Theory and Research
Supporting CART

Theory: The most concise way to summarize Dr. Carver's causal model of reading is displayed in the figure below.

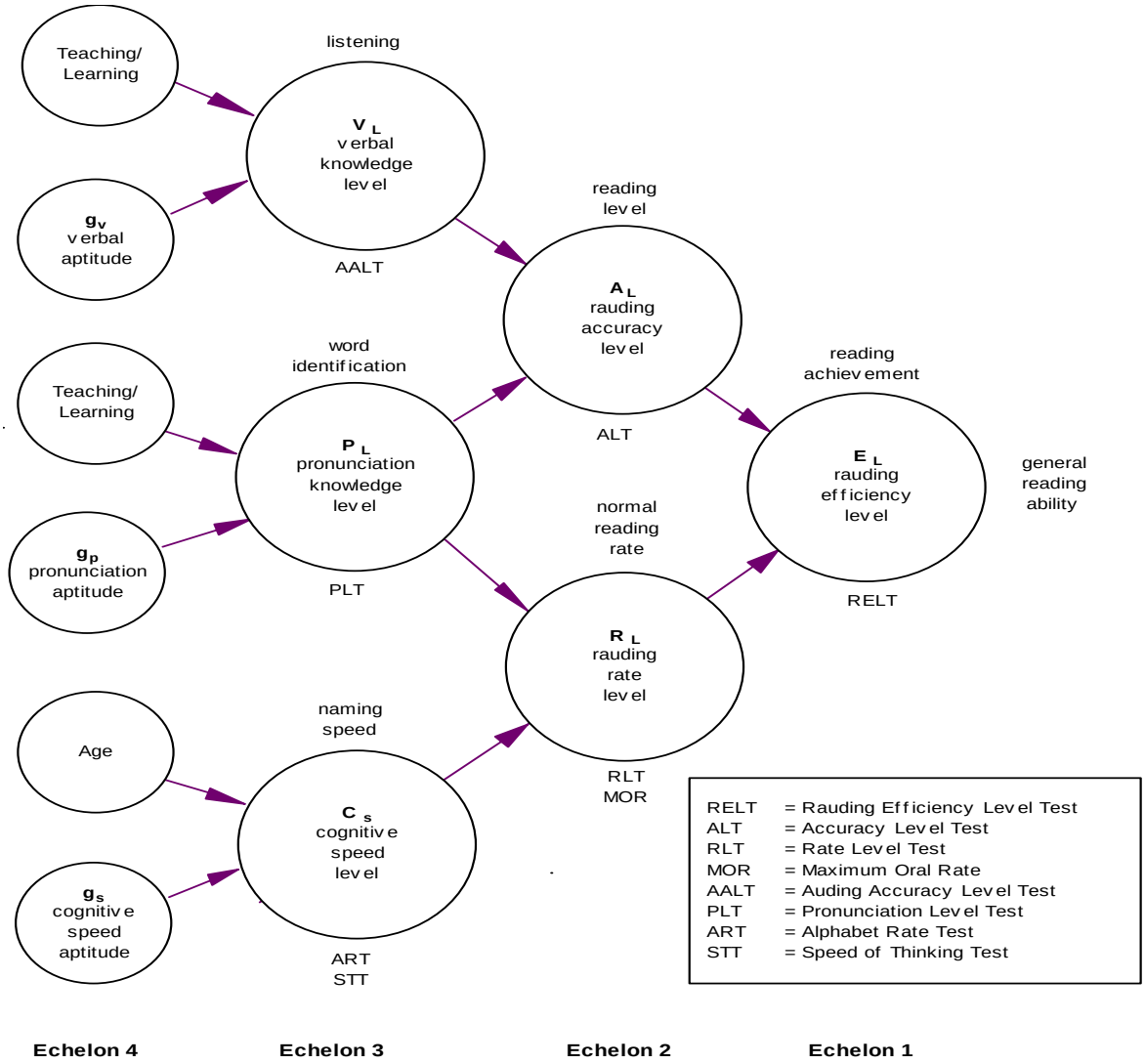

Figure 1. The causal model of reading achievement. (Note: This is a modified version of Figure 1 in Carver, 1997.)

Notice that this model is divided into four echelons. The first echelon begins with E_L, reading achievement, which is basically equivalent to general reading ability. E_L also represents what is often measured by standardized reading comprehension tests and is purported to represent what educators want students to improve each year. From the arrows running between circles in the model, it can be seen that A_L and R_L are key determiners of E_L. A_L is a construct that is similar to the traditional concept of reading level, or instructional level. R_L refers to rate level or the individual's typical reading rate. According to the causal model, the only way to increase E_L is to increase A_L or R_L. The factors that can improve A_L and R_L are represented in echelon 3 namely; V_L, P_L, and C_S. Increasing verbal knowledge level (listening level, V_L) and pronunciation level (word identification, P_L) can lead to improvement in A_L. With respect to R_L in echelon 2, again increasing P_L and making gains in cognitive speed level (naming speed, C_S) can lead to improved R_L. Lastly this model shows the predispositions or aptitudes (verbal knowledge, decoding, and cognitive speed) in echelon 4 that contribute to echelon 3 (V_L, P_L, and C_S) as well as the influence of teaching and age.

CART's basis in Theory. At the center of the causal model is word identification, pronunciation level (P_L). Instruction designed to increase pronunciation level, P_L, is theorized as simultaneously causing increases in reading level and reading rate, which are two of the main ingredients of reading achievement. It should also be noted that in this theory it has been hypothesized that level of word identification (or P_L) and level of spelling knowledge (S_L) are equal when measured in grade equivalent (GE) units ($P_L = S_L$); there is a great deal of empirical data supporting this part of the theory (Carver, 2003). This means that a treatment which increases word identification level, or P_L, should automatically increase spelling level, or S_L. Similarly, a treatment which increases spelling level, S_L, should automatically increase word identification level, or P_L. Then, increases in P_L and/or S_L should automatically increase reading achievement via increases in reading level and reading rate.

The above theory has an important qualification. The causality noted above should be limited to typical students who know more words when listening than when reading. This type of student will be called a Type I reader. For this type of reader, an instructional treatment designed to increase P_L and/or S_L should also transfer to an increase in reading achievement. The overwhelming majority of students in elementary school should be Type I readers because there are research data indicating that reading level typically does not catch up to listening level until about grade 7 or grade 8 (Sticht & James, 1984).

Any treatment that focuses upon increasing P_L and/or S_L should not increase the reading achievement of students who already know as many words when reading as when listening. Students of this type have been called Type II readers. Type II readers should not profit from instruction designed to increase word identification or spelling because teaching students to pronounce and spell words whose meanings are unknown when listening will not help them comprehend written sentences involving these words. That is, being able to correctly identify or pronounce new words found in texts is not helpful unless the meanings of these words are known when listening. Type II readers need to learn the meaning of new words in order to increase their reading achievement. Therefore, Type II readers should gain the most in reading achievement when they are given vocabulary instruction.

Another important factor to consider when discussing Type I and Type II readers is their reading rate, or the rate at which they can process words when comprehending sentences. When a student, Type I or Type II, learns to pronounce new printed words whose meanings are known, it will ordinarily take a few practice trials to get the word up to speed. This means that a new word needs to be practiced in order to be recognized as fast as old known words. If the necessary practice is not completed, then the word will be recognized more slowly, or haltingly, when reading silently (slower reading rate) or when reading aloud for others (less fluent). Each individual has his or her own optimal rate for reading, which ordinarily is at the individual's own speed limit for recognizing and comprehending words in sentences (Carver, 1990). This speed limit, or rate is limited by how fast an individual can name randomized letters of the alphabet out loud, called naming speed or cognitive speed. This means that both Type I and Type II readers need to practice the new words they learn until they can recognize them at their own rauding rate, or their own speed limit.

So, both Type I and Type II readers can improve their reading achievement by increasing the number of printed words whose meanings are known and can be recognized relatively quickly in print. Type I readers benefit most from a focus on word identification which is the focus of the spelling tutor in CART. Conversely Type II readers benefit the most for learning the meanings of new words, which is the focus of the vocabulary tutor in CART.

Research: CART has been rigorously tested for 3 years in an urban charter school, called University Academy (UA).

- In Year 1, an experimental version of CART was used by students for only 4 months in the evaluation. It contained the Spelling Tutor but did not yet contain the Vocabulary Tutor. After only 30.3 hours on the Spelling Tutor, the Tutored Group (a) gained 1.1 grade equivalents (GEs) more in spelling knowledge than the Classroom Group, (b) gained 0.9 GE units more in reading rate, and (c) gained 0.3 GE units more in reading vocabulary, which was not taught.

- In Year 2, an upgraded version of the CART was used for 6 months; it included both the Spelling Tutor for Type I poor readers and the Vocabulary Tutor for Type II poor readers. Students in the tutoring group gained 1.7 GEs, as compared to the average gain of 1.2 GEs for the Classroom Group. Results were also looked at in terms to the number of list completed. It was found that the students in the bottom 1/3 who averaged 26 lists, gained 1.2 GEs in reading achievement; the same gain as the control group. The middle 1/3 with an average of 42.3 lists gained 1.5 GEs. The top 1/3 averaging 65.0 lists gained 2.3 GEs. The gains of the Tutored Group would very likely have been larger had the study been conducted for an entire school year rather than 6 months.

- In Year 3, the CART was used for 8 months with the entire sixth grade class having been randomly assigned to two groups: experimental (Tutored Group) and control (Classroom Group). Their average GE was 5.3 in reading achievement at the beginning of their school year. At the end of the school year, the mean of the Tutored Group on a composite reading achievement measure was 7.0, which was slightly above grade level for sixth graders at this time of the school year (6.9). The mean of the Classroom Group

was 5.9, which was one full year below grade level (6.9). So, the Tutored Group was on grade level at the end of 8 months of tutoring while the students who did not receive the computer tutoring averaged a year behind. More importantly, out of the Tutored Group, 88% gained 1.0 GE units or more in reading achievement while only 37% of the Classroom group gained 1.0 GE units or more.

- Our best result to date occurred in the 2003-2004 school year at UA, where students' reading ability increased by almost 3 grade levels. Though research was not being conducted during this year, this marked improved demonstrates effectiveness after strict experimental control is removed.
- In summary, students who completed and passed 45 or more of the 50-word lists (out of 184 total) during the school year have had average gains around 2 grades in reading achievement; these students have gained an average of around 1 grade equivalent more than the students who did not get the tutoring.

References:

Carver, R.P. (1990). *Reading rate: A review of research and theory.* New York: Academic Press.

Carver, R.P. (1997). Reading for one second, one minute, or one year from the perspective of rauding theory. *Scientific Studies in Reading, 1(1*), 3-43.

Carver, R.P. (2003). The highly lawful relationships among pseudo word decoding, word identification, spelling, listening, and reading. *Scientific Studies of Reading, 7(2*), 127-154.

Sticht, & James, (1984). Listening and reading. In P.D. Pearson (Ed.), *Handbook of reading research*. New York: Longman, pp. 293-317.

Additional Resources:

Carver, R. P. (1987). *Reading comprehension and rauding theory.* Kansas City, MO: Revrac Publications, Inc.

Carver, R.P. (2000). *The causes of high and low reading achievement.* Mahwah, NJ: Lawrence Erlbaum.