing are members of English departments who have been trained in literary study, and who, in their teaching of composition, have tended to use literary
models for their students to imitate, statistical evi-
dence would be useful because many of them believe that
good writing is good writing no matter what the subject
matter is. But this is not necessarily true. Joseph
Mancuso describes his experience with technical writing
thus: "During my development as a technical writer and
teacher of that discipline, I continually find myself
modifying patterns of thought and modes of expression
formulated during my academic training and my early
teaching career" (52). Another teacher making the
transition from literary to technical writing talks
about "a willingness to undergo a transformation, a new
orientation to the business that English teachers have
been doing all along: communicating" (Barnum, 27).
Studies of technical writing style would help teachers
make this transformation by enabling them to teach
their students what stylistic devices technical writers
actually use.

Students also need help making the transition.
They too come to technical writing courses from a
background of composition courses which often stress
qualities found in literature, such as imaginination,
rich imagery, metaphor, and sophisticated sentence
structure. While it is true that devices such as
metaphor are used in technical writing, the purpose,
and thus the focus, of technical writing is different
from that of literary writing. John Mitchell talks about the ability of a technical writer to communicate facts logically and rationally, and says that students often resist these concepts because they have been taught to write by English teachers trained in literature (3). This resistance could be lessened if teachers had available studies that would show how technical writers actually write.

Scientists and humanists use language in different ways. To the scientist, language is a means of conveying information; to the humanist, language is not only a means to an end, but an end in itself. Consider, for example, the following sentence from a recent issue of College English:

But that even the private and narrowly familial canons of verse persist in the otherwise lonely spaces of personal and family life, and that they provide each of us and our various societies a necessary selection of reliable memories, however questionable in their broader values, a necessary support in the struggle to maintain self and company, I must re-emphasize (Piper, 146-47).

Most teachers of freshman composition would be delighted if they could teach their students to write such sophisticated periodic sentences as this one, with its 59 words, 23 syntactic chunks, and single major closure. A scientist or engineer, however, would never write such a sentence, at least not in his or her professional writing. It is too difficult to process, putting as it does, so much strain on short term memory.
Clearly Piper was not trying simply to communicate information or opinion. He was certainly aware that the sentence as he wrote it would be difficult to process, but he wrote it anyway. Writing it that way gave him pleasure, and he undoubtedly hoped that it would give his readers pleasure. But giving pleasure to readers is not part of the purpose of the technical writer. As Joseph Mancuso puts it, "Technical writers should learn quickly not to try to entertain . . . . Technical writing is a sharing of information, important information. Everything else is wasteful" (55).

But do technical writers actually follow the advice given in the textbooks? Research should be done to determine whether writing in science and technology requires a style different from that of the writer trained in the humanities, and if so, what the differences are. This knowledge would help teachers of technical writing make the transition from literary to technical writing by giving them specific information to impart to students about technical writing style and enabling them to recognize poor student writing. It would help students by showing them the kinds of stylistic devices employed by practicing technical writers. Finally, it would help technical writers by giving them objective standards against which to measure their own writing.
Although stylistic studies of technical writing would be useful, very few have been made. Francis Christensen compared sentence order in the works of twenty prominent writers, ten fiction writers and ten non-fiction writers. He found that professional writers used subject-verb-object or subject-verb-complement order more than seventy-five percent of the time. Edmund P. Dandridge, Jr. studied sentence length and type in samples of technical and non-technical writing. He found that the technical writers employed shorter sentences and more simple sentences than did the non-technical writers. These studies offer some of the information that teachers and students need to make the transition to technical writing, but more research needs to be done, and more stylistic characteristics need to be studied to determine how technical writing differs from non-technical writing.

Purpose of the Study

This study attempts to determine whether there are quantifiable differences between technical writing and non-technical writing by comparing samples of the writing of scientists and technicians with that of scholars in the humanities. The samples are taken from journals intended for audiences at the expert (Ph.D) level. The qualities to be compared are readability, conciseness, precision, and vigor.
The study attempts to answer the following questions:

1. Is technical writing measurably more readable than non-technical writing?
2. Is technical writing measurably more concise than non-technical writing?
3. Is technical writing measurably more precise than non-technical writing?
4. Is technical writing measurably more vigorous than non-technical writing?

**Readability** is measured by

1. average sentence length, shorter sentences being more readable.
2. average T-unit length, shorter T-units being more readable.
3. percentage of sentences using subject-verb-object or subject-verb-complement word order, sentences using these word orders being more readable.
4. the number of syntactic chunks per major closure, sentences having fewer syntactic chunks being more readable.
5. the ratio of arguments to propositions, passages having a higher ratio of arguments to propositions being more readable.
Conciseness is measured by the number of words per proposition, passages having fewer words per proposition being more concise.

Precision is measured by the ratio of nouns and verbs to adjectives and adverbs, passages having a higher ratio of nouns and verbs to adjectives and adverbs being more precise.

Vigor is measured by

1. the percentage of passive verbs, passages having a lower percentage of passive verbs being more vigorous.

2. the percentage of nouns that are nominalizations, passages with a lower percentage of nominalizations being more vigorous.

3. a comparison of the Noun-Word Quotient with the Verb-Word Quotient, passages with a higher Verb-Word Quotient being more vigorous.

4. the ratio of nouns and verbs to adjectives and adverbs, passages with a higher ratio of nouns and verbs being more vigorous.

The Hypotheses

This study posits 10 hypotheses. These are arranged below under the headings to which they are
related: readability, conciseness, precision, and vigor.

Readability

1. Technical writing has shorter sentences than non-technical writing.
2. Technical writing has shorter T-units than non-technical writing.
3. Technical writing has a higher percentage of subject-verb-object and subject-verb-complement sentences than non-technical writing.
4. Technical writing has fewer syntactic chunks per major closure than non-technical writing.
5. Technical writing has a higher ratio of propositions to arguments than non-technical writing.

Conciseness

6. Technical writing has fewer words per proposition than non-technical writing.

Precision

7. Technical writing has a higher ratio of nouns and verbs to adjectives and adverbs than non-technical writing.

Vigor

8. Technical writing has a lower percentage of passive verbs than non-technical writing.
9. Technical writing has fewer nominalizations than non-technical writing.
10. Technical writing has a lower ratio of Noun-Word Quotient to Verb-Word Quotient than non-technical writing.

**Definition of Terms**

Because some of the terms used in this study may be unfamiliar to the reader, and some of them are used in special limited contexts, the following definitions are offered.

*Adjective:* A word that will fit the following frame: The _____ (noun) is _____.

*Adverb:* A word that will fit one of the following frames: The happy man is happy _____.

The woman remembered the event _____.

The car went _____.

*Expert audience:* A reading audience at the Ph. D. level in the specific field of the writing sample under consideration.

*Major closure:* The end of an independent clause or the end of a dependent clause following an independent clause.

*Non-technical writing:* Expository writing in the humanities.

*Noun:* A word that will fit one of the following frames: (The) _____ is/was good.

_____s are/were good.
Noun-Word Quotient: The number of nouns divided by the total number of words in a passage.

Proposition: A combination of word concepts, one serving as a predicator and the others as arguments. For example, in the cat chased the mouse, chased is the predicator, and cat and mouse are arguments.

Style: The typical syntactic and lexical choices where the writer has an option.

Syntactic Chunk: One of the following syntactic units:

1. nouns (or pronouns) together with prenominal modifiers
2. verbs (except linking) together with adjacent modifiers
3. prepositional phrases
4. verbal phrases
5. linking verbs together with their complements.
6. conjunctions

T-unit: One main clause together with any subordinate clauses or nonclauses attached to, or embedded within it (Hunt, 92-93).

Verb: A word that will fit one of the following frames: The candy ______ good.
The man ______ the (noun).
The woman ______ there.
**Verb-Word Quotient:** The number of verbs divided by the total number of words in a passage.

**Delimitations**

This study examines only stylistic features, and makes no judgment of overall quality. Such judgments would involve not only style but content, and could be made only by experts in the various fields.

Further, the study does not attempt to examine all possible stylistic features in the samples analyzed, nor does it attempt to make definitive judgments concerning the four qualities of writing under consideration. It attempts only to examine tendencies in a limited number of stylistic features in samples of technical and non-technical writing at one audience level.
CHAPTER TWO

Review of Literature

This chapter will review the literature relevant to the study, explain the principles upon which the study is based, and give the rationale for the methods used in the analysis of the samples.

Section 1 reviews Pearsall's five audiences for technical writing. Section 2 briefly reviews the definitions of style given by two well known technical writing textbooks (Andrews and Blickle; Alvarez), and notes that these are too subjective for use in a study of this kind. It then gives definitions of style by three leading linguistic stylists, and indicates the definition of style that will be used in this study. Section 3 summarizes the qualities of good technical writing as given in a number of leading texts. Section 4 summarizes a number of studies in cognitive psychology that form the basis for the readability analysis in this study. Section 5 discusses precision, showing how adjectives and adverbs are less precise than other modifiers. Section 6 discusses words per proposition as a measure of conciseness. Section 7 sets out three measures of vigor, percentage of passive verbs, ratio of nouns and verbs to adjectives and adverbs, and ratio of Noun-word Quotient to Verb-word Quotient.
Section 1: Technical Writing Audience:

Before we can talk about technical writing style, we must consider audience, since style will be tailored to audience. Thomas E. Pearsall defines five audiences, the layman, the executive, the expert, the technician, and the operator. The expert is defined as a scientist or engineer with either an M. S. or a Ph.D., or with a B. S. and years of experience (xvii). In this study, the expert in a non-technical field is considered to be at about the same educational level as the expert in a technical field. The samples in this study are intended for the expert audience.

Section 2: Style

Style is a word often used and seldom defined. Yet if one is to make an objective comparison between two styles, an objective definition is imperative. Le style c'est l'homme will not do. Nor will descriptive adjectives such as graceful, pedantic, or stuffy. Even a descriptive word such as wordy, which at first thought might seem fairly objective, will not be easy to measure. Although there are examples of wordiness that most readers would agree on, such as due to the fact that instead of because, nevertheless, the decision as to how many words are enough to convey a particular body of information is largely a subjective one.
Joseph Alvarez defines style as the selection and arrangement of words (138). This, however, is not an adequate definition, since semantics is also involved in the selection of words, and grammar is involved in their arrangement. The choice between his eyes were bigger than his stomach and his ocular estimation exceeded his gastronomic capacity may be a stylistic one, but the choice between this is a physics book and this is a chemistry book is not.

Although most technical writing texts talk about the importance of style, most of them do not define the term, or define it in such vague terms as to be useless in an objective comparison of stylistic features. For example, Andrews and Blickle begin their chapter on style with a quotation from a beer commercial, "When it's right, you'll know it" (95). They go on to define "right style" as "expression that is appropriate to the writer, the material (the subject and purpose), and the audience." Joseph Alvarez is a bit more helpful. He defines style as the selection and arrangement of words. He goes on to say that our genes, environment, and experiences shape every sentence we write. The style is the person (138).

It can readily be seen that most of the above is highly subjective and of little use for comparative purposes. Michael Riffaterre notes that subjective
impressionism, normative rhetoric, and premature aesthetic evaluation have interfered with the development of stylistics as a science. He defines style as "an emphasis (expressive, affective or aesthetic) added to the information conveyed by the linguistic structure, without alteration of meaning (154-55.)"

Nils Enkvist defines style as "the aggregate of the contextual probabilities of its linguistic items." Aggregate is further defined as the frequencies of linguistic items. Contextual probability means that the frequency of linguistic items must be compared with the same items in another text which is considered a norm and which has a contextual relationship with the text being discussed. For example, Pope's poems may be compared with other poems written in iambic pentameter couplets. This would be a close contextual relationship. A more distant relationship would be with the poetry of Wordsworth. An example of very distant contextual norms would be a comparison of Gray's Anatomy with the London Telephone Directory (120).

According to Donald C. Freeman, the questions asked by the "style as deviation" school of linguistic stylistics are of the following kinds: "what does the language of a literary text convey in addition to information? What does a writer's language do in
addition to what the rules of grammar require it to do? what are a writer's typical patterns of syntactic and lexical choice where he has an option?" He believes that the "style as deviation" school of linguistic stylistics sometimes lets methodology overwhelm its subject. He quotes Bernard Bloch, who defines style in terms of the comparison of the transitional possibilities of a discourse's linguistic features with the same features in the language as a whole. This definition he calls a chimera, since the norms of language as a whole are not known and never will be (5-6). Nevertheless, the "style as difference" approach seems well adapted to a comparison such as that undertaken in the present study. However, instead of comparing a given style with some mythical "norm" of the language as a whole, the study compares the style of one specific set of samples with that of another specific set of samples.

Section 3: Qualities of Good Technical Writing

Readability, or clarity, is the single most mentioned quality of good technical writing. It is stressed by almost every text that mentions style, including Houp and Pearsall, Andrews and Blickle, Eisenberg, Weisman, Markel, Alvarez, Ulman and Gould,
and Bates. Conciseness is listed by Andrews and Blickle, Eisenberg, Weisman, Markel, and Alvarez. Precision is stressed by Eisenberg, Weisman, Sherlock, Lannon, and Bates. Vigor is mentioned by Bates, Miller and Saidla, Alvarez, Smith, and Marder. Other qualities mentioned are objectivity, correct usage, and accuracy.

To sum up, clarity, or readability is the single most frequently stressed characteristic in technical writing texts. It is also a quality that can be measured in a number of objective ways. Conciseness, precision, and vigor are more difficult to measure objectively, but there are some stylistic features that can be used to at least partially measure them. The other qualities mentioned do not relate directly to style. Accuracy and objectivity are matters of content, and grammatical correctness is not a matter of style, since style involves choice.

Section 4: Readability

Few discussions of technical style go into much detail about how to achieve readability, and few of them make use of the contributions of cognitive psychology in this area in the last fifteen or twenty years. Houp and Pearsall, for example, use the 1948 Flesch
scale which judges readability in terms of sentence length. On this scale, eight words per sentence is considered very easy, while 29 or more words per sentence is considered very difficult. They also recommend using the standard subject-verb-object word order most of the time. William Damerst recommends the 1968 Gunning Fog Index, a formula based on the average sentence length plus the percentage of words over three syllables multiplied by .4. A Fog Index of six to ten is considered easy, while an index of sixteen or seventeen is too difficult for the average reader. Damerst also stresses the basic sentence pattern of subject-verb-object.

While sentence length and sentence order are certainly useful measures of readability, more recent studies in psycholinguistics have focused on the propositional content of prose, the role of short and long term memory, and the representation of meaning in memory.

William James seems to have been the first to distinguish between short and long term memory, but it was George N. Miller who demonstrated the limits of short term memory and suggested a way that the brain can transcend those limits. Miller found in his experiments that the mind could retain only about seven bits of information. This held true no matter what the bits were—words, numbers, or even musical tones. But
the mind seems to be able to recode bits into chunks, and then to recode these chunks into larger chunks. He illustrated the process with a series of binary numbers as follows:

```
1 0 1 0 0 0 1 0 0 1 1 1 0 0 1 1 1 0
10 10 00 10 01 11 00 11 10
2 2 0 2 1 3 0 3 2
```

If the 18 digits in the top line are grouped in pairs, there are four possible pairs, 00, 01, 10, and 11. If 00 is called 0, 01 is called 1, 10 is called 2, and 11 is called 3, we can express the sequence in 9 digits as in the third line. Further, if we were to group the 18 digits in threes, we could express the sequence in six digits, and so on. Miller suggests that language is coded or chunked in much the same way (81-97).

Clark and Clark define these chunks as "meaningfully coded units." They further suggest that the mind can hold 20 to 25 words in short term memory when they are thus chunked (137). According to Kintsch, chunking is the result of the subject's perceptual coding process. Experimenters can affect this process by arranging stimuli in certain ways. For example, nonsense syllables can be read to the subject with a particular rhythm, and this rhythm will affect the chunking. Further, a subject can learn new principles of organization and apply them to chunking (1970, 175-77).

Roberta L. Klatzky, discussing Miller's concept of
the chunk, notes that the definition of the term is circular. We say that short term memory can hold seven chunks, and then define chunks as that which short term memory holds seven of. She divides chunking operations into two classes. The first occurs when the items to be remembered are presented as a cluster occurring closely in time and space but not forming any meaningful unit. It has been found that such units are remembered better when they are presented rhythmically than when they are presented at a fixed rate. The rhythmic pattern helps to identify the items as part of a spatial or temporal group. Klatzky refers to this kind of chunking as grouping. The second kind of chunking uses information from long term memory to relate the new units to a single previously known unit. For example, subjects hearing a sequence of letters such as TVF...BIJF...KY...MCA could not remember as many letters as those hearing the same sequence of letters grouped TV...FBI...JFK...YMCA. The same results were obtained when the groups were presented visually (72-84).

Neil F. Johnson found empirical evidence that the chunks created by the mind during processing correspond to syntactic constituents. When people were asked to memorize sentences and later to recall sequences of words, they were more frequently able to go on to the next word when it was in the same syntactic constituent
than when it was in a new constituent. Two of the sentences he used were:

((The (tall boy) (saved (the (dying woman))))

(((The house) (across (the street))) (burned down))

People recalled the tall boy as a unit, but not tall boy saved. The more constituent boundaries they had to cross, the less likely they were to recall the next word. The probability of a transitional error was low within a phrase and high between phrases. Johnson concluded that phrase structure rules are psychologically real (469-75).

More evidence for the validity of syntactic units as chunks was found by Aaronson and Scarborough. They used a computer scope to present sentences to subjects one word at a time. The subjects controlled how long each word was displayed, and the experimentors measured how long the subjects looked at each word, plotting the word-by-word reading time against the positions of words in the sentence. For subjects who were asked to remember each sentence immediately after presentation, the places where long reading times occurred corresponded to the breaks between syntax-defined units. Further, the more phrases that accumulated before the end of the sentence, the more time was taken at phrase boundaries (56-70). According to Kintsch, this extra time was taken because the subjects not only had to
worry about chunking the current phrase, but about connecting it to the previous chunks (1977, 309).
Whatever the reason, the fact that the reader is slowed down as more syntactic chunks accumulate is evidence that fewer syntactic chunks per closure make a more readable style.

W. J. M. Levelt used word relatedness judgments to assess the validity of syntactic structures. He asked subjects to judge the degrees of relatedness in all pairs of words in sentences. He found that for his subjects, the degree of relatedness was a function of the place of the P-marker including both words; the higher the dominating mode, the lower the relatedness. Two of the sentences follow (1970 b, 112-121):

```
the boy has lost a dollar
```

```
John eats apples and Peter eats pears
```
It is interesting that in the first sentence, the verb was perceived as more closely related to the object, while in the second, the verbs are most closely related to the subjects. Levelt suggests that possibly middle verbs such as eat are perceived as more closely related to the subject, while full transitives are perceived as more closely related to the object.

Fodor, Beaver, and Garret provide more evidence for the theory that sentences are chunked according to syntactic units. They had subjects listen to sentences with auditory clicks imposed upon them. The subjects were to try to remember the sentences and also indicate where the clicks occurred. The theory was that the clicks would not be placed according to where they actually occurred, but would be placed in such a way as not to interrupt a perceptual unit. The magnitude of the displacement error would serve as a measure of the size of the perceptual unit. The results showed that the perceptual units corresponded to units marked off by formal phrase structure analysis (414-20).

It is clear that the number of bits of information that can be retained in short term memory is increased tremendously by the chunking process, but it is also clear that even with chunking, there are finite limits to the capacity of short term memory. Long term memory, on the other hand, seems to have no theoretical
limits. But when and how does the transfer from short to long term memory take place, and in what form is information stored in long term memory?

Apparently verbatim constituents are not stored in long term memory. Clark and Clark assume that sentences are represented as propositions plus their interrelations. These propositions are units of meaning consisting of a verbal unit plus one or more nouns. Thus, sentence 1 can be thought of as consisting of the sentences in 2 (10-13).

1. The fresh young troops defeated Napoleon's army.

2. a. The troops were fresh.
   b. The troops were young.
   c. The army belonged to Napoleon.
   d. The troops defeated the army.

Kintsch defines a proposition as a combination of word concepts, one serving as a predicator and the others as arguments. Word concepts are abstractions which are represented in surface structures as words, phrases, or clauses. In theory, any word (not just a verbal unit) can serve as a predicator. Kintsch gives the following examples to illustrate this point. The first word is always the predicator, and the others are arguments.

1. John sleeps. (SLEEP, JOHN)

2. Mary bakes a cake. (BAKE, MARY, CAKE)
3. A robin is a bird. (BIRD, ROBIN)
4. The man is sick. (SICK, MAN)
5. If Mary trusts John she is a fool (IF, (TRUST, MARY, JOHN), (FOOL, MARY))

In 1 and 2 the predicator is a verb, in 3 a noun, and in 4 an adjective. Sentence 5 contains three propositions, two of which are embedded in the third, with a conjunction, a verb, and a noun as predications. The arguments are nouns and embedded propositions. Kintsch notes that it would be possible to use a predicator such as IS-A in (3), and write it as (IS-A, ROBIN, BIRD), but that it is better to omit the copula (1974,13).

It seems clear that there must be some closure point at which the verbatim constituents in short term memory are converted into their propositional forms and transferred to long term memory. What evidence is available seems to suggest that this process takes place at the ends of clauses and sentences. Jarvella found that verbatim memory for constituents faded rapidly after the passage of a sentence boundary (409-416).

One study which attempts to compare technical and non-technical writing in terms of stylistic features is that of Edmund P. Dandridge, Jr. His theory is that technical writing is stylistically simpler than non-technical writing. He compared 10 samples of technical
writing with 10 samples of non-technical writing for the following stylistic features: total words in sample, average sentence length, longest and shortest sentences in sample, frequency of occurrence of grammatical types of sentences, and number of words per paragraph. His results supported his hypothesis, though not as strongly as he had hoped. He found that the sentences in the technical samples averaged 24.5 words, and that those in the non-technical samples averaged 25.9 words. He also found that the technical samples had more simple sentences and fewer compound/complex sentences, and that the non-technical samples had a greater difference between their shortest and longest sentences. He concluded that technical writing was simpler and more direct, and that non-technical writers were possibly more concerned with variety than technical writers (265-71). A weakness of Dandridge's study is that he did not take into account audience level in his selection of samples.

In a comparison of a fairly difficult sample of technical prose with a fairly easy one, Vick found that there was a difference of only twenty-six percent in sentence length, but a difference of forty-eight percent in the number of syntactic chunks per major closure. Further,
he found that the fairly easy prose, taken from a car owner's manual and intended to be read by people at all levels of reading ability, averaged 21.9. This falls into the fairly difficult range on the Flesch scale, but the sample did not seem difficult to read. It was concluded that the number of syntactic chunks per major closure was a fairer measure of the difference in readability than the average sentence length (32-34).

William J. Vande Koppel has recently made a study of the effect on readability of Functional Sentence Perspective, a concept derived from the work of Henri Weill in 1887. The theory is based on the idea that a sentence has two parts, the topic and the comment. In English, the topic usually corresponds to the grammatical subject, and the comment to the grammatical predicate. The topic expresses old information, that is, information that is expressed in or recoverable from previous sentences. The comment expresses new information. Vande Koppel attempted to discover whether discourse that conforms to FSP (that is, discourse in which old information is expressed in the subject and new information in the predicate) is more readable than discourse containing the same propositional material but not adhering to FSP. In his experiments, paragraphs consistent with FSP were "significantly more readable and memorable than their
variants" (54). Because of the fact that FSP deals with content, it was not used as a measure in the present study, but it is a concept that should be examined further.

Although recent studies have suggested much more sophisticated measures based on the great amount of work done in cognitive psychology over the past fifteen or twenty years, sentence length is still often suggested as a rough measure of readability by many technical writing textbooks. Houp and Pearsall, for example, cite the following scale of average sentence length (173).

<table>
<thead>
<tr>
<th>Level</th>
<th>Average Sentence Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>very easy</td>
<td>8 words or less</td>
</tr>
<tr>
<td>easy</td>
<td>11</td>
</tr>
<tr>
<td>fairly easy</td>
<td>14</td>
</tr>
<tr>
<td>standard</td>
<td>17</td>
</tr>
<tr>
<td>fairly difficult</td>
<td>21</td>
</tr>
<tr>
<td>difficult</td>
<td>25</td>
</tr>
<tr>
<td>very difficult</td>
<td>29 words or more</td>
</tr>
</tbody>
</table>

If sentence length is a good general guide to readability, T-unit length is at least as good, and possible even better. Consider, for example the following sentence:

Rope, rope, hang butcher, butcher won't kill ox, ox won't drink water, water won't quench fire, fire won't burn stick, stick won't beat dog, dog won't bite pig, pig won't go over the style, and I shan't get home tonight.
This sentence is 39 words long, considerably past "very difficult" on the Flesch scale, yet most readers would consider it very easy. This is because it averages fewer than five words per T-unit. It is, in fact, characteristic of the writing of fourth graders (Hunt, 96). Although words per T-unit has been used typically to measure the maturity of writers, it can also serve as a rough guide to readability, just as sentence length can.

According to Houpp and Pearsall, professional writers, who are interested in getting their message across, use plain SVO or SVC word order in 75.5% of their sentences, and a short adverbial opener in an additional 23% (174). In an experiment conducted by James Deese, groups of students were asked to judge the comprehensibility of sentences and also to recall sentences. The sentences the students found hard to recall were those with unexpected impediments in syntax and unusual word order. DeGeorge, Olson, and Ray say that information in right branching structures is more readily comprehended than that in left or middle branching structures (123-26). J. P. Thorne also mentions the simplicity of right branching structures (187). Basically, right branching sentences are those with SVO or SVC patterns followed by additional material. Sentence order, then, would be one measure of
Another measure of readability, one that is closely linked to right, left, and center branching sentence structure, is the number of syntactic chunks per major closure. Consider the following sentence from the nursery rhyme, "The House That Jack Built."

This is the cock that crowed in the morn that waked the priest all shaven and shorn that married the maiden all forlorn that milked the cow with the crumpled horn that tossed the dog that worried the cat that killed the rat that ate the malt that lay in the house that Jack built.

Here is a sentence of 55 words, completely off the Flesch scale of readability, a sentence that contains but a single T-unit, yet one that can be readily comprehended by small children. By way of contrast, consider this sentence.

The cock that crowed in the morn that waked the priest all shaven and shorn that married the maiden all forlorn that milked the cow with the crumpled horn that tossed the dog that worried the cat that killed the rat was eaten for Sunday dinner.

This sentence, although shorter, is more difficult to process. In fact the reader might well have to go back to the beginning to pick up the fact that it was the cock that was eaten. The difference is that, in the second sentence, the subject must be retained in short term memory until the word eaten is reached. In other words, although there are certainly closures after each clause, there is not a major closure until the main
clause the cock was eaten for Sunday dinner is completed. This agrees with Jarvella's conclusion that only after a sentence boundary is passed does the mind purge the verbatim constituents and transfer the information to long term memory. It also agrees with the findings of Aaronson and Scarborough that as the number of chunks piles up in a sentence, the reading speed decreases. It should be noted, however, that these sentence boundaries are not always marked by sentence terminal punctuation. In the first sentence above, a sentence boundary occurs after this is the cock, another after that crowed in the morn, and so on, even though there is no punctuation. If this were not so, the mind could not process it so readily. Therefore, major closure is considered in this study to occur after independent clauses and after dependent clauses following independent clauses.

As has been seen earlier, empirical evidence suggests that the chunks created by the mind in processing a sentence correspond to syntactic constituents. In this study, the following kinds of constituents are considered to be syntactic chunks:

1. nouns (or pronouns) together with determiners and prenominal modifiers.

2. verbs (except linking verbs) together with adjacent modifiers.
3. prepositional phrases.
4. gerund phrases.
5. participial phrases.
6. infinitive phrases.
7. linking verbs together with their complements.
8. conjunctions

Copulative verbs together with their complements are considered as a single chunk, consistent with Kintsch's concept of complement as predicator, and also with the view of some grammarians that verbs and adjectives are not distinct in deep structure, but rather that both are verbals with a +V feature for verbs and a -V feature for adjectives (Jacobs and Rosenbaum, 63). An argument could well be made for chunking transitive verbs with their objects. However, as demonstrated earlier, Levelt's research indicates that what he referred to as middle verbs seem to be perceived as more closely related to subjects, while full transitives are perceived as more closely related to objects (112-21). It is not clear exactly what he means by middle verbs. Most grammarians consider middle verbs to be verbs such as cost and weigh, which appear to be transitive, but which cannot be subjected to the passive transformation. Nevertheless, his findings indicate that if transitive verbs are to be chunked with other constituents, they should sometimes be chunked with subjects, and
sometimes with objects. In an objective analysis it seems better to simply consider them separate chunks.

Verbal phrases consisting of the verbal plus a prepositional phrase have been considered as single syntactic chunks. Proper names which include a prepositional phrase have been considered as a single chunk, as in William of Orange, Ludwig von Beethoven, or Saint-Jean-d'Angely. Where a succession of two prepositional phrases could be considered to be a single phrase by assuming a compound preposition, it has been counted as one chunk. Finally, conjunctions have been arbitrarily counted as separate chunks, since there seems to be no empirical evidence of their chunking with other constituents.

It is difficult to devise a chunking system whose results are intuitively satisfying in all cases. The above system produces, for example, the following.

(The little old consumptive German Hausfrau) (swept) (the floor)

Here it might seem more reasonable to divide the sentence into two chunks of six and three words respectively, rather than three chunks of six, one, and two words, especially in light of the fact that the verb is one of the "full transitives" which Levelt found to be more closely related to the object. Or perhaps there could be further chunking of the subject. However, the
intuition of one reader might differ in some ways from that of another. It seemed necessary to set up arbitrary rules and apply them in all cases, even when the results appeared strange, so that any reader applying the rules would obtain the same results. This is particularly true since the purpose of the study is to make comparisons, not to make absolute judgments.

Below are two sentences divided into syntactic chunks to illustrate the method.

a. (When) (these patients) (entered) (the hospital) (at the University of Minnesota), (we) (first established) (their intravenous requirement) (for heparin) (by means of infusions) (from a pump) (outside the body).

b. (This) (is no cause) (for concern), (because) (you) (get) (the greatest fuel economy) (when) (there) (is occasional light spark knock).

The findings of Kintsch and others that reading rate and retention are both increased when the same number of propositions are expressed with fewer different arguments is clearly related to cohesion. One of the standard methods suggested by many composition textbooks for achieving cohesion is pronoun reference and the repetition of nouns. Consider the following sentence: Before spraying for insects, the farmer should consider that some hexapods are beneficial, and that some pests are resistant to certain chemicals. This sentence has five arguments, insects, farmer, hexapod, pests, and chemicals. Had the writer
been more concerned for readability and less for elegant variation, the sentence might have been written "Before spraying for insects, the farmer should consider that some insects are beneficial, and that some insects are resistant to certain chemicals." Or, the last insects might have been omitted, leaving some as an indefinite pronoun. Either version would have reduced the number of different arguments to three. Kintsch's findings would indicate that the second sentence is more readable than the first.

To illustrate the method of analysis, here is a passage used by Kintsch et al. in their experiments (208).

A comet is a celestial fountain spouting from a large snowball floating through space. We see the fountain as the head and tail of the comet. The tail extends for millions of miles, but we never see the snowball, which has a diameter of a few miles. A comet shines with reflected sunlight. Along its path it strews debris in space, which seen from the earth appears as the zodiacal light.

There are 25 propositions in this passage:

1. (is, comet, fountain)
2. (celestial, fountain)
3. (spout, fountain, snowball)
4. (large, snowball)
5. (float, snowball, space)
6. (consist of, fountain, 8)
7. (possess, comet, 8)
8. (see, we, 6)
9. (and, head, tail)
10. (extend, tail, mile)
11. (number of, mile)
12. (contrast, 9, 14)
There are 15 arguments: comet, fountain, snowball, space, we, head, tail, mile, million, diameter, sunlight, path, debris, earth, light.

Thus, the passage has a proposition to argument ratio of 1.67 to 1.

Section 5: Precision

It is difficult to find a style marker that will indicate precision in writing. Obviously, the best way to be precise is to use the exact word. As William Damerst points out, it will not do to use the word absorb if the word required for the exact meaning is adsorb. But this choice is constrained by semantics, and is therefore not a style marker.

One style marker that would seem to be at least a partial indicator of the precision of a text is the ratio of nouns and verbs to adjectives and adverbs. John Lannon cites a portion of a non-technical essay describing the eagle. The passage contains many
adjectives such as noble, large, and awesome. He contrasts this description with a technical description, pointing out how vague descriptive terms such as large and awesome are replaced by more precise terms such as 30 to 40 inches long and wingspan of 6 to 8 feet (4-5). Similarly, John Alvarez suggests using an adjective or adverb only if it adds precision to the word it modifies. He illustrates by suggesting toll bridge as more precise than bridge. He goes on to caution against the use of "vague" modifiers, such as substantial or considerable (1980, 22-23). It is interesting to note that the "precise" modifier toll is listed in dictionaries as a noun, while the "vague" modifiers substantial and considerable are listed as adjectives. Alvarez seems to have considered all three words to be adjectives.

What Alvarez apparently did not notice in his discussion of precision was the imprecise nature of the traditional definitions of the parts of speech. Nouns have traditionally been defined as "the names of persons, places, or things." Verbs have been defined as "words that show action or state of being." These are notion al definitions, relating the grammatical category to something in the real world. Some grammarians have questioned whether such definitions belong in the category of grammar or philosophy. Further, there is the
problem of cross classification. While nouns and verbs have been defined notionally, adjectives and adverbs have been defined syntactically. Adjectives have been defined as words that modify nouns and pronouns. Thus a word could fit into two categories.

(a) The paper airplane flew beautifully.

(b) The swimming coach was fired.

The word paper in sentence (a) can be defined as a noun because it is the name of a thing, but it can also be defined as an adjective because it modifies the noun airplane. The word swimming in sentence (b) can be defined as a verb because it shows action, but it can also be defined as an adjective because it modifies the noun coach.

In order to be as precise and as consistent as possible, this study uses the classifications of Charles C. Fries. Instead of the traditional categories of noun, verb, adjective, and adverb, Fries uses Class 1, Class 2, Class 3, and Class 4 (76-86).

Class 1 words are those which fit the following structural frame.

Class
1
(The) _____ is/was good
_____s are/were good

Class 2 words are those which fit the following structural frames.
Frame A

Class 1 2
(The) ______ is/was good
____ are/were good
seems/seemed/seem
sounds/sounded/sound
feels/felt/feel
becomes/became/becomes

Frame B

Class 1 2 Class 1
(The) ______ remembered (the) ______
______s wanted ______s
saw
discussed
preferred
struck
believed

Frame C

Class 1 2
(The) ______ went there
______s came
ran
started
talked

Class 3 words are those which fit the following structural frame.
(The) good ______ is/was good
______s are/were
large
necessary
foreign
best

Class 4 words are those which fit the following structural frames.

Frame A

Class 3 1 2 3 4
(The) ______ ______ is/was ______ there
______s are/were always

suddenly
generally

Frame B

(The) ______ remembered (the) ______ clearly
______s

sufficiently
repeatedly
soon
later

Frame C

Class 1 2 3
(The) ______ went there
back
out
upstairs
eagerly
safely

The words of Class 3, traditionally called adjectives, are not the kind of modifiers that add precision. With the exception of a few so-called "absolute" adjectives such as unique and dead, they are relative terms. Consider the following sentences.

(a) Bring me a long board.
(b) Bring me a six foot board.
(c) Bring me a useful wrench.
(d) Bring me a crescent wrench.

Sentences (b) and (d) are precise; sentences (a) and (c) are not. The words long and useful are Class 3 words; the words crescent and six foot are not. Or consider these sentences.

(e) The bearings must be milled precisely.
(f) The bearings must be milled to tolerances of one millionth of an inch.

Sentence (f) is precise; sentence (e) is not. The word precisely is a Class 4 word. None of the words of the modifying phrase to tolerances of one millionth of an inch is either Class 3 or Class 4.

It is true that some Class 3 words, such as unique,
round, and **dead**, and some Class 4 words, such as **up**
and **down** do have precise meanings, at least in certain
contexts. But the writer who is striving for precision
will certainly use fewer words of these two classes
than one who is not. Therefore, the ratio of nouns and
verbs to adjectives and adverbs is used in this study
as a partial measure of precision.

Section 6: Conciseness

It is easy to tell someone to be concise in
writing. Never use two words when one will do. The
problem is deciding when one will do. This is a highly
subjective judgment. Perhaps a more objective measure
of conciseness is the number of words per proposition.
Consider the following sentences.

(a) The house that is blue and that is on the
hill belongs to Mrs. Smith.

(b) The blue house on the hill belongs to Mrs. Smith.

Sentence (b) is clearly more concise than sentence
(a), and furthermore, readers would consider sentence
(b) a more mature sentence, even though it contains
fewer words per T-unit. The important thing is that
sentence (b) says as much as sentence (a). There is no
need for the extra words. As Newton put it "More is
vain when less will serve." In statistical terms,
sentence (b) has 3.33 words per proposition, while sentence (a) has 5 words per proposition, 50% more words per proposition.

There is, of course, a point at which conciseness may come into conflict with clarity. Joseph Williams warns against long noun + noun + noun constructions such as "early childhood thought disorder diagnosis" (1981, 22). The phrase is not only difficult to read; it is also ambiguous. One or two more words would clarify it. One meaning is misdiagnosis of thought disorder in early childhood, and the other is early misdiagnosis of thought disorder in childhood. Thus, a few extra words can sometimes make a passage clearer. Nevertheless, conciseness is one of the frequently mentioned characteristics of technical writing, and it is expected that it would be measureably more concise than non-technical writing.

Certainly, words per proposition does not completely measure conciseness. It does not, for example, indicate whether more propositions have been used than is necessary. But it is one objective measure, and is used as such in this study.

Section 7: Vigor

Vigor is frequently cited as a desirable characteristic in technical writing, although it is not
often mentioned in a list of characteristics. Miller and Saidla consider the chief weakness of the writing of one engineer, Sir Charles Parsons, to be a lack of vitality (193). They also refer favorably to the intensity of the prose of another engineer (113). Thus, although they do not mention a list of characteristics, they clearly regard vigor as a desirable quality.

A number of technical writing texts suggest ways to make writing more vigorous. Joseph Alvarez says that nouns and verbs generate the power in a sentence, while adjectives and adverbs dilute that power (23). Richard W. Smith says much the same thing. Comparing a passage from Hemingway with one from Marquand, he points out that the adjectives in the Marquand passage weaken rather than strengthen the nouns, while Hemingway's lack of adjectives contributes to the hard hitting effect (14-15). The ratio of nouns and verbs to adjectives and adverbs is used in this study as a measure of vigor as well as of precision.

Daniel Marder suggests that precise verbs give the writing vitality. Verbs are the power package. Hiding the action in nominalizations results in weak verbs, which in turn make weak, ineffective prose (288). The ratio of nominalizations to verbs is used as a second measure of vigor in this study.
Rulon Wells identifies a nominal style as one that tends to use nouns in preference to verbs, and a verbal style as one that tends to use verbs rather than nouns. He points out that those who appraise style usually consider a nominal style inferior to a verbal one. Among the reasons for this are that nouns are more static, less vivid than verbs. He also says that a nominal sentence is likely to be longer, and that in a nominal style, the number of distinct sentence patterns will decrease; therefore a nominal style will be more monotonous and less lively. However, he also points out that a nominal style helps impersonality and suggests that scientific writing, as opposed to literary and artistic writing, would make more use of it, particularly nineteenth and twentieth century scientific writing (302-03). Hake and Williams found that, although English teachers usually advise their students to use a lively, verbal style, they tend to give higher grades to papers with a heavily nominal style (433-51). As Wells puts it, "Those who judge nominal style good do so implicitly for the most part; nominal style is practiced more than preached" (302). He suggests an index that would have two parts: a Noun-Word Quotient (NWQ) and a Verb-Word Quotient (VWQ), the sum of which would equal 1.0 if there were no other parts of speech in the text (299). A comparison of the VWQ and the NWQ is
used in this study as a third measure of vigor.

Most authorities recognize the passive voice as characteristic of technical writing, and most of them also warn against its overuse. Herman Struck, a nationally known science editor, is frequently cited. He considers the passive a defect in science writing and says he eliminates at least five tons of passive verbs a month (Andrews and Blickle, 110). Herman Weisman says that active verbs are more lively than passive verbs and are therefore usually to be preferred (31). Charles R. Stratton quotes from the U. S. Geological Survey: "the passive form is wordy and weak, and it may mean that the author is trying to convince himself" (423).

Although there are many places in technical writing where the passive is the more appropriate choice, the modern tendency is to use the passive less. Many scientists now use first person pronouns rather than putting the sentence in the passive to avoid them for the sake of scientific objectivity. For example, Havrliak and King, in an article in the Journal of the American Chemical Society write "We denote a set of primitives. . . ." rather than "A set of primitives is denoted. . . ." (5). Fifty years ago this usage was considered completely inappropriate for scientific writing, and would never have appeared in a reputable
scientific journal.

Even though there are legitimate uses for the passive, most authorities seem to agree that it is weaker than the active; therefore, the percentage of passive verbs is used in this study as a fourth measure of vigor.

Conclusion

The above discussion has indicated that the most measurable of the characteristics of good technical writing is readability. Although conciseness, precision, and vigor are more subjective terms, there are some measures than can be used to evaluate them. Conciseness can be partially measured the the ratio of words to propositions. Precision can be partially measured by the ratio of nouns and verbs to adjectives and adverbs. Vigor can also be partially measured by the ratio of nouns and verbs to adjectives and adverbs, as well as by the ratio of nominalizations to verbs, a comparison of the NWQ with the VWQ, and the percentage of passive verbs. It has also shown that the traditional definitions of parts of speech cannot be used in objective measurements because of cross classification, and that this study will the Fries classification of parts of speech.

These four elements, readability, precision,
conciseness, and vigor will be the basis for this study of the stylistic differences between technical and non-technical writing.
CHAPTER THREE

Method

This chapter will explain why the particular journals were selected, how the random selection of samples was made, how the various stylistic devices were counted, and how the data were analyzed.

Samples

The selection of samples was made with the purpose of obtaining the closest possible contextual relationship with the exception of the contrast between technical and non-technical material. It was of crucial importance to assure that the educational level, and thus the reading level, of the target audiences be as nearly the same as possible. It was felt that this similarity would be best achieved at what Houp and Pearsall identify as the expert level. The technical journals selected were:

Journal of Physics B: Atomic and Molecular Physics
Agricultural Engineering
Journal of the American Chemical Society
New England Journal of Medicine
Experimental Mechanics
Analytica Chimica Acta
American Journal of Botany
Industrial Engineering
Computer Journal

The non-technical journals selected were:
Journal of English and Germanic Philology
Historian
Harvard Theological Review
Shakespeare Quarterly
Journal of Philosophy
The Journal of Aesthetics and Art Criticism
Modern Language Review
Theater Journal
The Historical Journal
Publication of the Modern Language Association.

Once the journals had been selected, the samples were chosen at random. Each sample consists of fifteen consecutive sentences beginning with the tenth paragraph of the second article in the first issue of 1983, except for the sample from Analytica Chimica Acta. The tenth paragraph of the second article of that issue consisted almost entirely of formulae, and was thus impossible to analyze in terms of sentences. Therefore the third article of this issue was chosen for analysis.
Counting of Stylistic Devices

In counting words to determine readability, chemical formulae were counted as single words, even when the names of the substances consisted of more than one word. For example, CO$_2$ would be counted as one word, even though carbon dioxide is two words.

In determining syntactic chunks per major closure to measure readability, the following were counted as syntactic chunks: nouns together with determiners and prenominal modifiers, verbs with adjacent modifiers (except linking verbs), prepositional phrases, verbal phrases, linking verbs together with the subjective complements, and conjunctions. When the object of a preposition was a verbal phrase, as in upon considering the matter, the prepositional phrase and the verbal phrase were counted as a single chunk. Major closures were considered to occur at the ends of independent clauses and at the ends of dependent clauses following independent clauses.

In counting arguments and propositions to determine readability, the system of Kintsch was followed. Each argument was counted only once, even though it may have occurred more than once. Arguments consisting of propositions were not counted, since they in turn consist of arguments already counted. Pronouns were not counted, since they refer to nouns already counted.
Example: If Mary likes John, she will tell him.

1. (likes, Mary, John)
2. (will tell, she, him)
3. (if, 1, 2)

There are only two different arguments, Mary and John. The pronouns she and him refer to arguments already counted, and the arguments of proposition (3) are propositions (1) and (2), containing the predicates likes and will tell, and the arguments already counted.

In determining sentence order to measure readability, sentences were counted as subject-verb-object or subject-verb-complement if there were no introductory words, phrases, or clauses before the subject of the main clause, and no interrupting constructions (non-restrictive material) between the subject and verb or between verb and object or complement.

Example: 1. The nut holding the generator was loose.

2. The nut, interestingly enough, was loose.

In sentence (1), holding the generator is restrictive and is not counted as an interrupting construction. In sentence (2), interestingly enough is non-restrictive and is counted as an interrupting construction.

In counting parts of speech to determine precision and vigor, nouns, verbs, adjectives, and adverbs were considered to be those words classified by Fries as
Class 1, Class 2, Class 3, and Class 4 words respectively. The words that Fries referred to as Class 1 "substitutes" (he, she, who, which, etc.) have been counted as nouns.

In counting nominalizations to determine vigor, only those words converted from verbs to nouns by addition of suffixes were counted as nominalizations. Words that are both nouns and verbs, sometimes with a change in pronunciation, were not counted. Example: convict. Agent nouns made from verbs by the addition of -er or -or were not counted, since they refer to agents rather than actions.

Material in parentheses was analyzed if it was part of the information of the sentence. Parenthetical references were not analyzed.

A complete analysis of a sample is given in Appendix 2.

Analysis of Data

For each of the ten hypotheses, the figures for the two sets of samples were averaged, and the difference between the technical and the non-technical samples was determined. The standard error and the T-ratio were then calculated. Since there were 20 samples, there were 18 degrees of freedom.

The consequences of a Type 1 error were not deemed
to be great; therefore, the .05 level of significance was considered to be adequate. This is the level at which the chance of the difference being due to sampling error is one in twenty. However, the .1 level of significance was not considered to be stringent enough. Therefore, if the difference was significant at the .05 level, the hypothesis was accepted; otherwise it was rejected.
CHAPTER FOUR

Findings

This chapter presents the results of the sample analyses, arranged according to the ten hypotheses. The hypotheses are tested at the .05 level of significance. The sample numbers refer to the samples as they are printed in Appendix 1.

Readability

Hypothesis 1: Technical writing has shorter sentences than non-technical writing.

The technical samples averaged 21.5 words per sentence, barely above what the Flesch scale rates as standard difficulty. The non-technical samples averaged 28.9 words per sentence, 33.5% longer, at the top of the difficult range on the Flesch scale, and within .1 words per sentence of the very difficult range. Table 1 shows the range of the individual samples, arranged from lowest to highest words per sentence. The sample numbers refer to the numbers of the samples as they are printed in the appendix.

The difference between the two samples is 7.4, and the standard error is 2.76. The t-ratio is thus 2.60, greater than the value required to reject the null
hypothesis at the .05 level of significance. The hypothesis is therefore accepted.

Hypothesis 2: Technical writing has shorter T-units than non-technical writing.

The technical samples averaged 18.5 words per T-unit, compared with 23.6 words per T-unit, 27.3% more for the non-technical samples. Table 2 shows the range

Table 1
Average Sentence Length

<table>
<thead>
<tr>
<th>Technical</th>
<th>Non-technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Article Number</td>
<td>Words per Sentence</td>
</tr>
<tr>
<td>2</td>
<td>14.3</td>
</tr>
<tr>
<td>3</td>
<td>15.7</td>
</tr>
<tr>
<td>7</td>
<td>17.9</td>
</tr>
<tr>
<td>5</td>
<td>18.6</td>
</tr>
<tr>
<td>8</td>
<td>19.5</td>
</tr>
<tr>
<td>4</td>
<td>21.3</td>
</tr>
<tr>
<td>9</td>
<td>22.5</td>
</tr>
<tr>
<td>1</td>
<td>24.8</td>
</tr>
<tr>
<td>6</td>
<td>26.5</td>
</tr>
<tr>
<td>10</td>
<td>35.2</td>
</tr>
</tbody>
</table>
of the individual samples arranged from smallest to largest number of words per T-unit.

The standard error for the two samples is 1.79 words per T-unit, and the difference between the means is 5.10 words per T-unit. The T-ratio is thus 3.41, considerably greater than the value required to reject the null hypothesis at the .05 level of significance. Therefore, the hypothesis is accepted.

Table 2
Average T-unit Length

<table>
<thead>
<tr>
<th>Technical</th>
<th>Non-technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Article Number</td>
<td>Words per T-Unit</td>
</tr>
<tr>
<td>2</td>
<td>13.4</td>
</tr>
<tr>
<td>5</td>
<td>14.7</td>
</tr>
<tr>
<td>3</td>
<td>14.8</td>
</tr>
<tr>
<td>7</td>
<td>14.8</td>
</tr>
<tr>
<td>8</td>
<td>16.2</td>
</tr>
<tr>
<td>4</td>
<td>18.8</td>
</tr>
<tr>
<td>1</td>
<td>20.7</td>
</tr>
<tr>
<td>9</td>
<td>21.1</td>
</tr>
<tr>
<td>10</td>
<td>23.0</td>
</tr>
<tr>
<td>6</td>
<td>26.5</td>
</tr>
</tbody>
</table>
Hypothesis 3: Technical writing has a higher percentage of subject-verb-object and subject-verb-complement sentences than non-technical writing.

The technical samples had SVO or SVC order in 75% of their sentences. They had an introductory opener before the subject in 21%, and an interrupting construction in 3%. The non-technical samples had SVO or SVC order in 45% of their sentences, an introductory opener in 45%, and an interrupting construction in 10%. The range of the individual samples is shown in Table 3.

The standard error for the two samples is 4.77, and the difference between the means is 30. The t-ratio is thus 6.28, greater than the value required to reject the null hypothesis at the .05 level of significance. Therefore, the hypothesis is accepted.

Hypothesis 4: Technical writing has fewer syntactic chunks per major closure than non-technical writing.

The technical samples averaged 5.21 syntactic chunks per major closure, well within Miller's magic number seven. The non-technical samples averaged 8.27 syntactic chunks per major closure, 58.7% more than the technical samples. Table 4 shows the range of the individual samples arranged from smallest to largest number of syntactic chunks per major closure.
Table 3

Sentence Order

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>% of SVO</th>
<th>% of Intro</th>
<th>% of Inter</th>
<th>Sample Number</th>
<th>% of SVO</th>
<th>% of Intro</th>
<th>% of Inter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>93</td>
<td>7</td>
<td>0</td>
<td>10</td>
<td>67</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>80</td>
<td>13</td>
<td>7</td>
<td>2</td>
<td>53</td>
<td>40</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>80</td>
<td>20</td>
<td>0</td>
<td>3</td>
<td>53</td>
<td>27</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>80</td>
<td>13</td>
<td>7</td>
<td>6</td>
<td>47</td>
<td>40</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>80</td>
<td>20</td>
<td>0</td>
<td>7</td>
<td>47</td>
<td>40</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>73</td>
<td>27</td>
<td>0</td>
<td>8</td>
<td>47</td>
<td>53</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>73</td>
<td>20</td>
<td>7</td>
<td>9</td>
<td>40</td>
<td>47</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>67</td>
<td>27</td>
<td>7</td>
<td>4</td>
<td>33</td>
<td>53</td>
<td>13</td>
</tr>
<tr>
<td>9</td>
<td>67</td>
<td>27</td>
<td>7</td>
<td>1</td>
<td>33</td>
<td>60</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>60</td>
<td>40</td>
<td>0</td>
<td>5</td>
<td>27</td>
<td>67</td>
<td>7</td>
</tr>
</tbody>
</table>

The standard error for the two samples is .502 chunks per major closure. The difference between the means of the two samples is 3.06 syntactic chunks per major closure. The T-ratio is thus 6.10, a value considerably greater than that required to reject the null hypothesis at the .05 level of significance. Therefore, the hypothesis is accepted.
Table 4

Syntactic Chunks per Major Closure

<table>
<thead>
<tr>
<th>Technical</th>
<th>Non-technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Article Number</td>
<td>Chunks per Closure</td>
</tr>
<tr>
<td>2</td>
<td>4.44</td>
</tr>
<tr>
<td>7</td>
<td>4.60</td>
</tr>
<tr>
<td>8</td>
<td>4.83</td>
</tr>
<tr>
<td>3</td>
<td>4.90</td>
</tr>
<tr>
<td>10</td>
<td>4.95</td>
</tr>
<tr>
<td>5</td>
<td>5.00</td>
</tr>
<tr>
<td>6</td>
<td>5.91</td>
</tr>
<tr>
<td>9</td>
<td>5.78</td>
</tr>
<tr>
<td>4</td>
<td>5.80</td>
</tr>
<tr>
<td>1</td>
<td>6.40</td>
</tr>
</tbody>
</table>

Hypothesis 5: Technical writing has a higher ratio of propositions to arguments than non-technical writing.

There were 3.34 propositions per argument in the technical samples. There were 2.86 propositions per argument in the non-technical samples. The ratio of propositions to arguments was 17% greater in the technical samples. Table 5 shows the range of the individual samples.
The standard error for the two samples is .365, and the actual difference is .48. The T-ratio is thus 1.32. This is short of the value required to reject the null hypothesis at the .05 level of significance. Therefore, the hypothesis is rejected.

Table 5

Ratio of Propositions to Arguments

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Propositions per Argument</th>
<th>Sample Number</th>
<th>Propositions per Argument</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.48</td>
<td>5</td>
<td>1.94</td>
</tr>
<tr>
<td>9</td>
<td>2.57</td>
<td>9</td>
<td>2.36</td>
</tr>
<tr>
<td>2</td>
<td>2.60</td>
<td>4</td>
<td>2.43</td>
</tr>
<tr>
<td>10</td>
<td>2.65</td>
<td>10</td>
<td>2.53</td>
</tr>
<tr>
<td>5</td>
<td>3.15</td>
<td>8</td>
<td>2.61</td>
</tr>
<tr>
<td>6</td>
<td>3.69</td>
<td>2</td>
<td>2.74</td>
</tr>
<tr>
<td>7</td>
<td>3.83</td>
<td>6</td>
<td>3.00</td>
</tr>
<tr>
<td>1</td>
<td>4.70</td>
<td>7</td>
<td>3.02</td>
</tr>
<tr>
<td>8</td>
<td>4.84</td>
<td>1</td>
<td>3.21</td>
</tr>
<tr>
<td>4</td>
<td>4.90</td>
<td>3</td>
<td>3.90</td>
</tr>
</tbody>
</table>

Conciseness

Hypothesis 6: Technical writing has fewer words per proposition than non-technical writing.
The technical samples averaged 2.03 words per proposition. The non-technical samples averaged 2.14 words per proposition, 5.4% more words. The range of the individual samples is shown in Table 6.

The standard error for the two samples is .11 words per proposition, and the actual difference is .11 words per proposition, exactly equal to the standard error. Therefore, the hypothesis is rejected.

Table 6
Words per Proposition

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Words per Proposition</th>
<th>Sample Number</th>
<th>Words per Proposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1.59</td>
<td>1</td>
<td>1.56</td>
</tr>
<tr>
<td>6</td>
<td>1.89</td>
<td>6</td>
<td>2.07</td>
</tr>
<tr>
<td>4</td>
<td>1.89</td>
<td>4</td>
<td>2.10</td>
</tr>
<tr>
<td>7</td>
<td>1.94</td>
<td>10</td>
<td>2.12</td>
</tr>
<tr>
<td>8</td>
<td>1.95</td>
<td>5</td>
<td>2.21</td>
</tr>
<tr>
<td>5</td>
<td>1.96</td>
<td>8</td>
<td>2.24</td>
</tr>
<tr>
<td>10</td>
<td>2.05</td>
<td>3</td>
<td>2.30</td>
</tr>
<tr>
<td>9</td>
<td>2.15</td>
<td>1</td>
<td>2.40</td>
</tr>
<tr>
<td>1</td>
<td>2.15</td>
<td>3</td>
<td>2.51</td>
</tr>
<tr>
<td>2</td>
<td>2.28</td>
<td>2</td>
<td>2.54</td>
</tr>
</tbody>
</table>
Precision

Hypothesis 7: Technical writing has a higher ratio of nouns and verbs to adjectives and adverbs than non-technical writing.

The ratio of nouns and verbs to adjectives and adverbs in the non-technical samples was 3.70 to 1. The ratio in the technical samples was 5.60 to 1, greater by a margin of 51%. The range of the individual samples is shown in Table 7.

Table 7

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Ratio</th>
<th>Sample Number</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>16.60-1</td>
<td>2</td>
<td>6.30-1</td>
</tr>
<tr>
<td>7</td>
<td>8.80-1</td>
<td>5</td>
<td>5.20-1</td>
</tr>
<tr>
<td>9</td>
<td>7.27-1</td>
<td>9</td>
<td>4.35-1</td>
</tr>
<tr>
<td>3</td>
<td>6.80-1</td>
<td>8</td>
<td>4.19-1</td>
</tr>
<tr>
<td>6</td>
<td>6.42-1</td>
<td>9</td>
<td>3.64-1</td>
</tr>
<tr>
<td>5</td>
<td>6.10-1</td>
<td>10</td>
<td>3.57-1</td>
</tr>
<tr>
<td>10</td>
<td>5.73-1</td>
<td>6</td>
<td>3.50-1</td>
</tr>
<tr>
<td>4</td>
<td>5.10-1</td>
<td>7</td>
<td>3.20-1</td>
</tr>
<tr>
<td>8</td>
<td>3.48-1</td>
<td>4</td>
<td>3.14-1</td>
</tr>
<tr>
<td>1</td>
<td>3.00-1</td>
<td>3</td>
<td>2.70-1</td>
</tr>
</tbody>
</table>
The standard error for the two samples is 1.33, and the actual difference in the means is 1.90. Thus the T-ratio is 1.42, less than the value required to reject the null hypothesis at the .05 level of significance. Therefore, the hypothesis is rejected.

**Vigor**

Hypothesis 8: Technical writing has a lower percentage of passive verbs than non-technical writing.

The percentage of passive verbs in the technical samples was 41. The percentage of passive verbs in the non-technical samples was 12.1. The technical writers used the passive voice more than three times as often as the non-technical writers. Therefore the hypothesis is rejected.

Table 8 shows the range of the individual samples.

Hypothesis 9: Technical writing has fewer nominalizations than non-technical writing.

In the technical samples 11% of the nouns were nominalized verbs. In the non-technical samples 13% of the nouns were nominalized verbs, 18% more than in the technical samples. Table 9 shows the range of the individual samples.

The standard error for the two samples is 2.6, and the actual difference in the two means is 2. Thus, the standard error is greater than the actual
Table 8
Percentage of Passive Verbs

<table>
<thead>
<tr>
<th>Technical</th>
<th>Non-technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Number</td>
<td>Percentage of Passives</td>
</tr>
<tr>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>56</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>46</td>
</tr>
<tr>
<td>10</td>
<td>44</td>
</tr>
<tr>
<td>8</td>
<td>43</td>
</tr>
<tr>
<td>1</td>
<td>27</td>
</tr>
<tr>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

difference between the two samples. Therefore, the hypothesis is rejected.

Hypothesis 10: Technical writing has a lower ratio of Noun-Word Quotient to Verb-Word Quotient than non-technical writing.

The technical samples had an average NWQ of .30 and a VWQ of .08. The ratio of NWQ to VWQ was thus 3.75-1. The non-technical samples had a NWQ of .28 and
Table 9
Percentage of Nominalizations

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Technical Nominalizations as Percentage of Nouns</th>
<th>Non-technical Nominalizations as Percentage of Nouns</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

a VWQ of .08. The ratio was thus 3.62-1. Table 10 shows the range of the individual samples.

The technical writing samples had a slightly higher ratio of NWQ to VWQ than did the non-technical samples. Therefore, the hypothesis is rejected.
### Table 10

Ratio of NWQ to VWQ

<table>
<thead>
<tr>
<th>Technical</th>
<th>Non-technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Number</td>
<td>Ratio of NWQ to VWQ</td>
</tr>
<tr>
<td>9</td>
<td>4.50-1</td>
</tr>
<tr>
<td>2</td>
<td>4.40-1</td>
</tr>
<tr>
<td>7</td>
<td>3.71-1</td>
</tr>
<tr>
<td>6</td>
<td>3.71-1</td>
</tr>
<tr>
<td>1</td>
<td>3.51-1</td>
</tr>
<tr>
<td>8</td>
<td>3.29-1</td>
</tr>
<tr>
<td>3</td>
<td>3.25-1</td>
</tr>
<tr>
<td>5</td>
<td>3.22-1</td>
</tr>
<tr>
<td>10</td>
<td>3.00-1</td>
</tr>
<tr>
<td>4</td>
<td>2.89-1</td>
</tr>
</tbody>
</table>

**Summary**

Table 11 summarizes the statistical information presented in this chapter. The T-ratio necessary to reject the null hypothesis at the .05 level of significance with 18 degrees of freedom is 2.101.
Table 11

Summary of Information

<table>
<thead>
<tr>
<th>Stylistic Feature</th>
<th>Tech Samples</th>
<th>Non-tech Samples</th>
<th>Diff</th>
<th>Std Error</th>
<th>T-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sentence Length</td>
<td>21.5</td>
<td>28.9</td>
<td>7.4</td>
<td>2.76</td>
<td>2.60*</td>
</tr>
<tr>
<td>T-unit Length</td>
<td>18.5</td>
<td>23.6</td>
<td>5.1</td>
<td>1.79</td>
<td>3.41*</td>
</tr>
<tr>
<td>SVO/SVC Order</td>
<td>75%</td>
<td>45%</td>
<td>30</td>
<td>4.77</td>
<td>6.28*</td>
</tr>
<tr>
<td>Chunks per Closure</td>
<td>5.21</td>
<td>8.27</td>
<td>3.06</td>
<td>0.502</td>
<td>6.10*</td>
</tr>
<tr>
<td>Props per Argument</td>
<td>3.34</td>
<td>2.86</td>
<td>0.48</td>
<td>0.365</td>
<td>1.32</td>
</tr>
<tr>
<td>Words per Prop</td>
<td>2.03</td>
<td>2.14</td>
<td>0.11</td>
<td>0.11</td>
<td>1.00</td>
</tr>
<tr>
<td>Ratio Noun/Verb to Adj/Adv</td>
<td>3.7-1</td>
<td>5.6-1</td>
<td>1.90</td>
<td>1.33</td>
<td>1.42</td>
</tr>
<tr>
<td>Passive Verbs</td>
<td>41%</td>
<td>12%</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Nom Verbs</td>
<td>11%</td>
<td>13%</td>
<td>2</td>
<td>2.6</td>
<td>N/A</td>
</tr>
<tr>
<td>NWQ to VWQ</td>
<td>3.75-1</td>
<td>3.62-1</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* significant at the .05 level
CHAPTER FIVE

Summary and Conclusions

Summary

Many teachers of technical writing are trained in literary studies, and have tended to use literary models in their teaching of composition. They are therefore not familiar with the style used by technical writers. Technical writing texts are not as helpful as they might be in that they discuss style in very general terms, and do not show specifically how technical writing differs from the models teachers and students are accustomed to. In fact, very little research exists in this area. Such research is needed in order to provide the information that authors of technical writing texts need.

This study was designed to determine whether there are significant differences between technical and non-technical writing style, defined as: readability, conciseness, precision, and vigor, and if so, precisely what they are. Measures of readability used were average sentence length, average T-unit length, percentage of sentences using SVO or SVC word order, the number of syntactic chunks per major closure, and the ratio of
propositions to arguments.

The measure of conciseness used was the number of words per proposition.

The measure of precision used was the ratio of nouns and verbs to adjectives and adverbs.

The measures of vigor used were the percentage of passive verbs, the percentage of nouns that are nominalized verbs, the ratio of Noun-Word-Quotient to Verb-Word-Quotient, and the ratio of nouns and verbs to adjectives and adverbs.

Ten samples of 15 sentences each from journals in science and engineering, and ten samples of 15 sentences each from journals in the humanities were analyzed.

Conclusions

The study attempted to answer four questions.

1. Is technical writing significantly more readable than non-technical writing? A comparison of the samples showed that the technical writing samples were significantly more easily readable in that they had shorter sentences, shorter T-units, a higher percentage of SVO and SVC sentences, and fewer syntactic chunks per major closure. While the difference in the ratio of propositions to arguments fell short of the .05 level of significance, it was very close.
2. Is technical writing significantly more concise than non-technical writing? A comparison of the samples showed that the technical writing samples were not significantly more concise, in that, while they did use fewer words per proposition, the difference was not significant at the .05 level.

3. Is technical writing significantly more precise than non-technical writing? The study showed that the technical writing samples were not significantly more precise in that, while they had a considerably higher ratio of nouns and verbs to adjectives and adverbs than did the non-technical samples, the difference was not quite great enough to be significant at the .05 level.

4. Is technical writing measurably more vigorous than non-technical writing? The study showed that technical writing was not significantly more vigorous than non-technical writing. While the technical samples did have a higher ratio of nouns and verbs to adjectives and adverbs, the difference was not significant at the .05 level. Further, the technical samples had a higher ratio of NWQ to VWQ, a higher percentage of nouns that were nominalized verbs, and a considerably higher percentage of passive verbs.
Discussion

The most striking difference found between technical and non-technical writing was in readability. This is probably because the technical writer is interested in conveying information as efficiently as possible, and has little interest in stylistic variation for aesthetic effect. This frequently means using a simpler style than a humanist might use.

English teachers do not always value simplicity, directness, and clarity as highly as do scientists and engineers. This is only natural. People trained in the analysis of literature frequently value the way something is said more highly than what is said. Consider, for example, the following sonnet by Shakespeare.

Let me not to the marriage of true minds
Admit impediments. Love is not love
Which alters when it alteration finds,
Or bends with the remover to remove:
O, no! It is an ever-fixed mark
That looks on tempests and is never shaken;
It is the star to ever wandering bark,
Whose worth's unknown, although his height be taken.

Love's not Time's fool, though rosy lips and cheeks
Within his bending sickle's compass come;
Love alters not with his brief hours and weeks,
But bears it out even to the edge of doom.
If this be error, and upon me prov'd,
I never writ, nor no man ever lov'd.

Few English teachers would teach this sonnet for its content. The idea that love does not change with time, whether true or false, was certainly not new in
the late sixteenth century. The poem has been read by
generations of readers not for what it says, but how it
is said. Its impact is emotional, not rational.

Language has many uses, and conveying information
is only one of them. It is only natural that the
teacher trained in literature should have some
adjustments, sometimes difficult adjustments to make in
teaching technical writing.

Further, many English teachers in their teaching of
composition have valued other elements more highly than
a simple direct style. They have used literary models
for their students to emulate, and have tried to teach
them to write more imaginatively, to use imagery and
metaphor, and to develop a more complex style. This
is as it should be. This study is in no way intended
to suggest that there is not great value in this kind
of writing and teaching. Many students, especially
those from primarily oral cultures, come to high school
and even college English classes writing what amounts
to primer prose. "I have a friend. My friend's name
is Jean. My friend lives in Chicago." One of the
tasks of the composition teacher is teach the students
to write longer sentences and T-units and to use more
subordination and embeddings, in short, to develop a
more mature style. It is sometimes difficult to re-
verse oneself, and teach a simpler style. But the
evidence examined in this study shows that professionals in science and engineering do indeed use a simple direct style, whose chief characteristic is its readability.

Although the difference in precision as measured by the ratio of nouns and verbs to adjectives and adverbs was not significant at the .05 level, it came very close. The difference that was evident was probably due more to the nature of the subject matter than to conscious stylistic choices. Subjective description requires adjectives and adverbs, while technical description requires exact measures.

There was no significant difference in conciseness between the technical and non-technical samples. This may have been due to the ineffectiveness of the measuring device. Words per proposition can only measure the efficiency with which a certain number of propositions is expressed. It does not tell us whether some of the propositions are redundant. Conciseness is a property of all good writing, but its measure is largely subjective.

The technical samples were not more vigorous as measured by three of the four criteria. This does not mean that vigor is not a desirable quality for technical writing, but it is one that may be difficult to achieve at least partly because of the subject
matter. Consider the use of the passive voice, for example. Technical writing deals a great deal with things as opposed to people, and things are not often agents.

(1) A catalyst was added to the mixture.

(2) The wings were studied carefully.

In these two sentences the agents, that is, the ones who did the adding and the studying, are not important; therefore, the passive is used and the agent is deleted. These passive sentences are typical of technical writing, and help account for the fact that the verbs in technical writing are frequently more than fifty percent passive.

It is clear from the above that the most important and the most objectively measurable differences between technical and non-technical writing are in readability. The technical writing was considerably more precise, but the difference was short of that required for significance at the .05 level. The difference in conciseness could easily have been due to sampling error, and the technical writing was actually less vigorous in three of the four measures.

Implications

Teachers trained in literary studies bring many strengths to the teaching of technical writing, among
them a sensitivity to language, a thorough knowledge of grammar and usage, and the tradition of close reading of texts. However, as Joseph Mancuso and Carol Barnum have pointed out, there is a sometimes difficult transition involved in becoming a technical writer or a teacher of technical writing. Technical writing texts could aid in this transition by providing more specific information about style than they do. Studies such as this one can provide information that can be used in these texts to help both teachers and students make the transition from traditional composition courses to technical writing.

Recommendations

1. Most stylistic studies done so far have been studies of literary texts in the service of literary criticism. More stylistic studies need to be made of non-literary texts to see what stylistic features characterize various kinds of writing in the work world, and what the implications are for the teacher of writing. Further studies in technical writing style are clearly needed.

2. Studies in technical writing style should concentrate on those stylistic characteristics that relate to readability, since, in the present study,
this is clearly the most important and most objectively measurable characteristic.

3. Studies should be made of technical writing at all audience levels. Since students will be writing for different audiences, they need to be aware of stylistic differences in writing for different audience levels.

4. Studies should include the extent to which Functional Sentence Perspective is used in technical writing. William J. Vande Kopple has shown that passages using FSP were significantly more readable than passages which did not. FSP was not used in this study because it requires taking into account the content of the passage. Nevertheless, it would provide a useful measure of readability.
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APPENDIX 1: SAMPLE PASSAGES

The sample passages used for the analyses are given below.

Technical Samples

1. The algorithms are based on the classic method of counting the negative signs of the Sturm sequences derived from the matrix. Thus, given a symmetric tridiagonal matrix with real eigenvalues lying between \( \lambda_{\min} \) and \( \lambda_{\max} \), then counting the number of negative signs of the Sturm sequences at a point \( \lambda_c \), gives the number of eigenvalues lying below \( \lambda_c \). Since the domain can be sampled at an arbitrary number \( (k) \) of interior points each domain fragments into up to \( k + 1 \) smaller domains containing 1 or more eigenvalues. Application of the method to the new set of smaller domains isolates the eigenvalues further and the process is repeated until the domain size is less than the required user accuracy.

Sequential methods sample each domain at only 1 interior point thus yielding 1 or 2 smaller domains containing eigenvalues. Parallelism is introduced by either or both of: (i) processing some or all of the current set of domains, (ii) sampling a domain with more than one point.

Parallel bisection uses only the first of these techniques and since it samples each domain only at the bisection point, the collection of sample points is identical to those of the sequential bisection scheme. The potential speedup obtainable from the parallel version thus depends on the balance between the amounts of parallelism in the various stages. It is clearly bounded from above by \( N \), the maximum number of separate domains. Since it is possible for the eigenvalues to remain bunched in a single domain until some final (minimal) set of bisections separates them, the lower bound on the potential speedup is unity.

An alternative parallel scheme is to treat each interval in turn (that is sequentially) but to sample in parallel each interval at \( p \) points: in this scheme an arbitrary large number of processors can be used. Bounds on the speedup obtainable with this version can be found by assuming two different eigenvalue distributions. Thus first assume that the eigenvalues are all bunched together and the \( p \) samples on the domain produce only one non-empty domain. Successive sequential bisection of the original domain produces
the same result with only $\ln_2(p+1)$ samples. This is the worst distribution for this method and results in a lower bound on the speedup of the $\ln_2(p+1)$ (Barlow, Evans, and Shanhchii, 6).

2. The measurements were carried out at argon pressures in the $10^{-1}$-$10^{-2}$ Torr range. The pressure was controlled by a thermocouple manometer.

3. Results and discussion

The diagram of the energy levels studied in this work and the spectral lines observed are shown in figure 1. The spectral lines classification is taken from the tables of Striganov and Sventitski (1966). Bashkin's Grotrian diagrams are also used (Bashkin and Stoner 1978).

The data obtained is presented in table 1. The mean-square error given corresponds to a confidence probability 0.95. In addition to the transitions indicated in table 1, measurements were carried out, whenever possible, on other transitions beginning at the respective states.

The results from other works are also cited in table 1. The data obtained by Denis and Gaillard (1970) differ by almost a factor of two from the present results. However, details are not given concerning the experiment. The error of Denis's results was 20%.

A comparison of the present results with the data obtained by Fink et al. (1970) shows a relatively good agreement. Fink's data, shown in table 1, have an error of 30%. Fink et al. (1970) measured the lifetimes of the $4d^{12}$D state using the spectral lines 3819.04 and 3825.70 Å (5.8, 5.9 ns), but according to Striganov and Sventitski (1966) and Norlen (1973) these lines have as an upper state the $4d^{12}P_{3/2}$ state (Blagoev, 34-36).

3. Site description—Field studies were made at the Elizabeth's Prairie section of the Lynx Prairie Preserve near Lynx, Adams Co., Ohio. The history, geology, and vegetation of the site were described by Braun (1921, 1928a, b) and others (Locke, 1838; Jones, 1945). The general vegetation of this prairie is dominated by Schizachyrium scoparium Nash. (equal Andropogon scoparius Michx., little bluestem) with lesser amounts of other tall grass prairie species, while the surface layer contains bryophytes and cladoniform lichens (Fovargue, 1979). Elizabeth's Prairie occupies 0.35 ha of the southwest slope of Burr Hill and is drained by Ellis Run and its tributaries. On the southwest half of the site along the tilted
dolomite substratum, groundwater seepage occurs following wet periods. Large Nostoc colonies (1-4 cm diam and up to 5 g fresh weight, Fig. 1) occur throughout the site, especially wherever such seepage is apparent.

In a detailed vegetation sampling of the Lynx Prairie Preserve, legumes (Cassia fasciculata, C. marilandica, Desmodium nudiflorum, Lespedeza sp., and Melilotus officinalis) were encountered at low densities (L. A. Kapustka and A. E. Annala, unpubl.). Ceanothus americanus, an actinorhizal diazotroph, is also present, but like the legumes occurs sparsely. On Elizabeth's Prairie, the only symbiotic diazotroph was C. fasciculata (I. P. = 0.28). At the low densities which the symbiotic diazotrophs occur, we consider them insignificant in the total N economy of this site.

MATERIALS AND METHODS—Determination of Nostoc sp. cover—The site was sampled biweekly from 29 March through 8 November 1980 (15 site visits). The percent cover of Nostoc sp. colonies was determined using Point-Frame Analysis (Whitman and Siggeirsson, 1954) along a 75-m transect. Forty frames of 10 pins each were used during each site visit. Nostoc sp. cover was expressed as the percentage of 400 pins contacting Nostoc sp. colonies.

Acetylene reduction assay for N\textsubscript{2}ase activity—N\textsubscript{2}(C\textsubscript{2}H\textsubscript{2})ase activity was measured using the Acetylene Reduction Assay (ARA) technique (Balandreau and Dommergues, 1973) (DuBois and Kapustka, 9).

4. LIFO saves taxes because it keeps high current cost out of inventory. This keeps inventory amounts down, which means that higher amounts are shown as a cost of goods sold. This higher cost of goods sold reduces the amount of income that can be taxed, thus providing significant savings for the manufacturer of agricultural machinery and equipment.

Before these new LIFO index rules came into effect, each manufacturer of agricultural machinery and equipment who wanted to use LIFO had to specifically account for each product or compute its own internal index. A manufacturer of agricultural machinery and equipment has so many different products that these computations are too burdensome on a product-by-product basis. A manufacturer of agricultural machinery and equipment can compute its own internal index, but this task is also too burdensome because a broad cross section of products has to be used to establish an internal index. To make matters worse, the IRS has been arguing with taxpayers as to whether their product sample is adequately representative of their business.
LIFO Made Easier

The new LIFO index rules eliminate most disputes concerning inventory values. Any increase in inventory is based on the index for the year. This inventory increase is taken into account at current prices because of the index, but these higher prices do not affect the remainder of the inventory.

Now a manufacturer of agricultural machinery and equipment can use the Producer Price Index (PPI) to determine its inventory increase for the year. A manufacturer will use the PPI index for one or more of the following items:

- Farm, lawn, and garden tractors.
- Agricultural machinery excluding tractors.
- Agricultural equipment.

Some effort may be necessary to categorize the existing inventory in accordance with the PPI. A manufacturer of agricultural machinery and equipment should do this reclassification well before its fiscal year ends.

Since higher price amounts apply to increases in inventory and lower price amounts apply to the starting inventory, a manufacturer must be able to determine its inventory increase (Feinschreiber, 11-12).

5. High technology areas such as robotics were particularly prominent among the topics addressed at the conference. For example, 15 segments on robots and flexible manufacturing systems were presented in the educational sessions. Keynote speaker George Rehfeldt, group vice president at Cincinnati Milacron, focused on this area as well in his talk, "Robotics: Applying the New Technology."

IEEs and robots

"I am sure that you all realize the enormous change brought to us by the industrial robot," Rehfeldt told the audience. Noting the large number of robotics sessions on the conference agenda, he observed that these would not have been there even two or three years ago.

"Industrial robots are now an integral part of industrial engineering," he said. "Every professional in the field must have more than a passing knowledge of the subject.

"The industrial robot is not a panacea," Rehfeldt continued. "But it does give us the opportunity to directly confront our problems in the next decade."
These problems include a declining number of skilled people entering the work force, our inability to attract people to tedious and repetitious jobs and the dire need to raise the quality level of our manufac-
turing output."

Rehfledt noted that half the robots at work in the U. S. today are doing spot welding. Arc welding is the next most common use of robots, he said, and appears to be the largest emerging market for robots. He then described other current uses for industrial robots, including material handling, drilling and routing, machine loading, foundry work and grinding.

Future applications of industrial robots predicted by Rehfledt include water jet cutting, laser cutting and laser drilling.

"The industrial robot is a computer tool par excellence," says Rehfledt (Filley, 30).

6. The general measurement procedure for this project consisted of the attachment of strain-gage rosettes on the exterior surface of the steam generators. Six rosettes were uniformly spaced around the circumference and at the midlength of the small diameter shells (as shown in Fig. 2). All four steam generators attached to one drum were instrumented. From sets of measure-
ments taken during various operating conditions, the stresses at the rosette locations were required to be calculated. Then from these stresses, three force parameters and three moment parameters were calculated for each steam generator for each unit condition.
(These forces and moments were reactions carried through the steam-generator shells and were considered to act through a single point--the intersection of the horizontal plane of the strain gages and the vertical axis of the steam generator). By means of piping and finite-element programs, the bending stresses in the juncture areas could then be calculated from the force and moment measurements.

Obstacles to a Conventional Analysis of the Measurements

There were two significant obstacles in performing the measurements to obtain the required information. The major difficulty centered on the general requirement that the strain-gage reading had to be compensated for the thermal-expansion data on the steam-generator steel. This was seen as a formidable problem con-
sidering that no accurate thermal-expansion data on the steam-generator steel could be obtained and that in situ calibration of strain gages to compensate for this effect was not possible. An appreciation of this
problem may be gained by considering that the thermal expansion of the instrumented steel over the measurement temperatures (25° C to 260° C) would be about 3000 μm/m (based upon handbook data), whereas it was estimated that the stress-induced strains (the required data) would likely be on the order of about 300 μm/m. If the handbook thermal-expansion data were in error by only ±5 percent—which would be quite possible—the unknown component in apparent strain would be ±150 μm/m, which would totally invalidate the calculation of stress. The second major difficulty in measurement performance centered on the requirement to obtain only the components of stress which were related to mechanical loads (i.e., forces and moments). During the measurements, unknown through-wall gradients would occur which would result in an unknown component of stress on the outside instrumented surface of the steam generators. Although these through-wall thermal stresses would not be related to mechanical loads, they would affect the strain-gage readings to an unknown extent (Flaman and Shah, 11).

7. We denote a set of primitives by round bracket notation, (,), and a set of contracted functions by square brackets, [\cdot]. Functions to the left of the solidus are located on nitrogen, and those to the right on hydrogen. A d shell or f shell contains 6 or 10 functions, respectively. Our standard core basis is an (11s,7p,2d/5s,2p) set contracted to [6s,1p,1d/3s,2p] giving \( n_\text{c} = 51 \). This is a Dunning (10s,6p) set augmented with a double set of polarization functions on nitrogen and hydrogen plus an extra diffuse s and p shell on nitrogen to improve the tails of the core orbitals. Exponential parameters, \( a_i \), and contraction coefficients, \( b_i \), are given in Table I. Under \( T_d \) symmetry the 7p shells can be completely contracted without error. The two d shells have been assigned contraction coefficients corresponding to their values in the t(2p) orbital. This reduces the size of the density matrix which defines the Fock operator, and raises the computed value of \( E_\text{core} \) by only 3\( \mu \)hartree. The p- and d-type contraction coefficients reported in Table I are optimized for NH4+ in \( T_d \) symmetry with \( R_{\text{NH}} = 1.0098 \) Å. They are reoptimized for each new value of \( R_{\text{NH}} \); and for less symmetric geometries the p and d contraction scheme is relaxed accordingly. For example, an unsegmented [3p,2d] contraction is used when NH2+ is distorted to \( C_{3v} \) symmetry. In these cases, the p,d contraction error for \( E_\text{core} \) is a small fraction of 1\( \mu \)hartree.

Our standard Rydberg basis is the 149-term
[20s,13p,11d/3s,1p] set described in Table II. The nitrogen basis in uncontracted (Havrliak and King, 7-8).

8. The Lewis Hills Massif is the southernmost exposure of both the Bay of Islands and Coastal Complexes. Only relatively deep structural levels of both complexes are exposed, but the contact between them is beautifully preserved. The Lewis Hills Massif may be divided into three structural assemblages separated by steeply dipping, approximately north-south-trending contacts (Fig. 2). From west to east, these include the Little Port Assemblage, the Mount Barren Assemblage, and the plutonic members of the Bay of Islands Ophiolite Complex. The Little Port and Mount Barren Assemblages are members of the Coastal Complex and have a gradational contact. The contact between the Mount Barren Assemblage and the Bay of Islands Complex to the east is quite sharp and marks a dramatic change in structural style, metamorphic grade, and lithology. This contact has been intruded by weakly deformed peridotite bodies described in detail below.

The Little Port Assemblage consists of little-deformed gabbros, metagabbros, and related rocks. This assemblage is similar to that of the upper plutonic levels of the Bay of Islands Complex (Casey and others, 1981; Casey and Karson, 1981) and other ophiolites. Individual and sheeted swarms of diabase dikes, often with abundant coarse plagioclase phenocrysts and well-developed chilled margins, trend east-west and cut poorly defined, streaky layering in the gabbroic rocks; minor trondhjemite bodies also occur in some places. To the east, the dikes have been progressively tectonically rotated toward a northwest-trending orientation. Near the contact with the Mount Barren Assemblage, numerous shear belts (Ramsey and Graham, 1970) occur, and some outcrops have penetrative linear and planar deformation fabrics.

In the Mount Barren Assemblage, most rocks are highly deformed and recrystallized. Metadiabase dikes have been tectonically rotated to a north-northwest trend, nearly parallel to locally developed metamorphic layering. Nearly all of the deformed rocks in this assemblage have been overprinted by a strong stretching lineation (Karson, Elthon, and DeLong, 15-29).

9. FVIII:C was assayed by a one-stage method based on the partial thromboplastin time. FVIII:C concentrations were expressed in units per deciliter with reference to pooled normal plasma calibrated against the second International Standard for factor VIII (Na-
tional Institute for Biological Standards, London). FVIII:Ag was assayed by quantitative immunoelectrophoresis with use of a commercial monospecific antiserum (Istituto Behring, Scopito, Aquila). FVIII:Cof was assayed with formalin-fixed platelets as previously described. FVIII:Ag and FVIII:RCof were expressed in units per deciliter with reference to the same pooled plasma used for the VIII:C assays, assigning it a content of 1 U per deciliter of each component. FVIII:VWF multimers were analyzed by thin-layer agarose electrophoresis in the presence of sodium dodecyl sulfate, using a discontinuous buffer system as described elsewhere, except that electrophoresis was performed for 18 hours at a constant current of 6 mA per gel (instead of five to six hours and 10 to 12.5 mA per gel). Agarose gels were prepared at a concentration of 1.6 per cent. FVIII:VWF multimers were identified by exposing the gels to I-labeled affinity-purified antibodies to human FVIII:VWF, followed by autoradiography. Fibronectin was assayed by quantitative immunoelectrophoresis using a commercial antiserum (Istituto Behring), and the results were expressed as a percentage of pooled normal plasma.

Platelets were counted by phase-contrast microscopy. Platelet retention on glass beads was measured in native blood by a modification of Hellem's method, using standardized glass-bead-filled columns and a constant-rate (1 ml of blood per 15 seconds) infusion pump (Adeplat "S" and Adeplat "S" Pump System, Mascia Brunelli, Milan). Intraplatelet cyclic AMP was measured by a radioimmunoassay according to the method of Steiner et al., with a commercial kit (Becton Dickinson, Novate Milanese, Italy). Residual prothrombin was determined as a measure of platelet factor 3 availability by the method of Quick and Favre-Gilly, using a rabbit thromboplastin supplied by Stago-Biochemia (Milan). Thromboxane B2 was measured on serum obtained from spontaneously clotted blood by a radioimmunoassay as previously described.

Statistical Analysis

Since the values for the FVIII:VWF properties were not normally distributed, they were transformed logarithmically before tests of the significance of the differences were performed with the analysis of variance and Student's t-test for paired data (Mannucio, et al., 8-12).

10. The trade-off becomes immediately manifest if it is realized that the effective $\sigma_{Y_A}$ value of a
device can be diminished at the expense of detecting power by simply admixing a solvent in a T-piece immediately in front of the detector (make-up flow). The cell or the detection volume is swept faster and this system behaves with respect to peak broadening as if the cell had a much smaller volume. The solution is of course diluted, so that the detecting power is adversely affected. It is to be noted that, when this is done, the detection limit in amount, the minimum detectable quantity, \( \underline{M} \), remains the same.

In order to have some point of reference in the following discussion of various measuring principles, a concentration detection limit \( c_d \) corresponding to 1 ng ml (a reasonable average for u.v.-visible absorption) and a contribution, \( \sigma_{vd} \), of 1 nl to the peak width are aimed at. The latter figure may appear extremely low in view of present experimental possibilities, and indeed it is, but was chosen as it follows from the work of Tijssen [8], Knox and Gilbert [9] and Reijn et al. [7] that with this order of magnitude very significant exploitation of the speed advantage of miniaturized systems is possible.

**ULTRAVIOLET-VISIBLE ABSORPTION PHOTOMETRY**

Ultraviolet-visible absorption photometry is by far the most important detection system in h.p.l.c., and for the rapidly expanding f.i.a. area the same will probably be true in the future, because of the storehouse of selective colour reactions available for all sorts of compounds and elements in the literature.

The detecting power of these devices is conveniently expressed as the smallest absorption coefficient (absorbance per unit length) \( k \) in \( \text{cm}^{-1} \) which can be detected. Current "state of the art" performance for rather expensive devices is of the order of \( k = 10^{-5} \) \( \text{cm}^{-1} \). This is accomplished with cell volumes of the order of 10 ul and observed \( \sigma_{vd} \) values range around this value, with flow rates around 1 ml min\(^{-1}\). (It should be noted that \( \sigma_{vd} \) values can only be obtained by experimental determination in the laboratory, because manufacturers generally refuse to give specifications on this point; this is a surprising and unfortunate situation which persists despite the fact that the same manufacturers have papers published on such topics.)

A further decrease of the \( \sigma_{vd} \) value, and consequently of the cell volume, appears to be possible only at the expense of a drastic increase in the detection limit characterized by \( k \). This problem was addressed some years ago by Baumann [10] who mainly considered the influence of shot noise. As the
stability of source and photo-detection (which Baumann treated as technical imperfections) is often equally important, the present discussion will take this limitation into account as well.

When the source is of sufficiently large dimensions, the amount of light (photons/second, \( \dot{\Pi}_{\text{cell}} \)) which can be passed through the cell is given by

\[
\dot{\Pi}_{\text{cell}} = b(\lambda) \Delta \lambda S \Omega S
\]

(2)

where \( b(\lambda) \) is the equivalent of the radiance of the source \( B(\lambda) \), but expressed as a photon rate; \( \Delta \lambda \) is the spectral band width; \( \Omega \) is the solid angle from within which light can be projected through the cell; and \( S \) is the area of the source which can be exploited in this projection (Poppe, 19-20).

Non-technical Samples

1. I'll take "is artistically good" as the value predicate to conjure with—and we see at once an advantage of relativizing relativism, since it enables us to evade the problem of deciding the absolute degree of polyvadicity of this predicate. Thus let Smith be cast in his usual role of (comparative) nonrelativist. It doesn't matter whether he holds that "is artistically good" is a simple monadic predicate or holds that this is a shorthand expression for "is a good y," where this variable ranges over species (types or genres) or works of art. In either case, Jones is, as usual, one variable ahead of him, insisting that for the expression

(5) "x is a good y"

to be complete, still one more variable must be supplied, even if it gives us a triadic predicate:

(6) "x is a good y with respect to z,"

--where, as I said earlier, z ranges over individual people or groups of people.

But now it is time to apply the lessons that we learned earlier in discussing hunger. For Jones the relativist cannot stop at this point, after making a bare claim. He must answer a few questions for us.

First, then, why cannot we be content to leave (5) as it is, and regard it as perfectly complete without further reconstruction or remodelling? The relativist
must begin by giving us the name of an artwork which can be substituted for x in (5), so that (5) turns out to be both true and false. He might, for example propose:

(7) Jackson Pollock's Autumn Rhythm is artistically good (or, a good painting).

(8) Jackson Pollock's Autumn Rhythm is not artistically good (or, a good painting).

Now, the relativist has to show us how both (7) and (8) can be true, though contradictory. This is tantamount to deciding what kind of relativist he wants to be—that is, what is the range of the variable he proposes to introduce as another place in the predicate. Does he claim, for example, that Autumn Rhythm was not artistically good when it was first painted in the 1950s, but after 1960 it was artistically good? Or that it is good in the United States but not, say, in Soviet Russia, where nonrepresentational art is officially (and no doubt popularly) condemned? Or that it is good in the West, but not in a very different cultural setting—say, Saudi Arabia, or Thailand, or among the Bantu? Or that it is good in relation to one art critic but not in relation to another (Beardsley, 267)?

2. When Henry opens his heart to Prince Hal in III.ii of Part One, he seems uncertain whether to associate [himself] with the pilgrim's lowliness—in Richard's time, he says, he "dress'd himself in such humility" (III.ii.51)—or with High-Church pomp—he also at that time kept "[his] presence like a robe pontificial" (l. 56). But is is remarkable how in this scene the King's longest, most impassioned, and most reminiscent speech follows immediately after his son uses a certain metaphor: "My youth," says Hal, "hath faulty wand'red and irregular" (l. 27). In the King's reproaches to Hal we are given an indication of how difficult, if not impossible, it is for Henry IV to move forward—forward, that is, not just to his crusade but from the great and terrible event of his life, the displacement of Richard. Richard was "the skipping King [who] ambled up and down" (l. 60) while Henry, he says, was "like a comet" (l. 47): doubtless some wish is expressed here to move serenely above all the plodding, marching, by-path dodging, skipping, and ambling. But Richard will not be dismissed as the trivial fellow who deserved to be overthrown; to Henry's dismay, he seems to be living on in Hal. It is in this scene that we glimpse both the extent and the delimiting nature of Henry's obsession with the memory
of Richard. His appeal to Hal to be more like him (the King) reveals that in Henry's eyes there are only two kinds of king and indeed only two kinds of man, Henry and Richard. He asks his son which one he is going to be, and he completely misses the splendid answer, which is "Neither":

Prince. I shall hereafter, my thrice gracious lord,  
Be more myself [my italics].

King. For all the world  
As thou art to this hour was Richard then  
When I from France set foot at Ravenspurg,  
And even as I was then is Percy now.  

(III.ii.92-96)

It is not surprising that Henry finds it difficult to grasp that Hal would be himself. The man who in Richard's time stole all courtesy from heaven and dressed himself in such humility, the man who disguises others to look like him at Shrewsbury, seems fated never quite to be himself. He is always envying or emulating (or both) someone else. Touched with Cain's guilt in the murder of his cousin Richard, Henry would make some acceptable offering in redemption and so has decided on the crusade. Expiating the sin in the way that Norfolk did his, Bolingbroke would imitate Norfolk's glory and peace. It is no wonder that his prescription for his son is that Hal should turn into Hotspur.

IV

Henry's imaginative brooding on Richard becomes more and more intense, especially as Richard himself has, by Part Two, changed into a martyr, a relic whose blood is "scrap'd from Pomfret stones" (2 Henry IV, I.1.205), and in Henry's own eyes a prophet (Black, 23,24).

3. If a framework like this (with or without the suggested special proposal for 'justified') is correct for moral language in general, it is obvious that all moral terms have close affinities. For the claim just is that every moral statement can be construed, at least roughly and as a first approximation, to affirm that the moral code (motivational and emotional dispositions) justified for the society of the agent requires/permits/prohibits something. (The motivational/emotional dispositions have been depicted so far as dispositions directed at acts or agents in view of their acts--sometimes, viz., in the case of
guilt feelings, the agent being the person who has the attitude, but we shall see shortly that there are other possible directions.) It follows from this view of moral language in general that 'has a moral right to' must be construed as functioning to claim that some emotional motivational dispositions, partly constitutive of the moral code of a society, are justified.

Reasoning from some meta-ethical thesis about moral language in general to a conclusion about rights language may seem dubious. But the reasoning appears not so shocking, or at least not very novel, when we consider some recent meta-ethical theories. Charles Stevenson did not develop a theory of rights language, but since he held that moral language expresses moral approval or disapproval and that moral approval and disapproval are the only moral attitudes, presumably he would construe rights talk as expressive of the same thing, in one way or another. Much the same may be said of the prescriptivist theory of R. M. Hare. Hare regards moral statements as primarily prescriptions, expressing desires and other motivational/emotional attitudes, directed at agents. Right language, as he makes explicit in his recent book, can be construed only in a similar fashion, and accordingly he regards 'a moral right to' as definable in terms of 'moral obligation'. Much the same may be said of the ideal-observer theory. Moral terms are construed by it as assertions that an 'ideal observer' would have an attitude of approval or disapproval toward something, or experience a 'requiredness-characteristic' in connection with it. If we reflect on how the ideal-observer theory might construe moral-rights language, it appears that there are no plausible options other than to construe it, roughly, in terms of the approval/disapproval (etc.) of the 'ideal observer' toward someone or some act. Even a nonnaturalist, who thinks that 'duty' or 'is right' or 'fitting' designates a simple property, will presumably at least want to define 'has a right to' in terms of this property, in order to avoid a proliferation of simple properties.

If we think that all moral terms have close affinities, in the sense of being adequately construed in terms of roughly a common conceptual framework, it will not be surprising that many philosophers have thought that "X has a moral right to Y against Z" can be explained roughly as "Z has a moral obligation to X with respect to Y" (Brandt, 33-34).

4. Such pessimism and determinism have no part in the world-view of authors writing in the Comic mode.
Whether they write in the "high" Comic modes of comedy or the "low" Comic modes of vaudeville, "Tableau grivois," and "apropos historique," Comic dramatists, like White's Organicist historians, are basically optimistic. They "tend to structure their plays in such a way as to depict the consolidation or crystallization, out of a set of apparently dispersed events, of some integrated entity whose importance is greater than that of any of the individual entities analyzed or described in the course of the [drama]" (p. 15). But since Comic dramatists are "more interested in characterizing the integrative process than in depicting its individual elements" and since Comic dramas "are given their structure and formal coherence as explanations of . . . processes . . . " (both p. 16; emphasis in the original), works cast in the Comic mode tend to present the past in largely abstract terms. What this means is that in Comic dramas we are likely to encounter typed rather than historically individualized characters and events. In such plays everything exists to prepare the conclusion, and each play reproduces in miniature the integrative tendencies of history in general. Dramatized historical incidents thus serve as synecdochic exemplars of a positive historical process.

Comic representations of the reign of Henry IV provide ideal illustrations of the integrative tendencies of history and Comedy. The three-act prose comedy Henri IV et d'Aubigné (1814), by Michel Nicolas Balisson de Rougemont and René Perrin, begins on a disruptive note. Under pressure from the Queen, the Queen Mother, and the Chancelier de Birague, Henri IV reluctantly exiles his good friend d'Aubigné from the court. But the public disgrace of the soldier-poet is softened by a private agreement which sends d'Aubigné to the nearby estate of M. de la Rochefoucault. As it turns out, d'Aubigné is in love with de la Rochefoucault's niece and ward, Suzanne de Lezey, and she loves him, although her uncle intends to marry her to M. Dampierre. By the end of the play, Henri IV is reunited with d'Aubigné, whose marriage to Suzanne is assured by his obvious return to the king's favor, and courtiers, peasants, and soldiers all join in a gala celebration of the wedding and Henri's reign. La Fête du Béarnais, tableau villageois, en un acte, mêlé de vaudevilles (1817), by Émile Cottonet and Charles Hubert, features other characters and other conflicts, but ends on much the same note—the celebration of an impending marriage and of the fête of good King Henri IV. Thus, within these plays, personal and national
unions are jointly celebrated, individual and collective happiness simultaneously proclaimed (Cooper, 27-28).

5. At the other end of the spectrum were the Zealots, Essenes, Covenanters of the Dead Sea, and their allies who interpreted their secular relationships in terms of apocalyptic and direct action. For these, the Romans were the idolatrous nation, the heathen oppressors for whom Armageddon was being prepared, and whose demands for tribute must be defied, for tribute was payable to God and his servants alone.28 One other feature of the Essenes as described by Philo (Quod omnis probus liber sit 79) was that they rejected slavery as an affront to natural justice, and that they possessed no slaves themselves.29 Significantly, these Essenes also despised urban life and the whole Temple set-up centered on Jerusalem. Theirs was a rural and agricultural economy based on communal living, and their social and religious outlook contrasted with that of their fellow Jews in the empire.30 These had come to accept the privileged status of city dwellers, even though, as the writers of the Sibylline Oracles books 3 and 4 show, they could be just as blistering in their hostility to Rome and its empire as the Zealots themselves.

Moments of crisis apart, the outlook of the articulate majority, represented by the Pharisees, whether in Palestine or the Dispersion, was a good deal less extreme. They were prepared to accept the Romans as a necessary evil for the maintenance of civil peace until the Messiah should come.31 Jesus, they had regarded as a "false prophet" (e.g., Deut 18:21) who had deserved his fate. While the Jews and Judaism, therefore, might represent an element of opposition to the religion and much of the tradition of the Greco-Roman state which the Roman authorities feared, they posed no threat to its basic social institutions, such as slavery. With the notable exception of the Zealots, they did not threaten the social and political order accepted in the ancient world. Least of all did they think of rousing the ninety percent or so of "barbarians" in the countryside with revolutionary ideas against the city-dwellers who exploited them. In the Dispersion their social ideals were those of Tobit and Ecclesiasticus, i.e., moral uprightness, scrupulous almsgiving, hospitality to strangers, care of the Jewish widow and orphan, and burial of the dead. These requirements were represented to the letter in the Christian Apology of Aristides (ca. 140).32 At the same time, there must be separation from the Gentiles, while
providing an example of righteousness before them (Frend, 57-58).

6. With slight variations in tense and reference, the refrain of "Prothalamion" is "Against the wedding day which is not long;/Sweete Themmes ronne softly till I end my song." While the second line is not a hexameter, as in "Epithalamion" (unless one pronounces the final e's in "Themmes" and "ronne"), it has somewhat the same effect, being one of the slowest and most fluent verses in all English poetry. The couplet as a whole builds on the contrast between the climactic awareness of time leading up to the marriage ceremony and the gentler time frame implied by the flowing Thames, as well as the more uncertain temporality of the poet's own song. The poet sets out to reconcile the sense of climax and the sense of flow, to unite them in a marriage larger than the historical event that occasions the poem. For as the poem progresses, the marriage itself becomes the axis of a number of unusual anxieties—related to Spenser's personal loss of patronage (st. 1), the excessive purity of the swans (st. 3), references to Jove's rape of Leda (st. 3) and to the fallen condition of the Knights Templar (st. 8)—and the happy expectation of the nuptial rites is marred by a strange fear. A portion of the poet's consciousness seems to be writing the poem not "against" (in preparation for) but "against" (in resistance to) the wedding day, as if with an obscure foreboding that the ineluctable moment of marriage will be not so much a joining as a rupture, a sudden break with the past and a destruction of all future hopes. In "Spenser's 'Prothalamion'," Harry Berger, Jr., analyzes these darker layerings of the poem in great detail and concludes that Spenser overcomes his anxieties only when he can see the marriage as the promise of an ongoing, imaginative transformation of actuality rather than as a singular event. One of Spenser's strategies is to elide the crisis, for in the closing stanza the marriage anticipated throughout the preceding lines is suddenly spoken of in the past tense, as already consummated and thus domesticated within the calmer time consciousness of retrospection. In the refrain itself, the main symbolic agent of this transformation is the river Thames, an image of natural power and continuity that relieves the mounting fears registered in the proleptic vision of the "against" line, a therapeutic repetition that counters the neurotic or compulsive one. The Thames (=times) also serves as a measure of the poet's own literary continuity, and Geoffrey Hartman fittingly invokes the
refrain of "Prothalamion" as a precedent for the antialiapocalyptic implications of Wordsworth's water and river imagery. He points out that Spenser's refrain "indicates by its steady return how much time is at man's disposal, how everything will flow along in order and degree, and how the world is too well established on the flood for any 'end' to be feared" (268). One must add, however, that the poem's concluding repetition of the unaltered line "Against the wedding day which is not long" obscurely points beyond the already accomplished historical wedding toward an occulted, apocalyptic union.

"Epithalamion," too, as A. Kent Hieatt has shown, presents the marriage of ceremonial and natural temporality; it recovers what Spenser wonderfully calls "that sweet paradise of day and night." The mythological and numerological materials of the poem undoubtedly set the marriage celebration within a cosmic frame, but the refrain itself, not unlike that of "Prothalamion," also limits the movement toward the transcendence of ordinary, successive time. For the final hexameter of each refrain diffuses the pressure of the moment, securing for the poet not only a ritualized time but an expansive, numinous, yet grounded space (again, "that sweet paradise of day and night") (Gross, 24-25).

7. Throughout the Legend of Cleopatra, the narrator attempts to suppress his heroine's reputed lust and aggressiveness; as Frank puts it, the infamous queen here becomes "a gentle, timorous creature, properly passive and colorless." The first five lines of the Legend identify her only as the successor to a male ruler and imply by omission that her reign was an uninteresting and irrelevant interlude between the death of one man and the arrival of the next:

After the deth of Tholome the kyng,
That al Egipt hadde in his governyng,
Regned his queene Cleopataras;
Tyl on a tyme befel there swich a cas,
That out of Rome was sent a senatour. . . .
(ll 580-84)

It is not unreasonable to expect that a fourteenth-century audience would recall here that Tholome died because Cleopatra poisoned him, and that before Antony arrived she had an affair with another important Roman; the narrator clumsily attempts to gloss over these facts because he understands that conventional medieval ideals for women demand a more passive figure than the "historical" Cleopatra.
Moreover, as poet and as man, this narrator is simply more excited about the world of politics and war than about the woman whose story he has been coerced into telling. He continues to focus on Antony's career rather than on Cleopatra's (see ll. 587-605); he uses occupatio (ll. 616-23) in order to devote almost thirty lines (or one-fifth of the whole Legend) to the battle of Actium, celebrated in a richly alliterative passage as a fourteenth-century naval engagement (ll. 624-52). Here Cleopatra is mentioned only once, in line 632, as "his [Antony's] wif." Her Legend is two-thirds over, in fact, before the narrator turns to its heroine, and then we are shown that her only acts are to run away "for drede" (l. 664), to bury her lover in a shrine made of rubies, and to commit suicide. Cleopatra's first and last words in the poem (ll. 681-95) reveal her concern with her reputation vis-à-vis Antony. She asserts as if to futurity that she has fulfilled her "wyfho" (l. 691) and her "covenant" (l. 693) with Antony; "and that shal ben wel sene, /Was nevere unto hire love a trewer quene" (ll. 694-95).

The narrator himself has the last word in this story, and uses it to bring us back to the subject of men:

And this is storyal soth, it is no fable.
Now, or I fynde a man thus trewe and stable,
And wol for love his deth so frely take,
I preye God let ooure heedes nevere ake!
(ll. 702-705)

His words ironically remind us to question the "storyal" nature of his rendering—the medievalized sea battle, for instance, is just one of many obvious departures from historical truth that might undermine his claim and make us read the legends as "fable" indeed, highly colored by the personal and time-bound perspective of this narrator. And one indisputable piece of historical evidence that the narrator does include, the fact that Antony committed suicide first (in ll. 657-62), also undercuts his final comment; he has already found, and shown us, a man who took his death for love (at least as much as Cleopatra did).

The comic, antiheroic, unromantic tone of the last line supports what we may have begun to suspect in the Prologue: the narrator here is much like that blundering jolly innocent we meet in so many of Chaucer's works. Following Cupid's instructions, he has tried to make Cleopatra fit the image of the good woman available in the clerical and courtly tradition. Passive, obedient, timid, subordinate, and devoted to
"wyfhod," in his version of her life she is able to act only in the last resort, to kill herself for love, "with good cheere" (l. 700) (Hansen, 15-18).

8. Both poems express Marcabru's criticism of what he saw as the social and moral disorder of human society, which he contrasts in Poem XXXVIII with the cleansing and purifying effected by winter in the natural world, and in Poem XXXI with the honourable order which would result from bon'Amors, if only men would follow that path. Instead;

Cazen levan trobaiola
Va.1 segles . . .
(XXXVIII, 36-37)

('The world of men heaves up and down in turmoil'
(Topsfield, p. 77.).)

Men are governed by Amars and behave in response to the impulses of lust.

In both cases the social and moral corruption is exemplified by the adulterous relationship of si dons and her lover. Although one is not always justified in assuming that troubadour fin'amors is essentially adulterous," as far as Marcabru is concerned there is often no doubt that the lovers he is criticizing are married, and in many of his poems he explicitly condemns adulterous promiscuity. It is possible to conclude from several indications in the texts of Poems XXXI and XXXVIII that the relationship is adulterous, and that the lover is probably a social inferior. These indications establish a context which could form the basis of a reinterpretation of the expression si dons as Marcabru uses it.

Whereas it is possible that Marcabru is using allusions to low-born lovers in a figurative way, in order to suggest that such men are vilan in a courtly rather than a social sense, this interpretation does not appear to suit so well those passages mentioning the man's work, and the various social consequences of his liaison.

In Stanzas 4 and 5 of Poem XXXVIII Marcabru describes a journeyman, a lowly hired labourer who 'fai de nuocht son jornau' (l. 33). He sires an illegitimate son 'through whom he lords it over everyone'. If the begetter of this son were himself a nobleman, this consequence would not be worthy of mention. Moreover, this passage echoes a theme expressed elsewhere in Marcabru's poems, that of the
adulteration of the noble blood of the ruling classes through the illegitimate offspring of such irregular, adulterous unions. Not only is the purity of the bloodline contaminated, but the bastard children lack the courtly qualities associated with the nobility; they are unworthy successors to power and influence, presiding over and incarnating the decline of Fœizia and the other virtues which Marcabru so often laments. That the extra-conjugal lover of Poem XXXVIII has the opportunity thus to lord it over everyone is clearly unnatural and deplorable.

The theme of mésalliance is again found in Poem XXXI. Marcabru criticizes the domna 'c'ama girbaut de maiso' (l. 46). In associating with an ill-bred, ill-mannered household servant, she does not act in accordance with the principles and elevated requirements of fin'amors (Harvey, 25-26).

9. The balance of court influence and country interest had resulted in a perfect solution to the dispute, and if carried out would have given both sides what each wanted. Unfortunately, solutions were never easy in fen drainage disputes. At the instigation of the gentlemen of South Holland, the commissioners had ordered that the sluice at Whaplode be rebuilt. The new sluice lasted only a month before collapsing. Without it the repair of the existing drainage system would not result in a favourable survey. Carleton's opponents, therefore, sued out a new general commission of sewers, superseding the special one. Carleton claimed that the purpose of the new commission was to prevent him from benefiting from the provisions of the law of October 1582 and to discourage him from attempting to drain the country. The gentlemen of South Holland, however, put forward a different explanation. The general commission was renewed because the special commission had discharged the lands on the south side of the Ravensdyke from maintaining banks 'of the greatest charge and most needful for the state of the whole country, rather than for the preventing of Carleton's action'. On 28 February 1583 the new commission was executed at Boston. There the commissioners enacted a law 'for the renewing, reviving, and continuance of all former laws, as well general as special, which heretofore have been established . . . for the preservation and safeguard of all parts of Holland.' The commissioners also ordered that the main sewers of Moulton, Whaplode, and Holbech should be repaired and the sluice at Whaplode rebuilt. But despite the gentlemen of South Holland's later assertion that the law of October 1582
was confirmed by that of February 1583, there were two significant omissions. There was no mention of any exemption of the lands south of the Ravensdyke from contributing to the cost of the repairs. Nor was there mention of the survey (Kennedy, 19).

10. In practice, the Act of 1870 was less than a halfway measure. But despite its shortcomings, the act was of fundamental importance. This was true not because of any benefits extended to the tenants but because of what the act implied. Its stipulation that improvements were considered to have been made by the tenant, unless proven otherwise, and its acceptance of the tenant's right to compensation for disturbance were highly significant. Parliament had given tacit recognition that the tenant had a certain property in his holding. The creation of this interest was to be one of the chief topics of contention during the debate over the Compensation for Disturbance Bill in 1880. Gladstone and many of those who supported the Act of 1870 failed to realize its far-reaching character, however, until confronted by the return of agricultural distress. The period 1870-76 was marked by good weather, high prices, and prosperity. At least farmers holding large- and middle-sized farms enjoyed prosperous times.

Bad weather resulted in poor crops in 1877 and the cycle continued during the next few years, reaching a peak in 1879-80. The period of crop failures coincided with the start of the great increase in British imports of butter and butter substitutes from Holland, Scandinavia, and France which resulted in a virtual collapse of Irish butter prices. The sharp increase in grain imports from the United States during the 1870s also provided a major contribution to the prevailing distress. This prevented Irish farmers from gaining the higher prices which had previously helped offset the effects of crop failures. Small farmers and cottiers whose share of the earlier prosperity had been marginal were hardest hit by the return of bad times. Many larger farmers also suffered decreased incomes which they found especially hard to accept after the prolonged period of prosperity (Michael Lyons, 171-72).
APPENDIX 2: ANALYSIS OF A SAMPLE

(1) The general measurement procedure for this project consisted of the attachment of strain-gage rosettes on the exterior surface of the steam generators. (2) Six rosettes were uniformly spaced around the circumference and at the midlength of the small diameter shells (as shown in Fig. 2). (3) All four steam generators attached to one drum were instrumented. (4) From sets of measurements taken during various operating conditions, the stresses at the rosette locations were required to be calculated. (5) Then from these stresses, three force parameters and three moment parameters were calculated for each steam generator for each unit condition. (6) These forces and moments were reactions carried through the steam-generator shells and were considered to act through a single point—the intersection of the horizontal plane of the strain gages and the vertical axis of the steam generator. (7) By means of piping and finite-element programs, the bending stresses in the juncture areas could then be calculated from the force and moment measurements. (8) There were two significant obstacles in performing the measurements to obtain the required information. (9) The major difficulty centered on the general requirement that the strain-gage reading had to be compensated for the thermal-expansion data on the steam-generator steel. (10) This was seen as a formidable problem considering that no accurate thermal-expansion data on the steam-generator steel could be obtained and that in situ calibration of strain gages to compensate for this effect was not possible. (11) An appreciation of this problem may be gained by considering that the thermal expansion of the instrumented steel over the measurement temperatures (25°C to 260°C) would be about 3000 μm/m (based upon handbook data), whereas it was estimated that the stress-induced strains (the required data) would likely be on the order of about 300 μm/m. (12) If the
handbook thermal-expansion data were in error by only ±5 percent—which would be quite possible—the unknown component in apparent strain would be ±150 μm/m, which would totally invalidate the calculation of stress. (13) The second major difficulty in measurement performance centered on the requirement to obtain only the components of stress which were related to mechanical loads (i.e. forces and moments). (14) During the measurements, unknown through-wall gradients would occur which would result in an unknown component of stress on the outside instrumented surface of the steam generators. (15) Although these through-wall thermal stresses would not be related to mechanical loads, they would affect the strain-gage readings to an unknown extent (Flaman and Shah, 11).

There are 397 words in this sample, with an average of 26.5 words per sentence. There are 15 T-units, the same as the number of sentences; consequently, there are also 26.5 words per T-unit.

There are 97 nouns in the passage: procedure, project, attachment, rosettes, surface, generators, rosettes, circumference, midlength, shells, Fig. 2, generators, drum, sets, measurements, conditions, stresses, locations, stresses, parameters, parameters, generator, condition, forces, moments, reactions, shells, point, intersection, plane, gages, axis, generator, piping, programs, stresses, areas, measurements, obstacles, measurements, information, difficulty, requirement, reading, data, steel, this, problem, data, steel, calibration, gages, effect, appreciation, problem, expansion, steel,
temperatures, 25°C, 260°C, µm/m, data, it, strains, data, order, µm/m, data, percent, which, component, strain, µm/m, which, calculation, stress, difficulty, performance, requirement, components, stress, which, loads, forces, moments, measurements, gradients, which, component, stress, surface, generators, stresses, loads, they, readings, extent.

The NWQ is .24

There are 28 verbs, 13 of which are passive: consisted, were spaced (p), were instrumented (p), were required (p), were calculated (p), were, were considered (p), could be calculated (p), were, centered, had to be compensated (p), was seen (p), could be obtained (p), was, may be gained (p), would be, was estimated (p), would be, were, would be, would be, would invalidate, centered, were related (p), would occur, would result, would be related (p), would affect.

It should be noted that some grammarians might consider had to be compensated as a verb had plus an infinitive to be compensated. This reading, however, would seem to make the verb active, with the subject reading seen as agent. This is clearly a distortion of the meaning. Further, had to be is parallel in construction to must be, the only difference being that the former is past tense. Since the modal auxiliary must is already past in form, though not in meaning,
there is no way to express its past tense except to paraphrase it as had to. The verbs of the passage are thus 46.4% passive.

The VWQ is .07.

There are 15 adjectives in the passage: general, exterior, small, various, horizontal, significant, major, general, formidable, accurate, thermal, major, unknown, unknown, unknown. There are 4 adverbs: uniformly, then, likely, totally. The ratio of nouns and verbs to adjectives and adverbs is 6.58 to 1.

There are 18 nominalizations: attachment, measurement, locations, reactions, intersection, piping, measurements, measurements, requirement, reading, calibration, appreciation, expansion, calculation, performance, requirement, measurement, readings. Nominalizations thus comprise 18.6% of the nouns in the passage.

There are 9 SVO or SVC sentences, 60% of the total. The other 6 sentences begin with introductory material.

For convenience, the syntactic chunks and propositions are given by sentences.

1. There are seven syntactic chunks in sentence 1:

   1. the general measurement procedure
   2. for this project
   3. consisted
   4. of the attachment
   5. of strain-gage rosettes
6. on the exterior surface
7. of the steam generators

There is one major closure at the end of the sentence.

There are 11 propositions:

1. consisted of, procedure, attachment
2. measurement, procedure
3. general, procedure
4. for, project
5. this, project
6. of, attachment, rosettes
7. strain-gage, rosettes
8. on, surface
9. exterior, surface
10. of, generators
11. steam, generators

2. There are eight syntactic chunks in sentence 2:

1. six rosettes
2. were uniformly spaced
3. around the circumference
4. and
5. at the midlength
6. of the small diameter shells
7. as
8. shown in Fig. 2

There is one major closure at the end of the sentence.

There are 11 propositions:

1. were spaced, rosettes,
2. six, rosettes
3. uniformly, 1
4. around, circumference
5. at, midlength
6. and, 4, 5
7. of, shells
8. diameter, shells
9. small, diameter
10. shown in, Fig. 2
11. as, 10
There are three syntactic chunks in sentence 3:

1. all four steam generators
2. attached to one drum
3. were instrumented

There is one major closure at the end of the sentence.

There are six propositions:

1. were instrumented, generators
2. steam, generators
3. four, 2
4. all, 3
5. attached to, drum
6. one, drum

4. There are six syntactic chunks in sentence 4:

1. from sets
2. of measurements
3. taken during various operating conditions
4. the stresses
5. at the rosette locations
6. were required to be calculated

There is one major closure at the end of the sentence.

There are ten propositions:

1. to be calculated, stresses
2. were required, 1
3. from, sets
4. of, measurements
5. taken, measurements
6. during, conditions
7. operating, conditions
8. various, 7
9. at, locations
10. stress, locations

5. There are eight syntactic chunks in sentence 5:

1. then
2. from these stresses
3. three force parameters
4. and
5. three moment parameters
6. were calculated
7. for each steam generator
8. for each unit condition

There is one major closure at the end of the sentence.

There are 16 propositions:

1. were calculated, parameters
2. force, parameters
3. three, 2
4. were calculated, parameters
5. moment, parameters
6. three, 5
7. and, 1, 4
8. then, 7
9. from, stresses
10. these, stresses
11. for, generator
12. steam, generator
13. each, 12
14. for, condition
15. unit, condition
16. each, 15

6. There are 14 syntactic chunks in sentence 6:

1. these forces
2. and
3. moments
4. were reactions
5. carried through the steam generator shells
6. and
7. were considered to act
8. through a single point
9. the intersection
10. of the horizontal plane
11. of the strain gages
12. and
13. the vertical axis
14. of the steam generator

There is one major closure at the end of the sentence.

There are 23 propositions:
1. were, forces, reactions
2. were, moments, reactions
3. and, 1, 2
4. these, forces
5. these, reactions
6. carried, reactions
7. through, shells
8. steam-generator, shells
9. were considered to act, 4
10. were considered to act, 5
11. and, 9, 10
12. through, point
13. single, point
14. point, intersection
15. of, plane
16. horizontal, plane
17. of, gages
18. strain, gages
19. of, axis
20. and, 15, 20
21. vertical, axis
22. of generator
23. steam, generator

7. There are five syntactic chunks in sentence 7:

1. by means of piping and finite-element programs
2. the bending stresses
3. in the juncture areas
4. could then be calculated
5. from the force and moment measurements

There is one major closure at the end of the sentence.

There are 13 propositions:
1. could be calculated, stresses
2. by means of, piping
3. by means of, programs
4. and, 2, 3
5. finite-element, programs
6. bending, stresses
7. in, areas
8. juncture, areas
9. then, 1
10. from, measurements
11. force, measurements
12. moment, measurements
13. and, 11, 12
8. There are four syntactic chunks in sentence 8:
   1. there
   2. were two significant obstacles
   3. in performing the measurements
   4. to obtain the required information

   There is one major closure at the end of the sentence.

   There are six propositions:
   1. were, obstacles
   2. significant, obstacles
   3. two, obstacles
   4. in performing, measurements
   5. to obtain, information
   6. required, information

9. There are eight syntactic chunks in sentence 9:
   1. the major difficulty
   2. centered
   3. on the general requirement
   4. that
   5. the strain-gage reading
   6. had to be compensated
   7. for the thermal-expansion data
   8. on the steam-generator steel

   There are two major closures, one after requirement, and one at the end of the sentence.

   There are nine propositions:
   1. centered on, difficulty, requirement
   2. major, difficulty
   3. general, requirement
   4. had to be compensated, reading
   5. for, data
   6. thermal-expansion, data
   7. on, steel
   8. steam-generator, steel
   9. that, 4

10. There are 13 syntactic chunks in sentence 10:
    1. this
    2. was seen
    3. as a formidable problem
4. considering that
5. no accurate thermal-expansion data
6. on the steam-generator steel
7. could be obtained
8. and
9. that
10. in situ calibration
11. of strain gages
12. to compensate for this effect
13. was not possible

There are three major closures, one after problem, one after obtained, and one at the end of the sentence.

There are 18 propositions:

1. was seen as, this, problem
2. formidable, problem
3. could be obtained, data
4. accurate, data
5. thermal-expansion, data
6. no, data
7. on, steel
8. steam-generator, steel
9. considering that, 3
10. was possible, calibration
11. not, 8
12. in situ, calibration
13. that, 8
14. and, 11, 7
15. of, gages
16. strain, gages
17. to compensate for, effect
18. this, effect

11. There are 20 syntactic chunks in sentence 11:

1. an appreciation
2. of this problem
3. may be gained
4. by considering
5. that
6. the thermal expansion
7. of the instrumented steel
8. over the measurement temperatures (25°C to 260°C)
9. would be
10. about 3000 μm/m
11. based upon handbook data
12. whereas
13. it
14. was estimated
15. that
16. the stress-induced strains
17. the required data
18. would likely be
19. on the order
20. of about 300 μm/m

There are three major closures, one after data, one after estimated, and one at the end of the sentence.

There are 23 propositions:

1. may be gained, appreciation
2. of, problem
3. this, problem
4. would be, expansion, μm/m
5. 3000, μm/m
6. about, 5
7. by considering that, 4
8. of, steel
9. instrumented, steel
10. thermal, expansion
11. over, temperatures
12. measurement, temperatures
13. 25°C to 260°C, temperatures
14. based upon, data
15. handbook, data
16. was estimated, it
17. would be, strains
18. whereas, 16
19. that, 17
20. on, order
21. of, μm/m
22. 300, μm/m
23. about, 22

12. There are 13 syntactic chunks in sentence 12:

1. if
2. the handbook thermal-expansion data
3. were in error
4. by only ±5 percent
5. which
6. would be quite possible
7. the unknown component
8. in apparent strain
9. would be ±150 μm/m
10. which
11. would totally invalidate
12. the calculation
13. of stress

There are two major closures, one after 150 μm/m,
and one at the end of the sentence.

There are 17 propositions:

1. were in, data, error
2. if, 1
3. thermal-expansion data
4. handbook, data
5. by, percent
6. ±5, percent
7. only, 6
8. would be possible, which
9. quite, 8
10. would be, component, μm/m
11. unknown, component
12. ±150, μm/m
13. in, strain
14. apparent, strain
15. would invalidate, which, calculation
16. totally, 15
17. of, stress

13. There are 10 syntactic chunks in sentence 13:

1. the second major difficulty
2. in measurement performance
3. centered
4. on the requirement
5. to obtain only the components
6. of stress
7. which
8. were related
9. to mechanical loads i.e. forces and moments

There are two major closures, one after stress,
and one at the end of the sentence.
There are 14 propositions:

1. centered on, requirement, difficulty
2. major, difficulty
3. second, difficulty
4. in, performance
5. measurement, performance
6. to obtain, requirement, components
7. only, components
8. of, stress
9. were related to, which, loads
10. mechanical, loads
11. are, loads, forces
12. are, loads, moments
13. and, 11, 12
14. i.e., 13

14. There are nine syntactic chunks in sentence 14.

1. during the measurements
2. unknown through-wall gradients
3. would occur
4. which
5. would result
6. in an unknown component
7. of stress
8. on the outside instrumented surface
9. of the steam generators

There are two major closures, one after occur, and one at the end of the sentence.

There are 11 propositions:

1. during, measurements
2. would occur, gradients
3. unknown, gradients
4. through-wall, gradients
5. would result in, which, component
6. unknown, component
7. of, stress
8. on, surface
9. instrumented, surface
10. of, generators
11. steam, generators

15. There are 8 syntactic chunks in sentence 15:

1. although
2. these through-wall thermal stresses
3. would not be related
4. to mechanical loads
5. they
6. would affect
7. the strain-gage readings
8. to an unknown extent

There is one major closure at the end of the sentence.

There are 11 propositions:

1. would be related to, stresses, loads
2. not, 1
3. although, 2
4. thermal, stresses
5. through-wall stresses
6. these, stresses
7. mechanical, loads
8. would affect, they, readings
9. strain-gage, readings
10. to, extent
11. unknown, extent

There are 54 different arguments in the passage:
procedure, project, attachment, rosette, surface, generator, circumference, midlength, shell, Fig. 2, drum, set, measurement, condition, stress, location, parameter, diameter, force, moment, reaction, shell, point, intersection, plane, gage, axis, piping, program, area, obstacle, information, difficulty, requirement, reading, data, steel, problem, calibration, effect, appreciation, expansion, temperature, μm/m, strain, calculation, performance, component, load, gradient, order, error, percent, extent.

There are a total of 199 propositions in the
passage, 3.69 propositions for each argument.

There are 136 syntactic chunks in the passage, and 22 major closures, 6.18 chunks per closure.