CHAPTER

# 1

# THE CAUSAL MODEL

The main purpose of this book is to present an explanation of why some students achieve at high levels in reading while others achieve at low levels, or fail to read well. This explanation will include implications for what we should be doing to help all readers achieve at higher levels, whether they read poorly or not. The explanation will take the form of a causal model. This model involves theoretical constructs and their causal connections. Later in this chapter, an overview of the causal model will be presented.

The causal model is based on rauding theory, so it will be necessary to explain what "rauding" means and what "rauding theory" entails, before presenting the causal model. The theoretical constructs in this model will be new for many readers, such as accuracy level and rate level, so they will be described briefly. After the model is presented, several measures of the constructs in the model will be described to help the reader understand the constructs better. Then, in subsequent chapters, each construct will be described in greater detail.

## Rauding and Rauding Theory

The term "rauding" was derived from a combination of two words, reading and auding; reading usually means to attempt to comprehend language in the form of printed words, and auding usually means to attempt to comprehend language in the form of spoken words. The term rauding was developed (Carver, 1977) to focus on the similarity between reading comprehension and listening comprehension when individuals are comprehending sentences in textual materials, without regard for whether the words in the sentences are (a) being read as they are looked at in printed text, or (b) being auded as they are read aloud by someone else.

Rauding is the process of comprehending sentences, or complete thoughts, during reading or auding. So, rauding focuses upon the similarities between the comprehension of sentences during both reading and auding. This common comprehension process has long been recognized by researchers. As early as 1972, Sticht acknowledged that reading and listening comprehension represented the same internal processes when he stated that "there is only one, holistic ability to comprehend by language, and one should be able to comprehend equally well by listening or by reading, if one has been taught to decode well and other task variables are equalized" (pp. 293-294).

Figure 1-1 depicts the theoretical connections among reading, auding, and rauding. The term "reading" usually involves looking at printed words in the form of sentences in order to comprehend the thoughts the author intended to communicate; however, reading may occur without comprehension. The term "auding" usually involves listening to spoken words in the form of sentences in order to comprehend the thoughts the speaker intended to communicate; however, auding may occur without comprehension. Rauding means that an individual is comprehending most, if not all, of the thoughts during reading or auding.

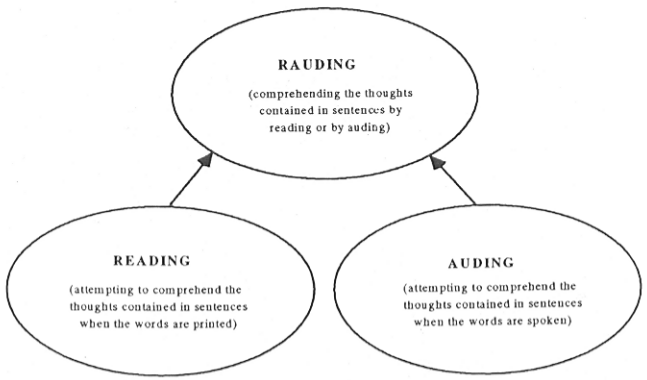


**Figure 1-1.** The theoretical connections among reading, auding, and rauding.

Before continuing, it should be acknowledged that there are many differences between listening and reading as they occur naturally in language situations (e.g., see Danks, 1980). When people are engaged in conversation there are many factors which would make a written transcript of the conversation more difficult to comprehend. For example, comprehension of conversation can involve cues from tone of voice and body language but this information is not available during reading. However, there are few differences between the process involved in comprehending relatively easy text when reading, and the process involved in comprehending the same text when it is read aloud for the individual at the typical reading rate of the individual.

During reading, rauding is similar to what has traditionally been referred to as ordinary reading, normal reading, typical reading, or simple reading. In this book, which is directed toward reading achievement, rauding will mean that an individual is recognizing each consecutive word in the sentences of printed text, and simultaneously understanding all, or almost all, of the complete thoughts in these sentences as they are being read. As will be explained in more detail in later sections, rauding refers to a particular reading process that is different from other reading processes that can be operated on text, such as scanning the words, skimming the sentences, learning from the text, and memorizing the text.



Rauding has a great deal in common with what is often called "fluency in reading." Individuals are said to be "fluent" readers when they read text orally (aloud) with accuracy of pronunciation and with appropriate expression which suggests that they are understanding the thoughts represented by the words they are saying aloud. A person who is reading relatively hard material aloud is not likely to be described as a fluent reader because the text is likely to contain (a) words incorrectly pronounced because they are unknown, and (b) incorrect expression because the thoughts are not being understood. Expressiveness is an important ingredient of oral reading because that is the only clue another person has about whether the reader is understanding what is being read. Yet, expressiveness can be faked, and it is only important for oral performance when the purpose is to help others comprehend or to entertain them; expressiveness is not a necessary ingredient for the accuracy of text comprehension by the readers themselves. Rauding and fluent reading are very similar except that rauding ordinarily refers to silent reading and fluency ordinarily refers to oral reading.

Although fluency in reading is a term usually applied to a speaker whose textual rendition is fluid or facile, the term may also be applied to silent reading or to the rapid identification of lists of isolated words so that fluency is sometimes used synonomously with skilled reading (e.g., see Beck & Carpenter, 1986). If the term "fluency" is used to refer to the silent reading of relatively easy text wherein the words are recognized effortlessly at the typical reading rate of the individual while the complete thoughts in these sentences are being comprehended as they are read, then "fluency" and "rauding" are synonymous terms.

With respect to reading, rauding means to read normally with high accuracy of comprehension. A theory of rauding, or rauding theory, refers to all the theoretical constructs, laws, equations, and models that have been developed to describe, explain, predict, and control rauding (e.g., Carver, 1977; 1981; 1990a; 1997). An overview of the earlier constructs of rauding theory plus an overview of its laws and equations is presented at the back of this book in Appendices A, B, and C. Those earlier ideas and terminology will be used and built upon in this book. Definitions of many important terms are contained in a glossary at the back of this book. Rauding theory has been used as the foundation for developing a causal model of reading achievement, which is the focus of this first chapter and the focus of this book.

## Overview of the Causal Model

This section will present a brief overview of the main factors which cause high and low reading achievement. These causes are organized into a theoretical framework, or a causal model. In order to understand this model, it will be necessary to learn new terminology. These new terms have meanings that are similar to older and more familiar concepts, but the new terms have meanings that are more precise and often different in important ways from earlier concepts. Because new terms are involved in the causal model, this overview will be difficult for most readers of this book to comprehend. However, immediately following this section, a more lengthy description of the causal model will be given, along with a graphic summary. The second and more lengthy description will provide redundancy and reinforcement of the new terms and causal connections which are presented later in this section. It may also help to remember that Chapters 3 through 14 of this book provide a detailed elaboration of the causal model. In the paragraphs which follow, the causal model will be outlined using theoretical constructs, but their similarities to older more traditional terms, called concepts, will also be pointed out along the way.

The focal point of the causal model is reading achievement. In order to explain what factors cause the most improvement in reading achievement during a school year, it is necessary first to define what is meant by the term "reading achievement." Traditionally, reading achievement has been measured by standardized reading comprehension tests. These tests usually involve (a) reading passages that vary in difficulty, (b) answering questions on each passage, and (c) working under a time limit. These tests provide a crude operational definition of general reading ability; high scores on one of these tests means high reading achievement and low scores mean low reading achievement. This traditional concept of reading achievement will be refined and clarified by using a newer construct called rauding efficiency level ($E_L$). This means that the older concept of reading achievement is being upgraded by a newer theoretical construct, which is symbolized as $E_L$ and is usually referred to as "efficiency level." So, using more precise terminology, this book will be devoted to the primary causes of efficiency level, $E_L$. Later in Chapter 3, a more extensive description of the $E_L$ construct will be given.

One primary cause of gain in efficiency level, $E_L$, is the gain in rauding accuracy level ($A_L$), according to the causal model. Accuracy level, $A_L$, is a construct that is similar to the traditional concept of reading level. For example, if a student is found to be reading at the ninth-grade level by an informal reading inventory, then this student is also likely to have an accuracy level around the ninth-grade level ($A_L = 9$). $A_L$ actually refers to the most difficult text a student can accurately read when it is read at the student's normal reading rate. This book will elaborate upon and clarify the connection between reading level and general reading ability by explaining how accuracy level, $A_L$, is a primary cause of efficiency level, $E_L$. An extensive description of $A_L$ is provided in Chapter 4, and then Chapter 9 elaborates upon how $A_L$ is a proximal cause of $E_L$.

The other primary cause of high and low efficiency level, $E_L$, is rauding rate level ($R_L$). This construct is similar to normal reading rate. For example, if a student is found to be reading at a rate equal to an average student in grade 4, then this student is likely to have a rate level around the fourth-grade level ($R_L = 4$). Most researchers are aware that the fastest rate at which an individual can accurately comprehend text does affect reading achievement. This book will make it clearer how normal reading rate affects reading achievement by explaining how gains in rate level, $R_L$, impact upon gains in efficiency level, $E_L$. An extensive description of rate level is given in Chapter 5, and Chapter 9 elaborates upon how $R_L$ is a proximal cause of $E_L$.

Figure 1-2 depicts how reading level and normal reading rate are the two causes of high and low reading achievement, or how $A_L$ and $R_L$ are the two causes of high and low general reading ability. For example, a student in grade 6 might have a high reading level ($A_L = 9$) but a low reading rate ($R_L = 4$), which combine to cause an average level of reading achievement ($E_L = 6$). If accuracy level, $A_L$, and rate level, $R_L$, are the two proximal causes of high and low reading achievement, that is, high and low efficiency level, $E_L$, then it is important to determine what causes gains in $A_L$ and $R_L$.

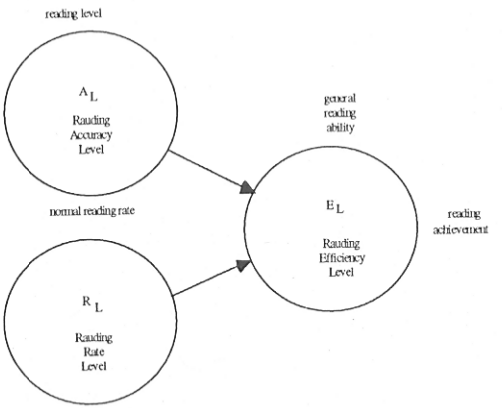


**Figure 1-2.** A graphic depiction of how $A_L$ (reading level) and $R_L$ (normal reading rate) are the two proximal causes of $E_L$ (reading achievement or general reading ability).

With respect to accuracy level, $A_L$, it has always been recognized that how much a person knows affects their reading level, and that idea has been clarified by advancing the theoretical construct of verbal knowledge level ($V_L$). This construct has much in common with the more traditional concepts of general knowledge, world knowledge, verbal knowledge, or the most difficult text a student can accurately comprehend when listening, called listening capacity. If we want to improve an individual's accuracy level, $A_L$, then we can do that by improving their verbal level, $V_L$. An extensive description of verbal level is contained in Chapter 6, and Chapter 10 explains in detail about how $V_L$ is causal for $A_L$.

Another way we can improve the accuracy level, $A_L$, of most students in elementary school is by helping them increase the number of words they can accurately pronounce, called pronunciation knowledge level ($P_L$). It has long been recognized by researchers that the ability to accurately decode or pronounce isolated words has a major impact upon reading level. This ability to identify isolated words has also been called word recognition, or word identification. The causal connection between decoding ability and reading level can be translated into the terminology of the causal model by saying that increases in pronunciation knowledge level, $P_L$, cause increases in accuracy level, $A_L$. A more detailed description of pronunciation level is provided in Chapter 7, and then Chapter 10 explains how $P_L$ is a proximal cause of $A_L$.

Figure 1-3 contains a graphic depiction of how verbal level (listening) and pronunciation level (decoding) are the two proximal causes of high and low accuracy level (reading level). For example, a student in grade 4 may have a high listening level ($V_L = 8$) but a low decoding level ($P_L = 2$), which combine to cause an average reading level ($A_L = 4$).

With respect to improving rate level, $R_L$, it turns out that increases in pronunciation level, $P_L$, are also purported to cause increases in rate level, $R_L$. So, improving pronunciation level has a double dividend. That is, gain in $P_L$ is likely to improve both $A_L$ and $R_L$, and therefore have a doubly high impact upon gain in $E_L$, or reading achievement. A lengthy description of how $P_L$ is an important cause of improvement in $R_L$ is given in Chapter 11.

The other primary factor which purportedly influences rate level, $R_L$, besides pronunciation level, $P_L$, is cognitive speed level ($C_s$). This construct is similar in concept to an older concept in reading called "thinking rate." It is also similar to a newer concept in reading called "naming speed." The causal connection between thinking rate, or naming speed, and reading rate has been translated into the terminology of the causal model by saying that increases in cognitive speed level, $C_s$, cause increases in rate level, $R_L$. The cognitive speed level construct is described in great detail in Chapter 8, and then Chapter 11 explains how $C_s$ influences $R_L$.



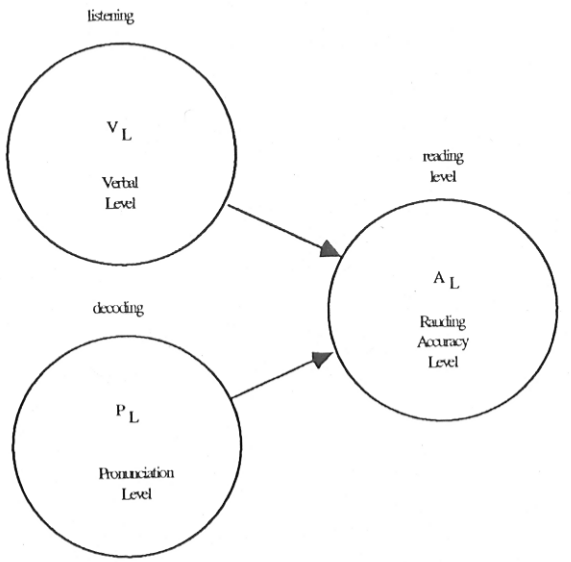


**Figure 1-3.** A graphic depiction of how $V_L$ (listening level) and $P_L$ (decoding level) are the two proximal causes of $A_L$ (reading level).

Figure 1-4 depicts how pronunciation level (decoding) and cognitive speed level (naming speed) are the two proximal causes of rate level (normal reading rate). For example, a student in grade 4 may have a low decoding level ($P_L = 2$) but a high naming speed level ($C_s = 8$), which combine to cause an average level of normal reading rate ($R_L = 4$).

The connections between traditional concepts in reading research and the six theoretical constructs of $E_L$, $A_L$, $R_L$, $V_L$, $P_L$, and $C_s$, have been summarized in Table 1-1 for reference purposes. For example, it can be seen in Table 1-1 that the traditional concepts of reading achievement, general reading ability, and the ability to read efficiently have been replaced by the theoretical construct of rauding efficiency level, which is symbolized as $E_L$ and is commonly called "efficiency level."

In summary, a gain in $E_L$ requires a gain in $A_L$ or a gain in $R_L$. Gains in $A_L$ and $R_L$ require gains in $V_L$, $P_L$, or $C_s$. Therefore, increases in efficiency level, $E_L$, come from increases in accuracy level and rate level, $A_L$ and $R_L$, which in turn are caused by increases in verbal level, pronunciation level, or cognitive speed level—$V_L$, $P_L$, or $C_s$.

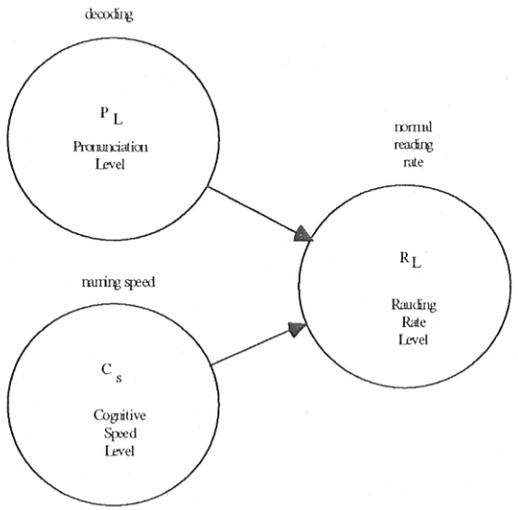


**Figure 1-4.** A graphic depiction of how $P_L$ (decoding) and $C_s$ (naming speed) are the two proximal causes of $R_L$ (normal reading rate).

Verbal level, $V_L$, and pronunciation level, $P_L$, are themselves influenced by extremely important root factors in the causal model that are not included in Table 1-1, such as teaching and learning experiences plus aptitudes. Any attempt to improve verbal level, $V_L$, by instruction will also be influenced by the verbal knowledge aptitude of the individual, symbolized as "$g_v$." Also, any attempt to improve pronunciation level, $P_L$, by instruction will be influenced by the pronunciation knowledge aptitude of the individual, symbolized as "$g_p$." Finally, it is theorized that cognitive speed level, $C_s$, cannot be improved by instruction or learning; $C_s$ can only be improved via maturation, or increases due to the passage of time during the school year. Differences between individuals in $C_s$ at the same age are referred to as "cognitive speed aptitude," and are symbolized as "$g_s$."

From this brief overview of the causal model, it can be seen that the most effective way to increase reading achievement during a school year, is to concentrate on providing the best instruction for increasing verbal level, $V_L$, and the best instruction for increasing pronunciation level, $P_L$. However, the amount of gain in reading achievement will also be importantly influenced by the individual's aptitude for verbal learning, $g_v$, aptitude for pronunciation learning, $g_p$, and aptitude for cognitive speed, $g_s$. That is, the root causes of high and low reading achievement are (a) excellent or poor teaching with respect to increasing an individual's verbal knowledge level and increasing an individual's pronunciation knowledge level, and (b) high or low aptitude in verbal knowledge, pronunciation knowledge, and cognitive speed.



**Table 1-1**
Six Theoretical Constructs, Their Symbols, Their Corresponding Traditional Concepts, and Their Commonly Used Names

| *Symbol* | *Theoretical Construct* | *Similar Traditional Concepts* | *Commonly Used Name* |
|---|---|---|---|
| $E_L$ | Rauding efficiency level | Reading achievement, general reading ability, or ability to read efficiently. | Efficiency level |
| $A_L$ | Rauding accuracy level | Reading level, or most difficult text that can be accurately comprehended during reading. | Accuracy level |
| $R_L$ | Rauding rate level | Normal reading rate. | Rate level |
| $V_L$ | Verbal knowledge level | General knowledge, or the most difficult text that can be accurately comprehended during listening. | Verbal level |
| $P_L$ | Pronunciation knowledge level | Decoding ability, or the number of words that can be accurately identified. | Pronunciation level |
| $C_s$ | Cognitive speed level | Rate of naming letters or numbers—or thinking speed. | Cognitive speed level |

In this brief overview of the causal model of reading achievement, older concepts have been used to help explain the new and upgraded constructs of the causal model. The same causal model will be presented again in the next section, but this time it will be described in more detail.

## The Causal Model in More Detail

***Introduction.*** The causal model for reading achievement, outlined briefly in the previous section, is graphically depicted in Figure 1-5—a slightly modified version of Figure 5 in Carver (1997). This figure contains all the factors

described earlier that purportedly cause high and low reading achievement; the theoretical constructs described earlier are inside the circles in Figure 1-5. For example, efficiency level, $E_L$, is inside the circle at the far right side of the figure; traditional concepts that are similar to each theoretical construct are noted above the circles. Notice that "general reading ability" is located above the circle containing $E_L$. Also notice that when one construct is the cause of another construct, this is indicated by an arrow on a line connecting the two constructs. For example, a line connects the $A_L$ construct with the $E_L$ construct, and the direction of the arrow indicates that $A_L$ is the cause of $E_L$.

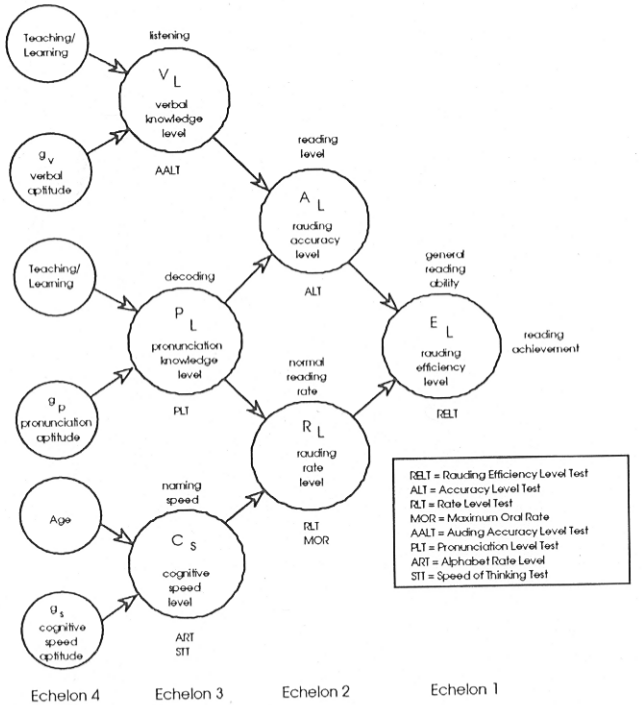


**Figure 1-5.** The Causal Model of Reading Achievement.

Below each circle is the abbreviated name of a test (or tests) that has been used to measure the construct, such as RELT located below the $E_L$ circle.



These abbreviated test names have been spelled out in a box in Figure 1-5, such as Rauding Efficiency Level Test for RELT. These tests will be described in more detail in the six chapters contained in Part II of this book.

Notice that there are four vertical columns of circles in the figure and they are labeled at the bottom of the figure as Echelons 1, 2, 3, and 4; $E_L$ is in the only circle in Echelon 1. The remainder of this section will be organized in terms of these four echelons.

***Echelon 1.*** As was noted earlier, the focal point of the causal model is "reading achievement," which is written beside the $E_L$ circle in Figure 1-5. Also, as noted earlier, general reading ability is above the $E_L$ circle because the $E_L$ construct replaces this more traditional concept. $E_L$ is a theoretical construct that represents the highest grade level of text difficulty ($D_L$) that an individual can comprehend accurately (64% or more) when the material is presented at a rate that is equal to the level of text difficulty. For example, if an individual has $E_L = 4$, this means that this person could accurately comprehend text at grade level four in difficulty when the text was presented for a length of time equal to a fourth-grade reading rate, but this individual could not accurately comprehend material at the fifth-grade level when it was presented for a length of time equal to a fifth-grade rate. This $E_L$ construct is similar to what Perfetti (1985) called "general reading ability," because it involves both accuracy and rate.

Measures of $E_L$ should correlate highly with scores on reading comprehension tests because these traditional reading tests usually contain texts to read that increase in difficulty, and these reading tests usually have time limits that make reading rate a factor that influences the test scores. Indeed, a number of research studies have provided support for the hypothesis that individual differences in $E_L$ and individual differences on standardized reading comprehension tests are usually measuring the same factor (e.g., see Carver, 1992a, 1992b).

In summary, reading achievement is the focal point of the causal model and it is represented by the theoretical construct called efficiency level. This $E_L$ construct also is (a) similar to the more traditional concept of general reading ability, and (b) similar to what is being measured by traditional standardized reading comprehension tests with time limits that put a premium on both accuracy and rate of comprehending textual material that varies in difficulty.

***Echelon 2.*** In Figure 1-5, $A_L$ and $R_L$ are inside the two circles in Echelon 2; they are purported to be the two proximal causes of $E_L$, or reading achievement.

As noted earlier, $A_L$ symbolizes the construct called rauding accuracy level which is very similar to the more traditional concept of reading level. For example, students who purportedly are reading at the third-grade level are likely to be found to have $A_L = 3$.

As noted earlier, $R_L$ symbolizes the construct called rauding rate level, which is very similar to the traditional concept of normal reading rate expressed in grade equivalent (GE) units. For example, students who purportedly read at the normal rate of fifth-graders are likely to be found to have $R_L = 5$.

Defined in more technical terms, accuracy level, $A_L$, is the highest level of text difficulty, $D_L$, that individuals can accurately comprehend (64% or higher) when they read this material at their own rauding rate ($R_r$). Rauding rate, $R_r$, is the relatively constant rate at which individuals read normally; it is also the rate at which they operate their rauding process on relatively easy material ($A_L > D_L$) and are accurately comprehending (64% or higher). Individuals normally read relatively easy material at a relatively constant rate, called their rauding rate (Carver, 1990a), because it is also their most efficient rate (Carver, 1982). When rauding rate, $R_r$, is expressed in GE units, it is called rauding rate level, $R_L$ (see Appendix D).

$A_L$ and $R_L$ are the two proximal causes of gain, growth, or improvement in efficiency level, $E_L$. This causal relationship between $A_L$ and $R_L$ at Echelon 2 and $E_L$ at Echelon 1, has been expressed mathematically (Carver, 1997) as follows:

$$E_L = \sqrt{A_L R_L} \qquad (1\text{-}1)$$

This equation means that efficiency level is purported to be equal to the square root of the product of accuracy level and rate level, or stated differently, $E_L$ is the average of $A_L$ and $R_L$ when the geometric mean is used to get the average. For example, if an individual is at the ninth-grade level of reading accuracy ($A_L = 9$) and is at the fourth-grade level of reading rate ($R_L = 4$), then the efficiency level of this student would be at grade 6 ($E_L = 6$) because the product of 9 and 4 is 36 and the square root of 36 is 6.

Equation 1-1 succinctly summarizes how the reading achievement of individuals is a function of their reading level and their normal reading rate. If we want to improve the reading achievement of students, then we must help them increase their accuracy level, $A_L$, or help them increase their rate level, $R_L$; according to this causal model there are no other choices.

***Echelon 3.*** Next to be discussed are the three factors in Echelon 3 which are purported to be the proximal causes of $A_L$ and $R_L$ in Echelon 2.

The two proximal causes of high and low accuracy level, $A_L$, are verbal knowledge level, $V_L$, and pronunciation knowledge level, $P_L$. Verbal level, $V_L$, is a construct that represents the level of verbal knowledge acquired by individuals, in GE units. $V_L$ represents level of knowledge in the form of oral language, or spoken words, so it is similar to the traditional concept of listening comprehension, or listening capacity. Therefore, measures of $V_L$ would include listening vocabulary tests, listening comprehension tests, and general knowledge tests that were administered auditorily.

$P_L$ is the number of real words an individual can accurately pronounce, expressed in GE units; it is similar to the more traditional concept of decoding ability, or decoding knowledge. Measures of $P_L$ would include word identification tests, and word recognition tests.

Theory and data already exist relevant to the above hypothesis which holds that the two primary factors causing improvement in reading level, $A_L$, are verbal level, $V_L$, and pronunciation level, $P_L$. That is, Gough and Tunmer (1986), as well as Hoover and Gough (1990), have advanced the simple view of reading which posits that reading is comprised of decoding and listening. The connections between this "simple view of reading" and the theory that $V_L$ and $P_L$ are the two proximal causes of $A_L$ will be examined in more detail later in Chapter 10.

The causal relationship between $V_L$ and $P_L$ at Echelon 2, and $A_L$ at Echelon 3, has been expressed mathematically (Carver, 1997) as follows:

$$A_L = \sqrt{V_L P_L} \qquad (1\text{-}2)$$

This equation means that accuracy level, $A_L$, is purported to be equal to the square root of the product of $V_L$ and $P_L$, or reading level is the average of listening level and decoding level when the geometric mean is used to get the average. For example, if an individual is able to comprehend text at the sixth-grade level when listening ($V_L = 6$) and is also able to correctly pronounce words at a grade equivalent level of 4.2 ($P_L = 4.2$), then this student would be reading at the fifth-grade level ($A_L = 5$) because $5 = \sqrt{6 \times 4.2}$ .

Equation 1-2 succinctly summarizes how reading level is a function of listening and decoding. If we want to increase the reading level of students, then we must help them increase their verbal level, $V_L$, or help them increase their pronunciation level, $P_L$; according to this causal model there are no other choices. It should be noted that when students become advanced readers, then Equation 1-2 is no longer valid. That is, when individuals have reached the eighth-grade level in both $V_L$ and $P_L$, then Equation 1-2 no longer holds; this is explained in more detail in Chapter 17.

The two proximal causes of high and low rate level in Echelon 2 are pronunciation level, $P_L$, and cognitive speed level, $C_s$, which are in Echelon 3 of Figure 1-5. Note again that $P_L$ is considered to be a proximal cause of both $A_L$ and $R_L$, whereas $V_L$ is only a proximal cause of $A_L$, and $C_s$ is only a proximal cause of $R_L$.

$C_s$ is similar in concept to the more recent concept of naming speed (Wolf, 1991), and it is also similar to the more traditional concept of thinking speed (Buswell, 1951). Measures of $C_s$ would include the ability to read aloud quickly

the letters of the alphabet in random order, e.g., using the Alphabet Rate Test, ART, as is explained in more detail in Chapter 8.

The causal relationship between $P_L$ and $C_s$ at Echelon 3 and $R_L$ at Echelon 2 has been expressed mathematically as follows:

$$R_L = \sqrt{P_L C_s} \qquad (1\text{-}3)$$

This equation means that rate level is purported to be equal to the square root of the product of pronunciation level and cognitive speed level, or that reading rate level is the average of decoding level and naming speed level when the geometric mean is used to get the average. For example, if an individual is able to pronounce words at the second-grade level ($P_L = 2$) and has a cognitive speed at the eighth-grade level ($C_s = 8$), then the rate level of this student would be at grade 4 ($R_L = 4$), because $4 = \sqrt{2 \times 8}$.

Equation 1-3 succinctly summarizes how the reading rate of individuals is a function of their decoding level and naming speed. If we want to improve the rate level, $R_L$, of students, then we must help them increase their pronunciation level, $P_L$; we cannot help individuals improve their cognitive speed level, $C_s$, as will be explained in more detail in Chapter 8 and Chapter 14.

***Echelon 4.*** Next, the proximal causes of $V_L$, $P_L$, and $C_s$ in Echelon 3 will be described by reference to their causal factors located in Echelon 4.

The proximal causes of verbal level, $V_L$, are theorized to be (a) teaching and learning experiences (T/L), and (b) verbal knowledge aptitude, $g_v$. In the causal model it is assumed that the $V_L$ of individuals can be improved if they (a) listen to new ideas such as those advanced by their teachers, (b) view and listen to the voice track on documentary films and videos, and (c) read new ideas in textbooks or other expository texts. Measurement of this T/L factor might include the amount of time a student was engaged in quality learning or a measure of the quality of instruction with respect to learning new information of a verbal nature. However, equal exposure of individuals to new ideas, concepts, and words will not result in an equal increase in $V_L$. Individuals are not equal with respect to how much they can learn from what they have been told orally or in print, that is, some individuals have more verbal aptitude than others. Verbal knowledge aptitude has been symbolized in the causal model as $g_v$. This causal factor, $g_v$, influences how much an individual learns from being told. Measures of $g_v$ would include memory for words on an auditorily presented reading span test (see Daneman and Carpenter, 1980, and Chapter 12).

Similar to $V_L$ discussed above, there are also two proximal causes of $P_L$; they are (a) teaching and learning experiences (T/L), and (b) pronunciation knowledge aptitude, $g_p$. If we want to improve $P_L$, then we can try to get individuals involved in teaching and learning activities designed to improve $P_L$,



such as learning to decode and spell. However, individuals are not equal with respect to how much instruction or repetition they need to learn sound-symbol connections, that is, some individuals learn faster than others. This aptitude for learning to pronounce words correctly has been symbolized in the model as $g_p$. Measurement of $g_p$ would include tests of the basic ability to learn the somewhat consistent associations between the sounds within spoken words and the letters within printed words (see Chapter 13).

Finally, in Echelon 4 there are two primary proximal causes of $C_s$; they are age and cognitive speed aptitude ($g_s$). $C_s$ advances one GE each year due to maturation, and there are no known instructional techniques which can increase $C_s$. However, at each age some individuals have more of this ability than others, due to an aptitude, or trait. Notice that $C_s$ and $g_s$ represent the same ability or aptitude with respect to cognitive speed, except that $C_s$ is measured in GE units, which reflect absolute amounts, and $g_s$ is measured in standard score units, which reflect individual differences at a particular age.

The root causes of high and low reading achievement, located at Echelon 4 in the causal model, reflect an interaction between nature and nurture factors. Vellutino et al. (1996) have articulated the importance of such an interaction as follows: "... any given level of reading achievement is a by-product of a complex interaction between one's endowment and the quality of one's literacy experience and instruction, such that the child who is endowed with an adequate mix of the cognitive abilities underlying reading ability is better equipped to profit from experience and instruction in learning to read than is the child who is endowed with a less than adequate mix of these abilities" (p. 602). Also, Olson et al. (1999) studied the genetics of learning disabilities and they concluded that the evidence for genetic influence helps explain why extra teaching and learning may be needed for some children.

***Summary.*** The causal model of reading achievement has been summarized graphically in Figure 1-5, as was presented earlier. In this model, reading achievement is represented by a more precise theoretical construct called efficiency level, symbolized as $E_L$. The two proximal causes of $E_L$ are accuracy level, $A_L$, and rate level, $R_L$. $A_L$ is similar to the concept of reading level in GE units. $R_L$ is similar to normal reading rate in GE units. The two proximal causes of $A_L$ are verbal level, $V_L$, and pronunciation level, $P_L$. $V_L$ is similar to listening level measured in GE units. $P_L$ is similar to decoding level measured in GE units. The two proximal causes of $R_L$ are pronunciation level, $P_L$, and cognitive speed level, $C_s$. $P_L$ was described above, and $C_s$ is similar to naming speed measured in GE units. The two proximal causes of $V_L$ are teaching and learning experiences, T/L, and verbal knowledge aptitude, $g_v$, which is the ability to learn and remember verbal information. The two proximal causes of $P_L$ are teaching and learning experiences, T/L, and pronunciation knowledge aptitude, $g_p$, which is the ability to learn and remember sound-symbol corre-

spondences. The two proximal causes of $C_s$ are age and cognitive speed aptitude, $g_s$, which is the ability to name a series of simple stimuli quickly. The root causes of high and low reading achievement are at Echelon 4 in the causal model; they are teaching and learning with respect to verbal knowledge and pronunciation knowledge, as well as verbal aptitude, pronunciation aptitude, cognitive speed aptitude, and age.

## Measures

***Introduction.*** The causal model can be grounded in the context of prior reading theory and prior reading research by describing how its constructs are measured and how these constructs relate to earlier measures used in reading.

One fundamental notion underlying the causal model is that each factor in the model can be measured in different ways. This idea was articulated by Cronbach (1957) as follows: "When there are many response variables, however, it is mandatory to subsume them under constructs, since otherwise we must have a separate set of laws for every measure of outcome" (p. 676). Thus, each construct in the causal model can be measured in different ways, although some ways are likely to be more valid than others.

***Types of Measures.*** Three different types of measures can be used to test the hypotheses involved in the causal model—direct measures, indicants, and indirect measures. A direct measure of a theoretical construct is a measure designed directly from a definition of the construct; therefore it is measured in the units of the construct. For example, the walking distance from the front door of my home to the closest grocery store can be determined by two persons using a 100 foot tape measure—yielding 934.6 feet, for example, as a direct measure.

An indicant is a measure that theoretically should be measuring something that is either very similar to the theoretical construct or is likely to be correlated very highly with the construct. For example, I might count the number of walking strides between the front door of my home and the nearest grocery store—yielding 370 strides, an *indicant* of the distance.

An indirect measure is an indicant that has been rescaled into the same units as a direct measure. For example, I might multiply the number of strides to the grocery store by my estimated stride length (e.g., 2.5 feet)—yielding a total of 925 feet, for example, as an indirect measure.

A direct measure should ordinarily be the most valid. However, it is possible for an indirect measure to be more valid than a direct measure. For example, if a tape measure was used to provide a direct measure of the distance to the grocery store, and the two persons using the tape measure were not reliable in writing down their successive measurements and adding them up, then it is



possible that a person who walked to the grocery store counting strides that were a consistent length would produce a more valid measure.

One disadvantage inherent in indicants and indirect measures is that experimental research may be required to prove beyond a reasonable doubt that these measures are valid for reflecting changes within individuals. For example, if an indirect measure shows the effect of a treatment, would a direct measure show the same effect?

The above fundamental ideas about measurement will be applied in the following subsection to the constructs in the causal model.

***Measuring the Constructs.*** Past research on rauding theory has usually involved indicants and indirect measures. For example, accuracy level, $A_L$, is the most difficult level of text difficulty, $D_L$, that an individual can read accurately ($A > .64$) when the text is read at the individual's own rauding rate. With this definition of $A_L$, a direct measure of $A_L$ would involve the presentation of increasingly difficult texts at the individual's own rauding rate, until the most difficult one that can be comprehended accurately is determined. However, most research on $A_L$ has involved a vocabulary test as an indicant that has been rescaled into GE units to provide an indirect measure of $A_L$. It has been determined empirically that a more direct measure of $A_L$ correlates highly with a vocabulary test that contains increasingly difficult words (Carver, 1994a). So, this vocabulary test has been scaled into GE units and used as an indirect measure of $A_L$. Indirect measures are indicants of a construct that can be used as an index or a surrogate to investigate the construct. In the example above, the scores on the vocabulary test (an indicant of $A_L$) were rescaled into the same GE units as a direct measure of $A_L$, so those scores can be said to provide an indirect measure of $A_L$.

Table 1-2 contains the three theoretical constructs at Echelons 1 and 2 of the causal model, along with related traditional concepts plus direct measures, indirect measures, and indicants. For example, rauding efficiency level (a) is a theoretical construct at Echelon 1 which is symbolized as $E_L$, (b) is similar to such traditional concepts as reading achievement, general reading ability, and reading efficiency, (c) can be measured directly by the Rauding Efficiency Level Test (see Chapter 3), (d) can be measured indirectly by the average of $A_L$ and $R_L$ (see Chapter 9), and (e) can be measured by an indicant such as the score on a standardized reading achievement test (see Chapter 3). Also, notice that indicants of $A_L$ are untimed or unspeeded standardized reading comprehension tests, and indicants of $R_L$ are standardized reading rate tests.

Table 1-3 contains information similar to Table 1-2 except it is for the three theoretical constructs at Echelon 3 in the causal model, namely, $V_L$, $P_L$, and $C_s$. Notice that decoding knowledge and word identification knowledge are traditional concepts related to pronunciation level, and that $P_L$ can be measured

by an indicant such as the score on a word identification test. Also, notice that verbal speed is another traditional concept similar to cognitive speed level, $C_s$.

**Table 1-2**
Theoretical Constructs, Symbols, Related Concepts, and Measures for $E_L$, $A_L$, and $R_L$ at Echelons 1 and 2

| *Symbol* | *Construct* | *Related Traditional Concepts* | *Measures* |
|---|---|---|---|
| $E_L$ | Rauding efficiency level | (1) reading achievement<br>(2) general reading ability<br>(3) reading efficiency | Direct Measure: RELT, Rauding Efficiency Level Test (see Chapter 3)<br>Indirect Measure: $E_L' = \sqrt{A_L R_L}$ (see Chapter 9)<br>Indicant: standardized reading achievement test (see Chapter 3) |
| $A_L$ | Rauding accuracy level | (1) reading level<br>(2) reading comprehension level | Indirect Measure: ALT, Accuracy Level Test (see Chapter 4)<br>Indicant: untimed (or not speeded) reading comprehension tests such as the Degrees of Power test, DRP (see Chapter 4) |
| $R_L$ | Rauding rate level | (1) normal reading rate<br>(2) rate level | Indirect Measures: RLT, Rate Level Test, or MOR, Maximum Oral Rate (see Chapter 5)<br>Indicants: typical reading rate, or reading rate as measured by standardized tests such as the Nelson-Denny Reading Test (see Chapter 5) |

Table 1-4 also contains information similar to Tables 1-2 and 1-3 except it is for three theoretical constructs at Echelon 4, namely, $g_v$, $g_p$, and $g_s$. Notice that (a) a listening span test measuring recall of verbal content could be developed into an indirect measure of $g_v$, and (b) verbal intelligence and crystallized intelligence are traditional concepts that are similar to $g_v$. Also, notice that an indicant of $g_p$ would include a test of phonological awareness. Finally, notice that indicants of $g_s$ would include: (a) a test of naming speed for colors, and (b) a test of naming speed for digits.

Not included in any of Tables 1-2, 1-3, and 1-4 is a measure of the two teaching and learning, T/L, factors at Echelon 4. If growth in $V_L$, $P_L$, and $C_s$ for a school year was being measured, then it would be necessary to have measures of these T/L factors at Echelon 4 as well as measures of $g_v$, $g_p$, and $g_s$ in order to predict this growth. The best indicants of T/L would probably measure the amount of time each student was involved in teaching and learning experiences directly related to improving $V_L$ or $P_L$. Another indicant of T/L would be the number of basal readers covered in a year, or the number of instructional units mastered. Measuring T/L for $V_L$, T/L for $P_L$, $g_v$, $g_p$, and $g_s$ is a challenge that must be met, eventually, for the causal model to be fully tested.



**Table 1-3**
Theoretical Constructs, Symbols, Related Traditional Concepts, and Measures for $V_L$, $P_L$, and $C_s$ at Echelon 3

| *Symbol* | *Construct* | *Related Traditional Concepts* | *Measures* |
|---|---|---|---|
| $V_L$ | Verbal knowledge level | (1) listening comprehension level<br>(2) listening vocabulary<br>(3) general knowledge | Indirect Measure: AALT, Auding Accuracy Level Test (see Chapter 6)<br>Indicants: listening comprehension tests, listening vocabulary tests, and auditory tests of general knowledge (see Chapter 6) |
| $P_L$ | Pronunciation knowledge level | (1) decoding knowledge<br>(2) word identification knowledge | Indirect Measure: PLT, Pronunciation Level Test (see Chapter 7)<br>Indicants: word identification tests, word recognition tests, and decoding tests (see Chapter 7) |
| $C_s$ | Cognitive speed level | (1) naming speed<br>(2) thinking speed<br>(3) verbal speed | Indirect Measures: ART, Alphabet Rate Test, STT, Speed of Thinking Test (see Chapter 8)<br>Indicants: naming speed for overlearned language symbols (see Chapter 8) |

## Summary, Conclusions, and Implications

The root causes of high and low reading achievement, or $E_L$, are contained in Echelon 4 of the causal model. This echelon contains the three aptitudes that influence reading achievement, namely, verbal knowledge aptitude, $g_v$, pronunciation aptitude, $g_p$, and cognitive speed aptitude, $g_s$. This echelon also contains the teaching and learning experiences that elicit improvement in $V_L$ and $P_L$.

Metaphorically, there are only two buttons which educators can push in the causal model (or circles in Figure 1-5) to get improvement in reading

achievement, or $E_L$. The harder educators depress the teaching/learning button in Echelon 4 that is connected to verbal level, the bigger the effect they will have upon $V_L$ at Echelon 3, and in turn the bigger the effect they will have on $A_L$ at Echelon 2, and in turn the bigger the effect they will have on $E_L$ at Echelon 1. The harder they depress the other teaching/learning button in Echelon 4 that is connected to pronunciation level, the bigger the effect they will have upon $P_L$ at Echelon 3, and in turn the bigger the effect they will have on $A_L$ and $R_L$ at Echelon 2, and in turn the bigger the effect they will have on $E_L$ at Echelon 1. Since $E_L$ is completely determined by $A_L$ and $R_L$, and since $A_L$ and $R_L$ are completely determined by $V_L$, $P_L$, and $C_s$, this means that the only way that educators can influence reading achievement, or $E_L$, is by their influence upon verbal level, $V_L$, and pronunciation level, $P_L$, at Echelon 3—educators cannot influence the other factor at Echelon 3, namely, $C_s$. Again, the root causes of reading achievement, or $E_L$, are teaching and learning with respect to verbal knowledge and pronunciation knowledge, as well as age and the three aptitude factors called verbal knowledge aptitude, pronunciation knowledge aptitude, and cognitive speed aptitude.

**Table 1-4**
Theoretical Constructs, Symbols, Related Concepts and Measures for $g_v$, $g_p$, and $g_s$ at Echelon 4

| *Symbol* | *Construct* | *Related Traditional Concepts* | *Measures* |
|---|---|---|---|
| $g_v$ | Verbal knowledge aptitude | (1) verbal aptitude<br>(2) verbal intelligence<br>(3) crystallized intelligence | Direct Measure: listening span tests measuring recall of verbal content (see Chapter 12)<br>Indicants: verbal intelligence tests such as the Peabody Picture Vocabulary Test, and verbal ability tests such as the SAT and GRE (see Chapter 12) |
| $g_p$ | Pronunciation knowledge aptitude | (1) decoding aptitude<br>(2) phonological awareness | Indicants: phonological awareness tests and letter-name accuracy tests (see Chapter 13) |
| $g_s$ | Cognitive speed aptitude | (1) naming speed ability<br>(2) speed of thinking<br>(3) verbal speed | Indirect Measures: age normed scores on ART and STT (see Chapter 14)<br>Indicants: naming speed for colors, and naming speed for digits (see Chapter 14) |

This causal model contains ideas that are somewhat different from much conventional wisdom. That is, it holds that three primary factors completely determine reading achievement, or general reading ability. If you know the



grade level scores for listening (verbal knowledge), word identification (pronunciation knowledge), and naming speed (cognitive speed), then reading achievement in grade level units is mathematically determined, or predicted with little error. Because cognitive speed is not amenable to improvement by education, this means that if we want to improve reading achievement of students, then (a) we have to improve their verbal knowledge or how much they know auditorily, or (b) we have to increase how many words they can accurately pronounce in isolation.

From this theory, it can be inferred that instruction in reading should be directed first toward activities that will produce the most gain in the number of words that individuals can accurately pronounce in a list, not pronounce in the context of a sentence. This instruction should continue until students can accurately pronounce all the words in print that they know when listening. When students are able to do this, instruction should then be directed toward increasing verbal knowledge and pronunciation knowledge simultaneously. For example, any new words learned by listening should simultaneously be learned by reading; newly learned spoken words should be practiced in written form until they can be spelled accurately and recognized quickly.

The causal model is being presented as a theory which purports to explain all of the variance in reading achievement for students in elementary school, high school, and college—as well as adults. That is, all of the variance in reading achievement, or $E_L$, is purportedly explained by variation in $A_L$, the rauding accuracy level of students, and $R_L$, the rauding rate level of students. All of the variation in $A_L$ and $R_L$ in students is purportedly explained by variation in their verbal knowledge level, $V_L$, their pronunciation knowledge level, $P_L$, and their cognitive speed level, $C_s$. Finally, it is likely that almost all of the variation in $V_L$, $P_L$, and $C_s$ in students can be explained by the following: their age, their teaching/learning experiences, their verbal knowledge aptitude, their pronunciation knowledge aptitude, and their cognitive speed aptitude. $V_L$, $P_L$, and $C_s$ completely determine reading achievement and the way to cause gain in these three primary factors is via appropriate instruction, but the effects of instruction are greatly influenced by individual aptitudes in the three specific areas noted above—$g_v$, $g_p$, and $g_s$.

The remainder of this book will be devoted to explaining this causal model in greater detail, as well as reviewing theory and research data relevant to the model. By the end of this book, the model should be understood very well, well enough to know its strong points and its weak points. Furthermore, it should be possible to use the model to cause improvement in reading achievement. Knowing the main factors which cause high and low reading achievement should help everyone who is devoted to increasing reading achievement in students.

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