2

The Challenges of Reading Disciplinary Texts

Zhihui Fang

As students move from elementary to middle and high school, the curricular content they are expected to engage with becomes increasingly specialized and complex. This content is typically presented in academic texts that students often find difficult to comprehend and challenging to critique. The 2007 National Assessment of Educational Progress, for example, reports that fewer than one-third (27%) of 8th graders were able to demonstrate an overall understanding when reading texts with grade-level-appropriate content (Lee, Grigg, & Donahue, 2007). Leading literacy organizations (e.g., Alvermann, 2001; Biancarosa & Snow, 2004; Heller & Greenleaf, 2007; Moore, Bean, Birdyshaw, & Rycik, 1999) have recognized the situation, calling for greater attention to adolescent literacy and urging educators to continue reading instruction beyond the elementary grades. What is it about academic texts in secondary content areas that makes them demanding to read for adolescent learners, many of whom have been successful in elementary reading? This chapter identifies some of the linguistic challenges involved in reading academic texts in the key secondary subjects of science, mathematics, and history. An understanding of the linguistic issues involved in reading disciplinary texts can make an important contribution to the improvement of teaching and learning in content areas.

LANGUAGE, KNOWLEDGE, AND DISCIPLINARY LITERACIES

Academic texts in the secondary curriculum are constructed in patterns of language that differ significantly from those that construct the texts students typically read in the elementary school. This difference is a major source of reading difficulty for adolescents. In the elementary grades, students are exposed primarily to everyday knowledge, and the texts they read typically deal with topics that are near and dear to them and with events that occur at specific times and places. The language that constructs such knowledge is, thus, commonsense, close to the language students use in everyday spontaneous conversation with friends, family members, and others with shared experiences and communal understanding. In secondary schools, students are exposed to more advanced, abstract, and complex knowledge, which they are expected to not only assimilate and reproduce but also question and critique. The language used to construct and challenge this specialized knowledge thus becomes more technical, dense, abstract, and hierarchically structured. In this literacy development trajectory, students are expected to develop increasingly sophisticated control over language during the school years, moving from the language of everyday talk to the language for construing and challenging disciplinary knowledge (Christie, 1998; Halliday, 2007; Schleppegrell, 2004).

Not only is the language of secondary schooling distinct from that of elementary schooling, it also varies from one content area to another (Fang & Schleppegrell, 2008, 2010). In science, for example, what we recognize as empirically sound, objective, and authoritative is often expressed in language patterns that are technical and dense and that promote certain ways of thinking and reasoning about the natural world. In history, what is perceived to be uncontroversial fact is often colored by judgment and interpretation. Such judgment and interpretation are often construed in abstract language that effaces the role of the historian as recorder, interpreter, and adjudicator of the past (Coffin, 2006). In mathematics, meanings are constructed in technical and dense language that works in close partnership with visual images and mathematical symbolism. These linguistic differences reflect the fundamental differences in the ways different disciplines produce, communicate, and critique knowledge.

Given the distinct ways different academic disciplines use language to make their own meanings, students need to develop differentiated literacy skills and strategies for interacting with the texts of each discipline. As Unsworth (2001) has argued, "It is no longer appropriate to talk about 'literacy across the curriculum.' Instead there is a need to delineate 'curriculum literacies,' specifying the interface between a

specific curriculum and its literacies rather than imagining there is a singular literacy that could be spread homogeneously across the curriculum" (p. 11). This view of disciplinary literacies has gained currency in recent scholarship on adolescent literacy (e.g., Fang & Schleppegrell, 2008, 2010; Moje, 2008; Shanahan & Shanahan, 2008).

The notion of "commonsense" versus "uncommonsense," "everyday" versus "specialized," or "generalized" versus "discipline specific" is at the core of the functional linguistics theory (Halliday & Matthiessen, 2004), a theory about language that informs the discussion of disciplinary literacies in this chapter. From a functional linguistics point of view, language is a principal resource for making meaning; it "construes, is construed by, and (over time) reconstrues the social context" (Martin, 1997, p. 4). Language constructs and reflects different kinds of knowledge in ways that are functional for each discipline, so the grammatical features of texts change as the knowledge they encode varies across disciplines (Halliday, 1993; Schleppegrell, 2004). The commonplace language that serves adolescents well in their daily lives does not suffice for comprehending, challenging, and composing the kinds of texts that present information in science, mathematics, and history at the secondary level. This linguistic variation across disciplines does not just occur at the word level; it also takes place at the level of grammar. Some of these lexical and grammatical differences, along with the challenges they present for reading comprehension, are the focus of discussion in this chapter. Recognizing disciplinary ways of using language is important because one cannot fully comprehend the texts of a specific discipline—where disciplinary knowledge is produced, stored, transmitted, and evaluated—without having a sense of how the discipline organizes knowledge through language.

READING SCIENCE

Science is a form of culture with its own social practices (Gee, 2004). It involves the use of not only scientific methods for observing, identifying, describing, and experimentally investigating natural phenomena, but also a specialized form of language for constructing and communicating scientific theories, principles, processes, and reasoning (Martin & Veel, 1998; Yore et al., 2004). The social practices of scientists are catalogued in a range of text types that students are expected to be able to read and write as part of their schooling experiences. The major text types of school science include procedure, procedural recount, description, report, explanation, and exposition (Martin, 1989; Schleppegrell, 2004; Veel, 1997). The structures and grammar of these texts are neces-

sarily different from those of stories that students are used to reading in elementary school, as they provide the semiotic means with which scientists perform, explain, theorize, organize, and challenge science.

A procedural text consists of step-by-step instructions on how to conduct an experiment or observation. A procedural recount, on the other hand, records the aim, steps, results, and conclusion of a specific scientific activity already conducted. A report text organizes information about things by describing the taxonomy of classes and subclasses or the attributes, properties, and behaviors of a single class. A description text can be considered an instance of report but differs from report in that it is the specific individual, place, or thing that is characterized or described. An explanation text offers an account of how something works or reasons for some phenomenon. It deals with the interaction of factors and processes rather than a sequence of events, and thus has a process, rather than thing, focus. It usually starts with a general statement about the phenomenon in question, followed by a logically organized sequence of explanatory statements. An exposition text is intended to convince the reader of a point of view, judgment, or theory through the analysis, interpretation, and evaluation of data. In such a text, the writer advances a thesis, introduces background information about the issue in question, presents evidence to support or refute the thesis, and sums up the position in light of the argument presented.

As students advance through the school years, there is a gradual shift of emphasis in their textual diet. In the early elementary grades, procedures, procedural recounts, and descriptions are popular, as the structure and organization of these text types reflect the world of physical activity occurring at specific times and places. In the late elementary through secondary grades, students are increasingly expected to handle reports, explanations, and exposition, as these text types are the major resources for constructing the more abstract and complex knowledge that characterizes the curriculum of the later years of schooling. These three more advanced text types are the focus of discussion here.

Table 2.1 presents three texts representing each of the three major text types that are valued in the secondary science curriculum—report, explanation, and exposition. Text 1 is a science report about tornadoes. It is excerpted from *Science Voyages* (Horton et al., 2000), a sixth-grade science textbook. Texts 2 and 3 both come from *Living in the Environment* (Miller, 2004), an environmental science textbook for grades 9–12. Text 2 is an explanation text discussing why we are losing ground in our war against infectious bacteria. Text 3, an exposition text, argues why we should care about coral reefs. These texts use language patterns, or grammar, that students often find unfamiliar and alienating.

In order to highlight the new challenges involved in reading these

TABLE 2.1. Sample Secondary Science Texts

Text 1 (Report)	Tornadoes Some of the most severe thunderstorms produce tornadoes. A tornado is a violent, whirling wind that moves in a narrow path over land. It usually moves from southwest to northeast. Most tornadoes form along a front. In severe thunderstorms, the wind at different heights blows in different directions and at different speeds. This difference in wind directions and speed is called wind shear. A strong updraft will tilt the wind shear and produce rotation inside the thunderstorm. A funnel cloud appears. (from *Science Voyages*, 2000, p. 308)
Text 2 (Explanation)	Are We Losing Ground in Our War Against Infectious Bacteria? The incredible genetic adaptability of bacteria is one reason the world faces a potentially serious rise in the incidence of some infectious bacteria diseases once controlled by antibiotics. Other factors also play a role, including (1) spread of bacteria (some beneficial and some harmful) around the globe by human travel and the trade of goods, (2) overuse of antibiotics by doctors, often at the insistence of their patients (with a 2000 study by Richard Wenzel and Michael Edward suggesting that at least half of all antibiotics used to treat humans are prescribed unnecessarily), (3) failure of many patients to take all of their prescribed antibiotics, which promotes bacterial resistance, (4) availability of antibiotics in many countries without prescriptions, (5) overuse of pesticides, which increases populations of pesticide-resistant insects and other carriers of bacterial diseases, and (6) widespread use of antibiotics in the livestock and dairy industries to control disease in livestock animals and to promote animal growth. The result of these factors acting together is that every major disease-causing bacterium now has strains that resist at least one of the roughly 160 antibiotics we use to treat bacteria infections. In 1998, health officials were alarmed to learn of the existence of a strain of bubonic plague in Madagascar that is resistant to multiple antibiotics. (from *Living in the Environment*, 2004, p. 239)
Text 3 (Exposition)	Why Should We Care About Coral Reefs? More than one-fourth of the world's coral reefs have been lost to coastal development, pollution, overfishing, warmer ocean temperatures, and other stresses that are increasing. One problem is coral bleaching, which occurs when a coral becomes stressed and expels most of its colorful algae. This occurs because of stresses such as increased water temperature and runoff of silt that covers the coral and prevents photosynthesis. This loss of algae exposes the colorless coral animals and the underlying ghostly white skeleton of calcium carbonate. Unable to grow or repair themselves, the corals eventually die unless the stress is removed and algae recolonize them. Coral reefs are sometimes called the aquatic equivalent of tropical rain forests because they harbor such a high species biodiversity with myriad ecological interrelationships. The decline and degradation of these colorful oceanic sentinels should serve as a warning about the health of their habitats. (from *Living in the Environment*, 2004, p. 144)

texts, a narrative text (story) typical of the materials that students read in elementary school is presented below. This text (Text 4) is the opening paragraph in Valerie Hobbs's *Defiance*, a book about an 11-year-old boy, Toby Steiner, who is determined to do normal things on his vacation rather than return to the hospital for cancer treatment. Winner of Kirkus 2005 Best Book for Young Adults and a *School Library Journal* Best Book, the novel was also included in the 2009–2010 Sunshine State Young Reader's Award Program for grades 3–5, which is cosponsored by the Florida Department of Education and the Florida Association for Media in Education.

> Text 4: Toby knew he was in trouble, but the cow didn't. She just kept gazing at him with her huge brown eyes, like she was in love or something. So he went on petting her, even though he wasn't supposed to be there. His mother would have a fit if she knew. She was always having a fit about something, even out here in the country, where they were supposed to be having a vacation. (Hobbs, 2005, p. 9)

Technical Vocabulary

One obvious challenge in reading the three sample science texts (Texts 1–3) in comparison to the story text (Text 4) is the presence of technical vocabulary. Two types of technical vocabulary are relevant here. The first consists of words that are unique to the realm of science. These are terms that have been specifically coined for science and, as such, are essential to the creation and organization of specialized knowledge in science. Without them, science would be incomplete, inaccurate, and imprecise. Words such as *tornado, wind shear, updraft*, *funnel cloud*, *antibiotics, pesticides*, *bacteria*, *algae, silt*, and *photosynthesis* belong to this category. Because these words are rarely used in students' everyday language, they present problems for both decoding (recognition) and understanding (meaning).

The second type of technical vocabulary involves words that occur with regularity in students' everyday language but assume specialized or metaphorical meanings when used in a scientific context. Words of this type from the three sample science texts include *front, strain(s)*, *stress(es)*, *skeleton*, *harbor*, *bleaching*, *runoff*, and *health*. These words are often taken for granted during reading because they present little challenge for recognition (i.e., decoding). While secondary students may be able to sound out the words, they may not always be aware of the technical meanings associated with these words in the context of science.

Significant comprehension problems can arise when a text contains a high proportion of technical vocabulary, as the following passage from a 10th-grade biology textbook by Postlethwait and Hobson illustrates.

> In prokaryotes, transcription and translation occur within the cytoplasm. In eukaryotes, however, transcription occurs in the nucleus, and then mRNA passes through the nuclear envelope and into the cytoplasm, where translation occurs. The physical separation of transcription and translation by the nuclear envelope gives eukaryotes more opportunities to regulate gene expression. (from *Modern Biology*, 2006, p. 424)

This short excerpt contains 21 technical words of both types (underlined) out of a total of 51 words. Such a heavy load of technical vocabulary can make the text taxing to process, disrupting reading fluency and causing comprehension failure.

Long Noun Phrases

Not only are science texts technical, they are also dense. The informational density of science texts is created by the use of long noun phrases. In English, nouns are a major grammatical resource for expanding information (Fang, Schleppegrell, & Cox, 2006), and science exploits this resource to the fullest extent. For example, a noun such as *scientist* can be expanded into a noun phrase like "the first Hispanic woman scientist in the United States who received this honor" by adding premodifiers and postmodifiers. Premodifiers can consist of articles (e.g., *a, an*), determiners (e.g., *the*), and demonstratives (e.g., *these, that*); numeratives (e.g., *first, ten*); adjectives (e.g., *Hispanic*); and nouns (e.g., *woman*). Postmodifiers are typically made up of prepositional phrases (e.g., *in the United States*) and embedded clauses (e.g., *who received this honor*). This way of expanding information is particularly useful in constructing scientific definitions, as it enables scientists to give terse but complete and accurate descriptions of technical concepts (e.g., *A hurricane is a large, swirling, low-pressure system that forms over tropical oceans*). It is also useful for integrating and compacting information that may otherwise be expressed in the more "fragmented" language of everyday speech. For example, the information presented in these sentences—*There is an attack of smallpox. The attack is imagined. It can "infect" hundreds of people. These people work in the health care profession.*—can be transformed into more scientific language as a long noun phrase: *a fake smallpox attack that can "infect" hundreds of people working in the health care profession*.

Texts 1, 2, and 3 are filled with long, complex noun phrases. Text 1 uses one long noun phrase to construct a definition of *tornado* (*a violent, whirling wind that moves in a narrow path over land*) and several others to concentrate information (e.g., *some of the most severe thunderstorms, the wind at different heights, this difference in wind direction and speed*). Texts 2 and 3 also use many long noun phrases to integrate and concentrate information, such as:

- *the incredible genetic adaptability of bacteria*
- *a potentially serious rise in the incidence of some infectious bacteria diseases once controlled by antibiotics*
- *at least half of all antibiotics used to treat humans*
- *the results of these factors acting together*
- *populations of pesticide-resistant insects and other carriers of bacterial diseases*
- *every major disease-causing bacterium*
- *strains that resist at least one of the roughly 160 antibiotics we use to treat bacteria infections*
- *the existence of a strain of bubonic plague in Madagascar that is resistant to multiple antibiotics*
- *more than one-fourth of the world's coral reefs*
- *runoff of silt that covers the coral and prevents photosynthesis*
- *the underlying ghostly white skeleton of calcium carbonate*
- *the aquatic equivalent of tropical rain forests*
- *such a high species biodiversity with myriad ecological interrelationships*
- *the decline and degradation of these colorful oceanic sentinels*
- *a warning about the health of their habitats*

Long noun phrases such as these significantly increase the informational density of the three sample texts. The informational density of a text can be measured by an index called lexical density (Halliday & Martin, 1993). Lexical density can be calculated as the ratio of the number of content words (e.g., nouns, verbs, adjectives, some adverbs) to the number of nonembedded clauses in a text. It is in fact a much more reliable tool for measuring text difficulty than the traditional readability formulas. According to Halliday and Martin (1993), the lexical density of everyday spoken language is between 2 and 3, but that of written texts is around 4 to 6; in science texts, the index can go up to 10 or higher. The lexical density indices for the three science texts are 5.2, 12.5, and 5.8, respectively. These numbers are much higher than that of Text 4 (the story text), which is 1.8. With such high informational density, science texts present considerable processing demands for adolescent readers, who are typically used to the kind of texts that resembles Text 4, where nouns are generally short and simple (e.g., *Toby, he, she, the cow, his mother, a vacation*).

Nominalizations

In reading science, students come into contact with not only technical vocabulary and dense noun phrases, but also abstract entities realized in nominalizations. Nominalizations are nouns that derive from other

grammatical structures such as verbs, adjectives, conjunctions, prepositional phrases, or clauses. For example, the nouns *adaptability* and *availability* in Text 2 derive from the verb *adapt* and the adjective *available,* respectively. When a verb (encoding action) or an adjective (encoding quality) is turned into a noun, it becomes a "thing" that also incorporates the action or quality from which it derives. Thus, instead of saying "bacteria adapt very well" and "antibiotics are available," which are more congruent with everyday ways of using language, Text 2 converts them into "adaptability of bacteria" and "availability of antibiotics," which are more abstract modes of expression. One advantage of this grammatical transference is that de-verbal and de-adjective nouns can be qualified by adding pre- and postmodifiers, as in *the incredible genetic adaptability of bacteria* and *availability of antibiotics in many countries without prescriptions*. This creates dense noun phrases with abstractions, which can cause considerable comprehension problems for readers.

Nominalization is a key grammatical resource in scientific writing and reasoning, as it enables scientists to synthesize information, create semitechnical concepts, and develop text flow. Unlike Text 4, which contains no nominalization, the three science texts, particularly the explanation and exposition texts, use many nominalizations. In Text 1, *this difference in wind directions and speed* is a nominalization that summarizes what is said in the sentence prior, *the wind at different heights blows in different directions and at different speeds*, and allows the idea to be discussed further. Other nominalizations such as *heights*, *directions*, and *rotation* are abstractions that become semitechnical concepts.

Text 2 is perhaps the most linguistically challenging of the three sample science texts. One major reason for this difficulty is that the text is packed with nominalizations, many of which are also embedded in long noun phrases. These noun phrases are listed below, with nominalizations underlined and their verb or adjective counterparts in parentheses at the end of each example:

- *the incredible genetic adaptability of bacteria* (to adapt)
- *a potentially serious rise in the incidence of some infectious bacteria diseases once controlled by antibiotics* (to rise, to occur)
- *spread of bacteria* (to spread)
- *human travel* (to travel)
- *the trade of goods* (to trade)
- *overuse of antibiotics by doctors* (to use too much)
- *the insistence of their patients* (to insist)

- *failure of many patients to take all of their prescribed antibiotics* (to fail)
- *bacteria resistance* (to resist)
- *availability of antibiotics in many countries without prescriptions* (be available, to prescribe)
- *overuse of pesticides* (to use too much)
- *widespread use of antibiotics in the livestock and dairy industries to control disease in livestock animals and to promote animal growth* (to use, to grow)
- *bacteria infections* (to infect)
- *the existence of a strain of bubonic plague in Madagascar that is resistant to multiple antibiotics* (to exist)

The use of nominalizations in this text enables the author to create abstract entities that can then be elaborated through the addition of pre- and postmodifiers. This, in effect, creates a text that is dense and tightly packed with information.

Text 3 also uses many nominalizations, as shown below (again with nominalizations underlined and their verb counterparts in parenthesis at the end of each example).

- *coastal development* (to develop)
- *pollution* (to pollute)
- *overfishing* (to fish too much)
- *coral bleaching* (to bleach)
- *stresses that are increasing* (to stress)
- *this loss of algae* (to lose)
- *myriad of ecological interrelationships* (to interrelate)
- *the decline and degradation of these colorful oceanic sentinels* (to decline, to degrade)
- *a warning about the health of their habitats* (to warn)

Nominalizations such as *development*, *pollution*, *overfishing*, *bleaching*, *stresses*, and *interrelationships* create semitechnical concepts that are key to the discussion of environmental protection for coral reefs. Other nominalizations allow the author to synthesize the information that has been discussed in the prior text so that they can become the focus of subsequent discussion. This in effect creates information flow and contributes to textual cohesion. For example, *this loss of algae* summarizes the discussion about the impact of human and natural activities (e.g., coastal development, pollution, coral bleaching) on the health of algae in the first paragraph and becomes the subject of the first sentence in the second paragraph. Similarly, the author uses *the decline and deg-*

radation of these colorful oceanic sentinels to summarize the effects of human and natural activities on coral reefs discussed in the preceding paragraphs and to serve as a departure point for saying more about the environmental consequences of human and natural activities. Readers who are unaware of how nominalizations work in scientific meaning making will likely have trouble comprehending the text.

Metaphorical Realizations of Logical Reasoning

An additional challenge in reading science texts is that logical reasoning is often metaphorically realized. In everyday language, logical connections among ideas are typically realized explicitly between clauses through conjunctions of various types (e.g., *however, and, if, because*). This is the case with the story text (Text 4), in which conjunctions such as *but*, *so*, *even though*, and *if* explicitly connect ideas in the text. In science texts, however, logical reasoning is not always realized through conjunctions. It is also conveyed through nouns, verbs, prepositional phrases, and nonfinite clauses. This makes logical connections among ideas implicit and difficult to identify for students.

In Text 1, for example, the verb *produce* in "*A strong updraft will tilt the wind shear and produce rotation inside the thunderstorm*" encodes a causal relation, that is, *a strong updraft* causes *rotation inside the thunderstorm*. In Text 2, causal relations are expressed by nouns (e.g., *reason*, *results*) instead of the conjunction *because*. In the first sentence of the first paragraph, the cause–effect relation between the adaptability of bacteria and the rise in the incidence of infectious bacteria diseases is conveyed through the noun *reason*. Similarly, the noun *results* in the first sentence of the second paragraph also indicates that bacteria resistance is caused by several factors acting together. The logical reasoning behind these two sentences could have been made more explicit had the sentences been rephrased congruently using the conjunction *because*, as in

- *Because bacteria genes adapt incredibly well, we see more cases of infectious bacteria diseases.*
- *Because these factors act together, every major disease-causing bacterium now has strains that resist antibiotics.*

Cause–effect relations can sometimes be indicated via prepositional phrases. For example, the prepositional phrase *at the insistence of their patients* implies a causal relation, meaning that doctors overprescribe antibiotics because their patients insist on using them. Using the conjunction *because* would have made the logical reasoning easier to discern. Prepositional phrases can encode other types of logical reasoning

as well. For example, "*with a 2000 study …* " indicates an additive relationship, giving an example of doctors' overuse of antibiotics. Here, the preposition *with* is equivalent to *for example*.

In Text 3, causal relations are realized through not only the conjunctions *because* and *because of*, but through verbs and other conjunctions. For example, the verb phrase *lost to* in the first sentence of the text suggests that costal development, pollution, and other natural/human activities are the causes of the coral reefs' disappearance. This same idea might be better understood were the sentence reworded as "*Because of coastal development. …, more than one-fourth of the world's coastal reefs disappear.*" In the second sentence of the text, the conjunction *when*, as in *which occurs when a coral becomes stressed*, also indicates some kind of causality (in addition to conditionality), suggesting that coral bleaching can be caused by corals getting stressed. This conflation of causality and conditionality is not uncommon in academic texts (see also Schleppegrell, 2004). Finally, in the non-finite clause *Unable to grow or repair themselves*, which means "because the corals are unable to grow or repair themselves," the logical meaning of causality is left implicit. Clearly, these ways of using language make logical reasoning more difficult to identify and can hinder readers' understanding of the true causes of—as well as solutions to—environmental problems.

Summary

The grammatical features identified above—technical vocabulary, long noun phrases, nominalizations, and metaphorical realizations of logical reasoning—are potential sources of reading difficulties in science. All of these features tend to co-occur in science texts, resulting in what is recognized as "the language of school science" (Fang, 2006). It is this language that many students find alienating and challenging.

READING MATHEMATICS

Like science, mathematics has its own language that is functional for constructing mathematical meanings. In mathematics, however, language alone is often insufficient for construing mathematical knowledge and reasoning (Lemke, 2003). In fact, mathematical texts are typically multisemiotic, drawing on not only linguistic but also symbolic and visual resources (O'Halloran, 2005). Mathematical symbols—such as Σ, $F(\chi)$, π, η, =, and β—are used to represent concepts, axioms, lemmas, corollaries, theorems, operations, and relationships that are sometimes awkward to express in language. For example, the equation $h = -16t^2 +$

$35t$ gives the altitude (h) a football will reach t seconds after it is kicked with an initial upward velocity of 35 feet per second. The complete pattern of the relationship between altitude (h) and time (t) is described here with both concision and precision, a feat hard to accomplish with language alone. Visual displays such as graphs, charts, and diagrams are also important in mathematical meaning making, as they enable mathematicians to represent the linguistically and symbolically encoded information in ways that are tangible to our perceptual sense. For example, the relationship between time and altitude encoded in $h = -16t^2 + 35t$ can be graphically represented in a parabola such as Figure 2.1. The figure gives the reader instant insights into the nature of this relationship.

The tripartite formation of mathematics texts evolved from everyday language to meet the new needs of mathematical meaning making. O'Halloran (2000) summarized the functions of the three semiotic resources in mathematics this way:

> The mathematical symbolism contains a complete description of the pattern of the relationship between entities, the visual display connects our physiological perceptions to this reality, and the linguistic discourse functions to provide contextual information for the situation described symbolically and visually. (p. 363)

Thus, any discussion of the linguistic challenges involved in reading mathematics texts must take into account the interaction of language with visual and symbolic elements.

Secondary mathematics textbooks are typically made up of chunks of text labeled as a hypothesis, theorem, proof, example, exercise, review, and so on. Table 2.2 includes three such chunks of text excerpted from two popular secondary mathematics textbooks. Text 5 comes from the review section of a chapter on quadratic equations and functions in an algebra textbook for grades 9–10 (Bellman, Bragg, Charles, Handlin,

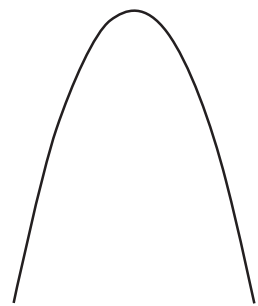

FIGURE 2.1. Parabola.

TABLE 2.2. Sample Secondary Mathematics Texts

Text 5	A function of the form $y = ax^2 + bx + c$, where $a \neq 0$, is a quadratic function. The shape of its graph is a parabola. The axis of symmetry of a parabola divides it into two congruent halves. The vertex of a parabola is the point at which the parabola intersects the axis of symmetry. The axis of symmetry is the line with the equation $x = -b/2a$. The x-coordinate of the vertex of the parabola is $-b/2a$. The value of a in a quadratic function $y = ax^2 + bx + c$ determines the width of the parabola and whether it opens upward or downward. The value of c is the y-intercept of the graph. Changing the value of c shifts the parabola up or down. When the parabola opens downward, the y-coordinate of the vertex is a maximum point of the function. When the parabola opens upward, the y-coordinate of the vertex is a minimum point of the function. (from *Algebra 1*, 2004, p. 569)
Text 6	Prove that the bases of a trapezoid have unequal lengths. Given: Trap. PQRS with bases $\overline{PQ}$ and $\overline{SR}$ Prove: PQ ≠ SR  Proof: Assume temporarily that PQ = SR. We know that $\overline{PQ} \parallel \overline{SR}$ by the definition of a trapezoid. Since quadrilateral PQRS has two sides that are both congruent and parallel, it must be a parallelogram, and $\overline{PS}$ must be parallel to $\overline{QR}$. But this contradicts the fact that, by definition, trapezoid PQRS can have only one pair of parallel sides. The temporary assumption that PQ = SR must be false. It follows that PQ ≠ SR. (from *Geometry*, p. 215)
Text 7	Theorem 9-13: When a secant segment and a tangent segment are drawn to a circle from an external point, the product of the secant segment and its external segment is equal to the square of the tangent segment. (from *Geometry*, 2004, p. 363)

& Kennedy, 2004). Text 6 is a proof listed under the example section of a chapter on geometry inequalities. It comes from a geometry textbook intended for grades 9–10 (Jurgensen, Brown, & Jurgensen, 2004). Text 7 is a theorem from the same geometry textbook.

Technical Vocabulary

One of the challenges in reading mathematics texts is technical vocabulary. Mathematics is a highly technical discipline requiring the use of

terms that are uniquely mathematical as well as everyday words that assume technical meanings. Words that are solely mathematical are usually of Latin or Greek origin (e.g., *apothem, cosine, quotient, vector, polynomial, diameter, integer*) and as such, they rarely cause confusion for students, even though they can still be difficult. A variety of such technical words are used in the three mathematics sample texts, including *quadratic, parabola, axis, equation, vertex, symmetry, trapezoid, quadrilateral*, *parallelogram*, *secant*, and *tangent*. These words are central to the construction of specialized knowledge in the fields of algebra and geometry.

One of the challenges in learning technical vocabulary words such as these is to understand hierarchies of relationships among the terms. For example, a square, a rectangle, a rhombus, and a trapezoid are all quadrilaterals, with different properties: rectangles and squares are parallelograms, but trapezoids are not; a square is always a rhombus or a rectangle, but a rhombus or rectangle is not a square. The relationships among these terms can be stated as follows: a quadrilateral becomes a trapezoid when there is one pair of parallel sides, but a parallelogram when there are two pairs of parallel sides; a parallelogram becomes a rectangle when its four angles are all right angles, but a rhombus when its four sides are of equal length; a parallelogram becomes a square when all sides are equal and all angles are right angles. Understanding the properties associated with each of these technical terms is important to understanding logical reasoning in mathematics, as students are sometimes required to write the converse, inverse, and contrapositive of *if–then* statements (e.g., "If a quadrilateral is a rhombus, then it is a parallelogram" "If a quadrilateral is a parallelogram, then it is a rhombus") and to judge whether the conditionals are true or false.

The use of everyday, nontechnical items as technical lexis also presents a challenge to the reader. Words such as *face, solid, find, suppose, power, absolute, times, order, acute,* and *volume* belong to this category. These words can cause confusion because students have to distinguish between their meaning in mathematics and their meaning in nonmathematical fields. In the three sample texts, everyday words like *function, value, coordinate, intercept, bases, congruent, segment, product, square,* and *circle* have specifically mathematical meanings.

Semitechnical Terms

In addition to technical vocabulary, mathematics also uses many semitechnical terms, which are created through nominalization. Nominalization is an indispensible tool for mathematical meaning making. It helps create abstract "things," or virtual entities, that can then be elabo-

rated or quantified, reified as mathematical concepts, or put into new relationships with other entities and concepts (Veel, 1999). For example, when mathematical operations such as *add* or *divide* are turned into *addition* and *division*, they become topical areas of mathematics that mean much more than the concrete operations of adding and dividing. Veel (1999) distinguishes between "operational facility" and "conceptual understanding," noting that it is possible for a student to be able to divide but still not fully understand the concept of division. In fact, the development from knowing how to add and divide (as in elementary mathematics) to understanding the concepts of addition and division (as in secondary mathematics) is a giant step that involves induction and abstraction.

Similarly, adjectives such as *long*, *wide*, and *high* can, when nominalized, become mathematical concepts of *length*, *width* and *height*, which are key to the discussion of the volume of three-dimensional geometric shapes. These concepts capture more than the properties encoded in the adjectival forms and can be further quantified (e.g., *a width of 50 feet*, *one-fourth of the height of a square prism*). And when a verb such as *measure* is nominalized, the virtual entity *measure* can then be qualified (e.g., *the measure of each angle of a regular polygon*) or entered into relationships with other concepts or virtual entities (e.g., *The sum of the measures of the interior angles of a polygon equals the product of 180 degrees and two less than the number of sides*).

Nominalization is a salient feature of mathematical discourse, as can be observed in the three sample mathematics texts in Table 2.2. In Text 5, for example, the nominalization *equation* comes from the verb *equate* and is used as a semitechnical term to refer to the symbolic expression $x = -b/2a$. The mathematical concept of *width*, as in *the width of the parabola*, derives from the adjective *wide*. In Text 6, the bases of the trapezoid PQRS are characterized as having *unequal lengths*, a virtual entity that derives from the adjective *long*. Similarly, the word *definition*, as in *the definition of a trapezoid*, evolves from the verb form *define*. The mental process of *assume temporarily* at the beginning of the proof gets turned, at the end of the proof, into an abstract concept, *the temporary assumption*, which is then qualified with the addition of an embedded clause: *that PQ = SR*. In Text 7, *the product of the secant segment and its external segment* and *the square of the tangent segment* can be seen as virtual entities that derive from the mathematical processes of multiplying the secant segment and its external segment and of squaring the tangent segment, respectively.

These ways of using language help create an abstract textual world with semitechnical entities and virtual objects working in conjunction with technical vocabulary to construct specialized meanings in math-

ematics. Students who are used to the commonsense reality construed through everyday language need experience and guidance when interacting with mathematics texts.

Long Noun Phrases

Technical vocabulary and semitechnical lexis do not occur in isolation in mathematics texts. Rather, they interact with each other and with other grammatical elements to construct meanings (Schleppegrell, 2007). Like other academic texts, mathematics texts are "rhetorical in nature, addressing and attempting to persuade a reader" (Morgan, 1998, p. 9). It is therefore necessary to look beyond the level of vocabulary at the overall grammatical patterns in the text. While the challenges of technical vocabulary and semitechnical lexis may be obvious to students, the challenges associated with the grammatical patternings that these terms bring with them are more difficult to recognize. Mathematics texts in English have a tendency to exploit long noun phrases and linking verbs (e.g., *be, have, equal*). These grammatical resources facilitate the construction of mathematical definitions, theorems, propositions, lemmas, corollaries, proofs, scholiums, problems, and so forth, as they enable mathematicians to include a large number of technical and semitechnical concepts (e.g., *the degree of a polynomial with one variable*, *the value of the greatest exponent of the variable that appears in any term; a cylinder with a height of 500 feet and a volume of* 1×10^6 *cubic feet*^{3}, *about 89% of the surface area of a square prism with the same height and volume; the absolute value of a real number, the distance between the origin and the point representing the real number*) and then relate them to each other or to other mathematical concepts through the use of linking verbs (e.g., *The degree of a polynomial with one variable is the value of the greatest exponent of the variable that appears in any term. A cylinder with a height of 500 feet and a volume of* 1×10^6 *cubic feet*^{3} *has about 89% of the surface area of a square prism with the same height and volume. The absolute value of a real number is the distance between the origin and the point representing the real number.*)

Long noun phrases are found throughout the three mathematics texts in Table 2.2. Samples of these noun phrases follow:

- *a function of the form* $y = ax^2 + bx + c$
- *the axis of symmetry of a parabola*
- *the point at which the parabola intersects the axis of symmetry*
- *the line with the equation* $x = -b/2a$
- *the x-coordinate of the vertex of the parabola*
- *the value of a in a quadratic function* $y = ax^2 + bx + c$

- *two sides that are both congruent and parallel*
- *the fact that, by definition, trapezoid PQRS can have only one pair of parallel sides*
- *the temporary assumption that PQ = SR*
- *product of the secant segment and its external segment*

Long noun phrases such as these increase the informational density of the texts. In addition, they often encode mathematical processes and reasoning that must be unpacked in order for them to be fully understood. For example, several mathematical operations are embedded in the long noun phrase *the sum of the angle measures divided by the number of angles in the polygon*. These operations include (1) counting (count the number of angles in the polygon), (2) measuring (measure the degrees of each angle in the polygon), (3) adding (add up the degree measures of the angles), and (4) dividing (divide the result from step 3 by the result from step 1).

Word problems in mathematics often exploit long noun phrases, as can be seen in this example from a mathematics textbook for grades 6–8 (Charles, Branch-Boyd, Illingworth, Mills, & Reeves, 2004, p. 348): Find *the final balance in an account with $1,200 and an interest rate of 5% compounded annually for 7 years*. Here, students are asked to find, or figure out (not physically locate), a virtual object called a "balance," but all the given information related to this virtual object is constructed in a long noun phrase (underlined) that encodes several mathematical processes and assumptions. This long noun phrase can be unpacked into phrases that correspond to the concrete reality of the everyday world: *there is a bank account; the account has $1,200 in it now; the money will earn interest; the interest rate is 5% and it is compounded every year; the money will remain in the account for 7 years; we want to know the amount of money left in the account at the end of the 7th year.* Examples like this show the highly dense and abstract nature of mathematics texts and why it can be challenging for students to read the texts and solve the problems presented in them.

Symbolism and Visual Display

Another challenge in reading mathematics texts is that mathematical symbolism and visual displays are often juxtaposed with language in the construction of mathematical meaning. When mathematical symbolism and visual display are not explicitly included in the linguistic text, it is often necessary to translate the language (e.g., *the volume of a cylinder equals the area of a base times the height of the cylinder*) into mathematical symbols (e.g., $V = \pi r^2 h$, where r is the radius of the cylinder

base and *h* is the cylinder height) and/or visual displays (see Figure 2.2) in order for students to truly understand the information presented and solve the problem posed.

Like mathematical language, mathematical symbolism too can leave many mathematical processes implicit, requiring the reader to unpack the symbols and equations and perform the mathematical operations and reasoning buried in them. Text 5, for example, embeds a quadratic equation, $y = ax^2 + bx + c$ that encodes several arithmetic and algebraic operations, such as addition and multiplication. Students need to know the relevant theorems, corollaries, axioms, and propositions subsumed under these operations in order to make sense of the text. O'Halloran (2000) has likened the structure of equations like this one to the structure of a linguistic clause, showing how mathematical symbols are combined to form operations and equations in the same way that words are combined to form phrases and clauses. From this perspective, the quadratic equation $y = ax^2 + bx + c$ can be conceived of as a linguistic clause, where *y, a, x, b,* and *c* (called *atoms*) are combined into x^2, ax^2, and *bx* (called *expressions*), which are further combined into an *equation*. With each combination in the hierarchical ordering, the reader is taken further away from the everyday construal of meaning. Here, the terms *atom*, *expression*, and *equation* in mathematical symbolism are analogous to *word*, *phrase,* and *clause*, respectively, in language. Deconstructing the "grammar" of mathematical symbolism this way shows that reading mathematics texts often involves "long chains of reasoning that provide little or no indication of the results, definitions, axioms,

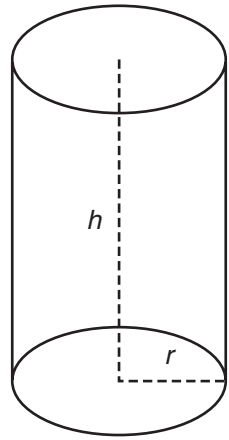

FIGURE 2.2. Cylinder.

operational properties or laws that have been used" (O'Halloran, 2000, p. 377).

Understanding language and symbolism may not be enough to comprehend Text 5. Students also must be able to construct and interpret an appropriate visual display of a parabola, such as Figure 2.1, based on the values of *a* and *c*. In short, full comprehension of the text often depends on simultaneous engagement with all three meaning-making resources: language, symbolism, and visual display. The same can be said about Texts 6 and 7, where the ability to comfortably switch among language, symbolism, and visual display is key to understanding the logical reasoning behind the proof or the theorem. In Text 6, mathematical symbols such as — (line segment), = (equality), ≠ (inequality), and || (parallel) must be understood in relation to other symbols within the systems of symbols that are part and parcel of basic geometry. For example, the concept of a line segment is related to, but different from, other concepts such as a line (↔) and a ray (→). Students also need to learn to interpret a visual display, recognizing how order, position, relative size, and orientation may alter its meaning (O'Halloran, 2005). Likewise, an understanding of the theorem in Text 7 would be difficult for students to attain without the aid of a visual display such as Figure 2.3. The visual display renders the technical and abstract language concrete, enabling the construction of a mathematical equation ($QR \times KR = RS^2$) that captures the mathematical processes and reasoning construed in language.

Summary

The foregoing discussion highlights the discursive features of mathematics texts and the potential challenges these features present to reading comprehension. In mathematics texts, language, symbolism, and visual display interact in synergistic ways to construe mathematical knowledge, processes, and reasoning. Students need to develop facility in these three meaning-making resources in order to be successful in reading and learning mathematics.

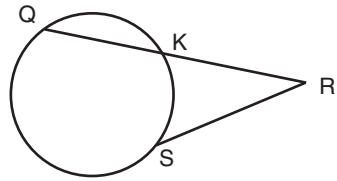

FIGURE 2.3. Visual display of a secant segment.

READING HISTORY

History is a discipline that involves the retelling, analysis, and interpretation of significant past events. It is construed through a distinct kind of discourse that comprises three major text types: recording, explaining, and arguing (Coffin, 2006; Martin, 2002). The recording texts record events of the past as they unfolded naturally through real time; the explaining texts explain the causes, consequences, and significance of historical events; the arguing texts advance a particular interpretation of past events and defend it with a series of arguments and supporting evidence. Each of these text types enables the historian to think and write about the past in a different way (Coffin, 2006). The typical historical texts that students are expected to read in secondary schools (e.g., textbooks, trade books) juxtapose these three text types in different ways, with some texts relying heavily on chronological recounting of past events whereas others focusing on causality or argument (Schleppegrell, 2004).

The three types of historical texts draw on different constellations of lexical and grammatical features that present varied degrees of comprehension challenges to students. The recording texts construct the past as story; they are temporally organized, with a focus on concrete events unfolding in real time and involving specific historical figures. These texts tend be objective, truthful records of the past; however, as Martin (2002) pointed out, the selection and arrangement of events, as well as the attribution of historical significance to these events, may not be entirely objective. Therefore, while students generally find recording texts more accessible because of their prior experience with stories in the elementary grades, they may not always be aware of the bias and interpretations embedded in these texts. The explaining and arguing texts, on the other hand, present explanations and debates about the past. They are organized rhetorically around a set of abstract theses and use language that is metaphorical and evaluative (Schleppegrell, 2004). Thus, the explaining and arguing texts are more challenging for students to read.

In elementary school, history is typically constructed as story-like representations of the past, whereas in secondary schools, it is often constructed as abstract interpretations of the past (Coffin, 2006; Martin, 2002). Even when past events are retold as stories in secondary school history, the stories do not simply record the events as they happened in real time, but usually also include explanations of causal relations among the events and statements regarding their historical significance. This shift from organizing events along a chronological sequence to embedding them as part of a larger sequence of explanation or argu-

ment is accomplished largely through linguistic choices that are different from the storytelling language with which students are familiar. Specifically, secondary school history features a greater degree of generalization and interpretation, which calls for the use of more abstract and evaluative language (Coffin, 2006; Martin, 2002; Schleppegrell, 2004; Unsworth, 1999). Some grammatical features of this language are illustrated through three sample texts presented in Table 2.3. Text 8 is a recording text from a high school AP history textbook (Faragher, Buhle, Czitrom, & Armitage, 2007) giving an account of the Panic of 1857. Text 9 discusses why the trial in the Emmett Till murder case received so much national attention. It is an explanation text from *Getting Away with Murder* (Crowe, 2003), an award-winning social studies trade book for middle school chronicling the historically significant trial of two white men who abducted and killed an African American boy named Emmett Till. Text 10 is an arguing text about why Nazi Germany was a genocidal state. It was taken from *The World Must Know* (Berenbaum, 2006), a book about the history of the Holocaust as told in the United States Holocaust Memorial Museum in Washington, DC.

Generic Nouns

As historical discourse moves from simple recounting of past events to analysis and interpretation of these events, there is a shift in focus from specific human actors to groups of people, things, and places (Coffin, 2006; Schleppegrell, 2004). This shift necessitates the use of generic, instead of specific, nouns and enables historians to highlight the impact of historical events on collective groups, rather than on single individuals. Text 8, although a recording text, is unlike many of its textual cousins in the elementary school history. The text is not a simple recounting of what happened during the Panic of 1857; it also introduces explanations of the causes and consequences of the sequence of events that took place in 1857 and 1858. Generic nouns are used to refer to places (*the North, the South*), groups of people (*southerners, some*), and groups of things (*technology*, *economic system, other financial markets, agricultural exports, cotton exports, northern exports*). When a specific individual (*James Henry Hammond*) is mentioned in the text, it is done to exemplify the collective activity of those who liked to gloat about the superiority of the southern economic system, and this individual is defined in terms of his institutional role as senator from South Carolina.

Similarly, Text 9, an explaining text, uses generic nouns to refer to groups of people (*Blacks in the South*, *people, entrenched Southern segregationists*, *all citizens*, *many African Americans*) who were impacted by the Emmett Till murder case. When specific individuals (*Emmett,*

TABLE 2.3. Sample Secondary History Texts

Recording (Text 8)	Explaining (Text 9)	Arguing (Text 10)
The Panic of 1857 Adding to the growing political tension was the short, but sharp, depression of 1857 and 1858. Technology played a part. In August 1857, the failure of an Ohio investment house—the kind of event that had formerly taken weeks to be widely known—was the subject of a news story flashed immediately over telegraph wires to Wall Street and other financial markets. A wave of panic selling ensued, leading to business failures and slowdowns that threw thousands out of work. The major cause of the panic was a sharp, but temporary, downturn in agricultural exports to Britain, and recovery was well under way by early 1859. Because it affected cotton exports less than northern exports, the Panic of 1857 was less harmful to the South than to the North. Southerners took this as proof of the superiority of their economic system to the free-labor system of the North, and some could not resist the chance to gloat. Senator James Henry Hammond of South Carolina drove home the point in his celebrated "King Cotton" speech of March 1858. (from *Out of Many*, 2007, p. 513)	The Boy Who Triggered the Civil Rights Movement The trial captured the outside world's interest for several reasons. The *Jet* magazine photo of Emmett publicized the gruesome details of the murder, making it more than just another Southern lynching. The nature of the crime itself, a 14-year-old boy brutally murdered by two men, made it news, but the reason for the kidnapping and killing—Emmett had allegedly whistled at and made "ugly remarks" to a white woman—turned it into big news. The racial context of the case also contributed to its notoriety; at the same time, Medgar Evers and the NAACP were fighting hard to gain equal rights for Blacks in the South, and Emmett's senseless murder seemed to symbolize the plight of Blacks in the region. Finally, the murder indictment against Milam and Bryant was a landmark event in Mississippi, a state where more than 500 lynchings had occurred since 1880, because, as far as people knew, it was the first time white men had been indicted for killing a Black person. The trial gave many African Americans hope that, finally, equal rights for all citizens, regardless of race, might be on the way. For entrenched Southern segregationists, the trial confirmed the fears that had begun with the Supreme Court's *Brown v. Board of Education* ruling: The white-dominated Southern way of life was in jeopardy. (from *Getting Away with Murder*, 2003, p. 22)	The Wannsee Conference, 1942—The Decision to Kill All Jews Nazi Germany became a genocidal state. The goal of annihilation called for participation by every arm of the government. The policy of extermination involved every level of German society and marshaled the entire apparatus of the German bureaucracy. Parish churches and the Interior Ministry supplied the birth records that defined and isolated Jews. The Post Office delivered the notifications of definitions, expropriation, denaturalization, and deportation. The Finance Ministry confiscated Jewish wealth and property; German industrial and commercial firms fired Jewish workers, officers, and board members, even disenfranchising Jewish stockholders. The universities refused to admit Jewish students, denied degrees to those already enrolled, and dismissed Jewish faculty. Government transportation bureaus handled the billing arrangements with the railroads for the trains that carried Jews to their death. (from *The World Must Know*, 2006, p. 103)

Milam, Bryant, Medgar Evers) are mentioned, they are historically significant figures defined by their institutional roles of, respectively, murder victim, defendants, and NAACP official.

In Text 10, institutional participants, rather than specific individuals, are given priority in support of the argument that genocide was an institutional policy of Nazi Germany, not random acts of specific individuals. This is evidenced in the use of generic nouns that refer to social institutions (*Parish churches, German industrial and commercial firms*) and government agencies (*the entire apparatus of German bureaucracy*, *the Interior Ministry*, *the Post Office*, *the Finance Ministry*, *the universities*, *government transportation bureaus*). The text also uses generic nouns to refer to groups of people (*Jewish workers, officers, board members*, *Jewish stockholders*, *Jewish students, Jewish faculty, Jews*), suggesting that it is the entire Jewish population, not just single individuals, that was being targeted for extermination by the Nazi government. Taken together, these generic nouns contribute to the argument that Nazi Germany was indeed a genocidal state.

Nominalizations

Another linguistic accommodation that historians make in moving from concrete recounts to abstract interpretations of the past is nominalization. One consequence of nominalization is that information is sometimes lost when verbs or adjectives are converted into nouns. In using verbs or adjectives, we usually have to name the actor who performs the act and the party who is acted upon (e.g., Milam and Bryant killed Emmett Till) or the carrier that possesses the attribute (e.g., the economic system of the South is superior to the free-labor system of the North). However, when the verb *killed* is turned into a noun, as in *the killing,* the information about the party who killed or the party who was killed is buried, and the noun can now be qualified by adding, for example, an adjective, as in "the senseless killing," to encode the author's interpretation of the event. In the same way, when the adjective *superior* is turned into *this superiority,* the carrier of the quality is left unidentified. Historians often exploit the grammatical resource of nominalization to efface historical actors or the writer, inject judgment, and obscure interpretation (Unsworth, 1999). Readers have to understand what nominalization entails in order to read historical texts critically.

Nominalizations are functional in historical meaning making. They enable historians to package a series of events over a long period of time into a "thing" that has ideological connotations (e.g., *the Great Depression, the Great Proletarian Cultural Revolution, the Green Movement*). They also allow historians to construe a specific action (e.g., *criticize*)

or quality (e.g., *dead*) as a "thing" (e.g., *criticism, death*), which can then be "colored" with desired ideological perspectives by adding pre- or postmodifiers (e.g., *relentless criticism of the gruesome killing*). As such, nominalizations participate in historical processes and reasoning in ways that embed the historian's attitude and naturalize his or her interpretation.

Text 8 is packed with nominalizations. For example, the author bundles together a sequence of events following the failure of an Ohio investment house in August of 1857 and refers to them as "the Panic of 1857," an abstract "thing" that reflects the author's judgment of the historical period. This "thing" is then given a prominent place in the text as a subheading; it also becomes a historical actor with the capacity to inflict harms to the North and the South. This is clearly the author's interpretation of the events of 1857 and 1858, but the interpretation becomes naturalized as facts because the role of the author as interpreter is obscured through nominalization. As Unsworth (1999) points out, nominalization in effect effaces the author as interpreter of events, disguises interpretation as facts, and positions the reader to accept the interpretation as unproblematic.

Other nominalizations in the text also create abstract grammatical participants that foreground the author's interpretation and background the real historical actors (e.g., *the growing political tension*, *a wave of panic selling, recovery*). Some nominalizations are expanded into long noun phrases that enable the author to add information while also embedding his or her own judgment of the historical events (underlined):

- *the short, but sharp, depression of 1857 and 1858*
- *the failure of an Ohio investment house*
- *a sharp, but temporary, downturn in agricultural exports to Britain*
- *business failures and slowdowns that threw thousands out of work*
- *the major cause of the panic*
- *proof of the superiority of their economic system to the free-labor system of the North*
- *his celebrated "King Cotton" speech of March 1958*

These nominalizations, coupled with other long noun phrases (e.g., *the kind of event that had formerly taken weeks to be widely known*, *the subject of a news story flashed immediately over telegraph wires to Wall Street and other financial markets*), make the text not only abstract but also dense.

In Text 9, the social and political practices of the South are summarized at the end of the text as *the white-dominated Southern way of life*, an abstract noun that encodes the author's attitude toward the segregated South and that becomes an historical participant to be further qualified (*was in jeopardy*). Some nominalizations in the text create abstract nouns (e.g., *the trial, the kidnapping and killing, the murder indictment*) that are placed in textually prominent positions as the departure point for discussion in the clause. This helps the author develop explanations. Other nominalizations enable the author to inject his judgment into the text (e.g., *its notoriety, Emmett's senseless murder, the plight of Blacks in the region*) and to construct relationships among them (e.g., *Emmett's senseless murder seems to symbolize the plight of Blacks in the region*). In these cases, the role of the author as interpreter or adjudicator is obscured and the interpretation becomes naturalized as indisputable facts. Sometimes, a nominalization is embedded within another nominalization (e.g., *the fears that had begun with the Supreme Court's Brown v. Board of Education ruling*), creating long noun phrases with layers of abstraction that can hinder comprehension.

In addition to the linguistic indications of judgment, the author also uses intensifiers such as *just* (*more than just another Southern lynching*) to indicate emphasis, and hedges such as *seemed* (*seemed to symbolize*) and *might* (*might be on the way*) to indicate the indeterminacy of history. Wineburg (1991) pointed out that historical writing frequently uses linguistic indications of judgment, emphasis, and uncertainty. Naive readers who are not yet socialized into disciplinary ways of knowing can miss out on these subtle, but important, historical meanings.

In Text 10, the heavy use of nominalizations (e.g., *annihilation, participation, extermination, notifications, definitions, expropriation, denaturalization, deportation, wealth, billing arrangements, death*) makes the text exceedingly abstract to process. These nominalizations become "things" that can be delivered to, taken away, or handled by the various branches of the Nazi government. In this way, they help build up the argument that the Nazi atrocities are not random acts of individuals, but a state policy. Unlike Text 9, Text 10 presents no linguistic evidence of uncertainty, suggesting that the author presents his argument about the Holocaust as an indisputable historical fact.

Causality

Secondary school history texts rarely just record past events. They often juxtapose explanations within the chronology, where logical connections are realized not only explicitly through conjunctions (e.g., *because*, *therefore*), but also implicitly through nouns (e.g., *reason, effects*), verbs

(e.g., *make, lead to*), and prepositional phrases (e.g., *for, through, from*) (Martin, 2002). This metaphorical realization of causality can make it more difficult for students to understand the real causes and effects of historical events. In Text 8, the verb "*adding to*" in the first sentence expresses a causal relation between two abstract "things": *the depression of 1957 and 1858* contributes to *the growing political tension*. The second sentence uses *played a part* to indicate that technology is partially responsible for the depression. Later in the text, *a wave of panic selling* is presented as both the consequence of *the failure of an Ohio investment house* and the cause of *business failures and slowdowns*, which are in turn responsible for making thousands of people lose their jobs. The logical connection between *the downturn in agricultural exports to Britain* and *the panic* is indicated through a noun (*cause*), which is then qualified (*the major cause*). Packaging a causal conjunction (e.g., *because, so*) as a noun (*the cause*) enables the author to give the causal dimension of the event a more prominent position as the subject of the sentence.

It is worth noting that causal relations in Text 8 are realized primarily within clauses through verbs (*adding to, played a part, ensued, leading to*), nouns (e.g., *cause*), and embedded clauses (e.g., *business failures and slowdowns that threw thousands out of work*), but rarely between clauses through conjunctions (*because*). This way of using language necessitates the causes and effects of historical events to be constructed as abstract "things." It can also conflate causality and temporality (Schleppegrell, 2004). For example, the verbs *ensued* and *lead to* construe not only causality but also a temporal sequence of the events happening in real time. Thus, within-clause realizations of causal relations could pose comprehension challenges to students who are used to having causality realized between clauses through conjunctions.

In Text 9, the nonfinite clause *making it more than just another Southern lynching* encodes a consequential relation, suggesting that it is the publication of the gruesome details of the Emmett Till murder that causes the public to view the murder case differently. The cause–effect relation in the text is also constructed in other ways, as shown below:

- *… the reason for the kidnapping and killing … turned it into big news* (meaning that the murder becomes big news because of the reason for the murder)
- *The racial context of the case also contributed to its notoriety* (meaning that the murder case gains notoriety because of the racial context)
- *… because … it was the first time White men had been indicted …*

Like Text 8, the causes and effects in Text 9 are also constructed as abstract "things," often realized in nominalizations that are then linked together with verbs (*contributed to*, *turned into*) so as to facilitate further analysis and elaboration of the explanation. The same can be said about Text 10, where *the goal of annihilation called for* (meaning caused) *participation by every arm of the government* and where *the policy of extermination involved every level of German society* (meaning the policy caused every level of Germany society to participate).

Texture

Unlike the typical recording texts of elementary school history that structure the past chronologically (e.g., *By 1820 … In 1854 … In 1859 … The following year … In December of 1860*), the texts of secondary school history are often organized in what Martin (2002, p. 107) called "waves of abstraction"—that is, the beginning paragraph of a text (topic paragraph) and the beginning sentence of a paragraph (topic sentence) are highly nominalized and abstract, the more narrative recounting of events that follows the introduction becomes less abstract, and the ending paragraph (conclusion) or the end of a paragraph is again highly nominalized and abstract. This "sandwich texture" (Martin, 2002, p. 107) draws on the grammatical resource of nominalization to facilitate prediction (for making an introduction) and summation (for drawing a conclusion).

Text 8, for example, starts with a sentence that is constructed in highly nominalized, abstract language (*Adding to the growing political tension was the short, but sharp, depression of 1857 and 1858*). Following this thesis statement, the text describes a sequence of events in 1857 and 1858 that is later summarized as "the Panic of 1857." The account embeds explanations that are constructed in nominalized and abstract language (e.g., *a wave of panic selling ensued, leading to business failures and slowdowns that threw thousands out of work*; *the major cause of the panic was a sharp, but temporary, downturn in agricultural exports to Britain*). The text ends with a thesis—again constructed in abstract, highly nominalized language—that echoes the one stated in the introduction, *Southerners took this as proof of the superiority of their economic system to the free-labor system of the North*, meaning that the political tension between the North and the South escalated as a result of "the Panic of 1857."

In Text 9, the topic sentence, *The trial captured the outside world's interest for several reasons*, makes predictions about what is to come in the text. As the text unfolds, the author lists four factors that explain why the Emmett Till murder case attracted so much public interest: the

gruesome details of the murder publicized through the *Jet* magazine photo, the reason why Milam and Bryant kidnapped and kill Emmett Till (i.e., the Black boy whistled at a white woman), the racial context of the case, and the murder indictment against the two white men. These four factors are not listed in any numerical order (e.g., *first, second, third*), but subtly organized rhetorically as follows:

- The nature of the crime … *made it news*
- *But* the reason for the kidnapping and killing … *turned it into big news*
- The racial context of the case *also contributed to its notoriety*
- *Finally*, the murder indictment … was *a landmark event in Mississippi*

The text concludes with a summary comment, constructed in abstract and generic language, about the impact of the Emmett Till murder case (*The trial gave many African Americans hope that, finally, equal rights for all citizens, regardless of race, might be on the way. For entrenched Southern segregationists, the trial confirmed the fears that had begun with the Supreme Court's Brown v. Board of Education ruling: The white-dominated Southern way of life was in jeopardy*).

In Text 10, the first sentence makes a thesis statement that establishes a relationship between two abstract entities, *Nazi Germany* and *a genocidal state*. The rest of the paragraph enumerates how every branch of the government (from the Interior Ministry and the Post Office to the universities and transportation bureaus) and every sector of society (from churches to industrial and commercial firms) in Nazi Germany were actively involved in carrying out the goal of annihilation and the policy of extermination. The text is constructed in highly abstract language, with generic nouns and nominalizations used as historical evidence to help the author make the argument.

Summary

Historical discourse in secondary schools is often constructed in abstract language that infuses the historian's ideological perspectives. The abstraction is realized through the use of (1) generic nouns, which refer to groups of people, classes of things, or institutions; (2) nominalizations, which turn a series of events, an action, or time sequences into "things"; (3) evaluative vocabulary to indicate affect, judgment, and valuation; (4) a sandwich texture with layers of abstraction; and (5) within-clause realizations of causal relations that sometimes conflate causality and temporality. Students need to be aware of the ways

historians exploit these grammatical resources in order to become critical readers of history.

RETHINKING SECONDARY READING PEDAGOGY

This chapter describes some of the linguistic features of disciplinary texts, their functions in disciplinary meaning making, and the challenges they present to reading comprehension. It shows that secondary content-area texts are constructed in "complex nominal syntax with technical and abstract vocabulary and clause structure that often reasons clause-internally" (Schleppegrell, 2004, p. 136). This language, with its focus on things and relations, is distinct from the more commonsense language of the elementary school texts that typically foregrounds agents and action. This difference is a major source of reading and learning difficulties for many adolescents, including those who have been declared "good readers" in elementary school. Secondary reading pedagogy needs to recognize and respond to this difference. The traditional emphasis on vocabulary and fluency in secondary reading instruction is, while important, woefully inadequate in addressing the new challenges of secondary content-area texts. As this chapter has demonstrated, the difficulties of disciplinary texts lie not just in vocabulary, but more broadly in the discourse grammar, or language patterns. As the content of these texts gets richer and conceptually more complex in secondary schools, their discourse grammar also becomes more complex and challenging. Thus, students need to periodically stop and analyze the language patterns and sort out potential linguistic issues as they read and reason with the text. This suggests that an emphasis on oral reading fluency, while making sense in texts with language that approximates everyday speech, may not be a sound pedagogical practice with secondary content-area texts.

Not only is the language of secondary content-area texts different from the language of elementary school texts, it also varies from one content area to another, as demonstrated in this chapter. For example, while nominalization is a prevalent feature of academic texts in all secondary content areas, it serves quite different functions across the subjects. In science, nominalization helps accumulate meanings so that a technical term can be defined or an explanation sequence synthesized for further discussion. In history, nominalization is often used to portray events as things so that historians can develop a chain of reasoning that simultaneously embeds judgment and interpretation. In mathematics, nominalization helps create semitechnical terms that are then quantified, reified as mathematical concepts, or put into new relationship with other concepts. This variation requires that secondary reading pedagogy

pay due respect to discourse grammar as linguistic technology, helping students understand and appreciate how language is used as a creative resource to present information, convey perspective, and structure text in discipline-specific ways. The long-standing emphasis on teaching generalizable strategies such as K-W-L, SQ3R, anticipation guides, and note taking in content-area reading courses in some sense equates, for example, reading texts about DNA with reading about the American Civil War. It fails to take account of the significant linguistic differences between disciplinary texts that emerge from the distinct social practices engaged in by content experts in different disciplines. It is not surprising, then, that although there has been much talk of late about disciplinary literacies, there is still much to be learned about the nature of the pedagogy that can promote the development of discipline-specific literacies.

Recent research has investigated how content experts such as scientists, mathematicians, and historians read and write disciplinary texts (e.g., Shanahan & Shanahan, 2008; Wineburg, 1991; Yore, Hand, & Florence, 2004; Yore, Hand, & Prain, 2002) and described the discursive features of these texts (Coffin, 2006; Halliday & Martin, 1993; O'Halloran, 2005; Schleppegrell, 2004). These studies of disciplinary language and literacy practices have yielded valuable insights into the nature of disciplinary reading and writing that have the potential to guide the teaching of disciplinary literacies. Informed by this body of work, Fang and Schleppegrell (2010) have recently proposed a new approach to secondary reading. The approach, called functional language analysis (FLA), recognizes that disciplinary texts are constructed in patterns of language that adolescents often find unfamiliar and challenging. Grounded in functional linguistics (Halliday & Matthiessen, 2004), FLA offers teachers a set of practical strategies for engaging students in systematically analyzing the language patterns and discussing the meanings of these patterns in disciplinary texts. The analysis and discussion focus on three key comprehension issues that are important to all reading: (1) content (e.g., What is the text about? What does the text tell us?), (2) structure (e.g., How is the text organized? By what logic is the text produced?), and (3) style/voice/tone (e.g., What is the author's perspective? How does the author interact with the reader?). These FLA strategies enable students to learn about the characteristic language patterns that construct the texts of each discipline at the same time they are learning disciplinary content through language. Using FLA, teachers can help students learn to recognize the patterns of language that construe knowledge and value in different ways across different school subjects, enabling adolescents to more effectively engage in the advanced literacy tasks of generalization, abstraction, exposition, reflection, critique, and renovation.

The disciplinary texts of the secondary school curriculum are challenging to read. To engage with these texts, adolescents need to expand the repertoire of reading skills and strategies they have accumulated over the elementary school years, learning to recognize how language is used in different disciplines to present knowledge, provide value, and create specialized texts. This new reading ability is best developed with the help of teachers who are conversant in both disciplinary content and disciplinary language. Unfortunately, most secondary teacher education programs in the United States are at present not in a position to prepare such teacher candidates. This means that the literacy development work must be done, at least for now, through collaboration between content teachers (who are knowledgeable about disciplinary practices and values) and reading/language-arts teachers (who can provide insights into the language that constructs disciplinary texts). The actualization of such collaboration requires a radical revamping of both curriculum and pedagogy in secondary schooling.

REFERENCES

Alvermann, D. E. (2001). Effective literacy instruction for adolescents. *Journal of Literacy Research, 34*(2), 189–208.

Bellman, A., Bragg, S., Charles, R., Handlin, W., & Kennedy, D. (2004). *Algebra 1*. Upper Saddle River, NJ: Prentice Hall.

Berenbaum, M. (2006). *The world must know: The history of the holocaust as told in the United States Holocaust Memorial Museum* (2nd ed.). Washington, DC: United States Holocaust Memorial Museum.

Biancarosa, G., & Snow, C. (2004). *Reading Next—A vision for action and research in middle and high school literacy: A report from Carnegie Corporation of New York*. Washington, DC: Alliance for Excellent Education.

Charles, R., Branch-Boyd, J., Illingworth, M., Mills, D., & Reeves, A. (2004). *Mathematics: Course 3*. Upper Saddle River, NJ: Prentice Hall.

Christie, F. (1998). Learning the literacies of primary and secondary schooling. In F. Christie & R. Mission (Eds.), *Literacy and schooling* (pp. 47–73). London: Routledge.

Coffin, C. (2006). *Historical discourse: The language of time, cause and evaluation*. London: Continuum.

Crowe, C. (2003). *Getting away with murder: The true story of the Emmett Till case*. New York: Phyllis Fogelman Books.

Fang, Z. (2006). The language demands of science reading in middle school. *International Journal of Science Education, 28*(5), 491–520.

Fang, Z., & Schleppegrell, M. J. (2008). *Reading in secondary content areas: A language-based pedagogy*. Ann Arbor, MI: University of Michigan Press.

Fang, Z., & Schleppegrell, M. J. (2010). Disciplinary literacies across content

areas: Supporting secondary reading through functional language analysis. *Journal of Adolescent and Adult Literacy, 53*(7), 587–597.

Fang, Z., Schleppegrell, M. J., & Cox, B. E. (2006). Understanding the language demands of schooling: Nouns in academic registers. *Journal of Literacy Research, 38*(3), 247–273.

Faragher, J. M., Buhle, M. J., Czitrom, D., & Armitage, S. H. (2007). *Out of many: A history of the American people* (15th ed.). Upper Saddle River, NJ: Prentice Hall.

Gee, J. P. (2004). Language in the science classroom: Academic social languages as the heart of school-based literacy. In E. W. Saul (Ed.), *Crossing borders in literacy and science instruction: Perspectives on theory and practice* (pp. 13–32). Arlington, VA: National Science Teachers Association.

Halliday, M. A. K. (1993). Towards a language-based theory of learning. *Linguistics and Education, 5*(2), 93–116.

Halliday, M. A. K. (2007). Some thoughts on language in the middle school years. In J. Webster (Ed.), *Language and education* (Vol. 9, pp. 49–62). London: Continuum.

Halliday, M. A. K., & Martin, J. R. (1993). *Writing science: Literacy and discursive power.* Pittsburgh, PA: University of Pittsburgh Press.

Halliday, M. A. K., & Matthiessen, C. (2004). *An introduction to functional grammar* (3rd ed.). London: Arnold.

Heller, R., & Greenleaf, C. (2007). *Literacy instruction in the content areas: Getting to the core of middle and high school improvement.* Washington, DC: Alliance for Excellent Education.

Hobbs, V. (2005). *Defiance.* New York: Square Fish.

Horton, P., Werwa, E., Ezrailson, C., McCarthy, T., Feather, R., Jr., Burns, J. E., et al. (2000). *Science voyages: Exploring the life, earth, and physical sciences* (Level Red, Grade, 6). Columbus, OH: Glencoe.

Jurgensen, R., Brown, R., & Jurgensen, J. (2004). *Geometry.* Evanston, IL: McDougal Littell.

Lee, J., Grigg, W., & Donahue, P. (2007). *The nation's report card: Reading 2007: National Assessment of Educational Progress at Grades 4 and 8* (NCES 2007-496). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Lemke, J. (2003). Mathematics in the middle: Measure, picture, gesture, sign, and word. In M. Anderson, A. Saenz-Ludlow, S. Zellweger, & V. V. Cifarellis (Eds.), *Educational perspectives on mathematics as semiosis: From thinking to interpreting to knowing* (pp. 215–234). Ottawa: Legas.

Martin, J. R. (1989). *Factual writing.* Oxford, England: Oxford University Press.

Martin, J. R. (1996). Waves of abstraction: Organizing exposition. In T. Miller (Ed.), *Functional approaches to written text: Classroom applications* (pp. 87–104). Washington, DC: U.S. Information Agency.

Martin, J. R. (1997). Analysing genre: Functional parameters. In F. Christie & J. Martin (Eds.), *Genre and institutions: Social processes in the workplace and school* (pp. 3–39). London: Continuum.

Martin, J. R. (2002). Writing history: Construing time and value in discourse of the past. In M. J. Schleppegrell & M. C. Colombi (Eds.), *Developing advanced literacy in first and second languages: Meaning with power* (pp. 87–118). Mahwah, NJ: Erlbaum.

Martin, J. R., & Veel, R. (Eds.). (1998). *Reading science: Critical and functional perspectives on discourses of science*. London: Routledge.

Miller, G. T., Jr. (2004). *Living in the environment: Principles, connections, and solutions* (13th ed.). Pacific Grove, CA: Brooks/Cole.

Moje, E. B. (2008). Foregrounding the disciplines in secondary literacy teaching and learning: A call for change. *Journal of Adolescent and Adult Literacy*, *52*(2), 96–107.

Moore, D., Bean, T., Birdyshaw, D., & Rycik, A. (1999). Adolescent literacy: A position statement. *Journal of Adolescent and Adult Literacy*, *43*(1), 97–112.

Morgan, C. (1998). *Writing mathematically: The discourse of investigation*. London: Palmer Press.

O'Halloran, K. (2000). Classroom discourse in mathematics: A multisemiotic analysis. *Linguistics and Education*, *10*(3), 359–388.

O'Halloran, K. (2005). *Mathematical discourse: Language, symbolism and visual images*. London: Continuum.

Postlethwait, J., & Hopson, J. (2006). *Modern biology*. New York: Holt, Rinehart & Winston.

Schleppegrell, M. J. (2004). *The language of schooling: A functional linguistics perspective*. Mahwah, NJ: Erlbaum.

Schleppegrell, M. J. (2007). The linguistic challenges of mathematics teaching and learning: A research review. *Reading and Writing Quarterly, 23*, 139–159.

Shanahan, T., & Shanahan, C. (2008). Teaching disciplinary literacy to adolescents: Rethinking content area literacy. *Harvard Educational Review*, *78*(1), 40–61.

Unsworth, L. (1999). Developing critical understanding of the specialized language of school science and history texts: A functional grammatical perspective. *Journal of Adolescent and Adult Literacy*, *42*(7), 508–521.

Unsworth, L. (2001). *Teaching multiliteracies across the curriculum: Changing contexts of text and image in classroom practice*. Philadelphia: Open University Press.

Veel, R. (1997). Learning how to mean—scientifically speaking: Apprenticeship into scientific discourse in the secondary school. In F. Christie & J. R. Martin (Eds.), *Genre and institutions: Social processes in the workplace and school* (pp. 161–195). London: Continuum.

Veel, R. (1999). Language, knowledge and authority in school mathematics. In F. Christie (Ed.), *Pedagogy and the shaping of consciousness: Linguistic and social processes* (pp. 185–216). London: Continuum.

Wineburg, S. (1991). On the reading of historical texts: Notes on the breach between school and academy. *American Educational Research Journal*, *28*(3), 495–519.

Yore, L., Hand, B., & Florence, M. (2004). Scientists' views of science, models of writing, and science writing practice. *Journal of Research in Science Teaching*, *41*(4), 338–369.

Yore, L., Hand, B., Goldman, S. R., Hildebrand, G. M., Osborne, J. F., Treagust, D. F., et al. (2004). New directions in language and science education research. *Reading Research Quarterly, 39*(3), 347–352.

Literature Cited

Yore, L., Hand, B., & Prain, V. (2002). Scientists as writers. *Science Education*, *86*, 672–692.

Guilford Publications
72 Spring Street
New York, NY 10012
212-431-9800
800-365-7006
www.guilford.com