

Rationale and Overview of the CTOPP

IN THE PAST DECADE, MANY professionals working in education, psychology, and speech and language pathology have focused on the study of phonological skills and their relationship to early reading. These professionals have expressed a need for well-constructed standardized tests that assess phonological abilities, specifically tests that (a) measure reading related phonological skills, (b) provide the examiner with a comparative index of phonological processing strengths and weaknesses, (c) are sufficiently reliable that the examiner can have confidence in their results when they are used with individuals, (d) are sufficiently valid that the examiner will know what abilities are being measured, (e) are short enough that the fatigue of both examiner and examinee is held at a minimum, and (f) have norms that are based on a large normative sample that includes representatives of a broad spectrum of Americans. As documented in the chapters of this manual, the *Comprehensive Test of Phonological Processes* (CTOPP) has been designed to satisfy these six requirements. In this chapter, we provide an orientation for the CTOPP by describing the theoretical frame of reference upon which the test is conceptualized, including the three-dimensional model upon which the test is built; an overview of the test; the subtests and the composites that can be formed by grouping the subtest results; and the reasons for testing phonological processes using the CTOPP.

Theoretical Frame of Reference

Most well-constructed tests are based on a model or frame of reference that provides the rationale for the formats, content, and items of their subtests. We describe the theoretical framework that served as the basis of the CTOPP by presenting (a) an introduction to phonological processing abilities, (b) levels of phonological representation, (c) three kinds of phonological processing, and (d) the model of phonological processing.

Introduction to Phonological Processing Abilities

Auditory processing and auditory processing disorders have been of interest to researchers and clinicians in the fields of psychology, education, and speech and language for much of the present century. Interest in auditory processing and its disorders has been heightened by evidence that their importance is not limited to comprehending spoken language. They play a critical role in learning to read, write, and spell, particularly for alphabetic writing systems. They also appear to be involved in mathematical computation. The past decade has witnessed a profound advancement in the understanding of phonological processing—the kind of auditory processing that is most strongly related to mastery of written language, and is clearly implicated as the most common cause of reading disabilities or dyslexia.

Phonological processing refers to the use of phonological information, especially the sound structure of one's oral language, in processing written language (i.e., reading, writing) and oral language (i.e., listening, speaking) (Jorm & Share, 1983; Wagner & Torgesen, 1987). When kindergarten children are given phonological processing tasks, their performance is remarkably predictive of how well they will read several years later. On the basis of a growing number of longitudinal correlational and training studies of beginning readers, one may conclude that causal relations seem to exist between the development of phonological processing abilities and the acquisition of word-level reading skills: Some phonological processing abilities exert a substantial causal influence on the subsequent development of word reading skills; conversely, letter knowledge exerts a more modest causal influence on the subsequent development of phonological processing abilities (Ball & Blachman, 1988; Bradley & Bryant, 1985; Ehri, 1987; Lundberg, Frost, & Petersen, 1988; Perfetti, Beck, Bell, & Hughes, 1987; Wagner, Torgesen, & Rashotte, 1994; Wagner et al., 1997). A deficit in some aspect of phonological processing ability is viewed as a cause of the most common form of reading disability (Bruck, 1990; Bruck & Treiman, 1990; Felton & Wood, 1990; Olson, Wise, Conners, & Rack, 1990; Shankweiler & Liberman, 1989; Stanovich & Siegel, 1994; Torgesen & Wagner, in press). The critical problem for the majority of cases of reading disability is at the level of decoding individual words and components of words (i.e., the ability to decode a word phonetically and pronounce it correctly). Deficits in phonological awareness, phonological memory, and rapid naming are common in children with reading disabilities. These deficits appear to be the root of many of the decoding difficulties faced by individuals with reading disabilities.

Levels of Phonological Representation

The term *phonological* derives from the Greek word *phone*, which means “voice” or “sound.” At its most basic level, a spoken word such as *cat* is represented by varying

waves of acoustic energy (Crowder & Wagner, 1991). This representation can be captured in a spectrogram, which represents amounts of acoustic energy by frequency. Analysis of spectrograms reveals that the separation of words into distinct sounds, or even of sentences into discrete words, is largely a cognitive-perceptual phenomenon rather than a result of features of the acoustic signal itself. Breaks in the presence of acoustic energy do not correspond to breaks between letters or even words for the most part. The acoustic signal that travels from the speaker's voice to the listener's ear is largely continuous, despite the perception of individual words and sounds within words.

At the phonetic level, a level that is one step removed from the actual acoustic signal, speech is represented by strings of phones or basic sounds of a language. Phones are the universal set of speech sounds found in languages. Each phone represents a particular combination of articulatory gestures, including the placement of the tongue in the mouth, the position of the lips, whether the mouth is opened or closed, and whether the vocal cords are vibrating. The sounds corresponding to the letter 'p' in the words *pit*, *tip*, and *spit* represent different phones, despite the fact that they are represented by a single letter in written English. To verify that the 'p' in each of the three words is produced by subtle differences in articulatory gestures, hold your hand several inches in front of your mouth while saying each word. You will feel a pronounced burst of air associated with the 'p' in *pit*, a lesser burst of air associated with the 'p' in *tip*, and virtually no burst of air associated with the 'p' in *spit*.

At the phonological level, which is one step removed from the phonetic level, related phones (called allophones) are combined into families called phonemes. Phonemes represent differences in speech sounds that signal differences in meaning—they are differences listeners hear when attending to speech in everyday conversation. At this level, the three phones associated with the 'p' in *pit*, *tip*, and *spit* are allophones of the single phoneme /p/. The phoneme /p/ is distinguished from the phoneme /k/, which signals the fact that the words *pit* and *kit* have different meanings. All spoken words in Midwestern American English (i.e., what typically is spoken by news anchorpersons of national networks, except Canadian-born Peter Jennings) can be represented with a set of 35 to 45 phonemes, depending on which classification system is used (Denes & Pinson, 1963). At still higher levels, phonemes can be combined into larger units, such as onsets (i.e., the initial consonant or consonant cluster of a syllable), rimes (i.e., the remaining vowel and consonant or consonant cluster), syllables, and words.

Three Kinds of Phonological Processing

Three kinds of phonological processing appear to be especially relevant for mastery of written language: phonological awareness, phonological memory, and rapid naming.

Phonological Awareness. Phonological awareness refers to an individual's awareness of and access to the sound structure of his or her oral language (Mattingly, 1972). The spoken words of a language represent strings of phonemes that signal differences of meaning. The spoken word *cat* has three phonemes, each of which happens to correspond to the sound made by the three letters of the printed word CAT. Change the first sound from /k/ to /b/ and you have the spoken word *bat*. Of the nearly infinite number of possible strings of phonemes that might be represented in an oral language, only a relatively small number actually occur, and these occur in multiple words. Children who have some awareness of this structure seem to have an advantage learning to read the printed forms of a language. This makes sense given that many printed languages attempt to convey pronunciation as well as meaning, and even more so for alphabetic languages such as printed English because letters of the alphabet have a rough correspondence to phonemes.

As children develop, they demonstrate awareness for increasingly smaller phonological units of speech. Initially, their awareness is limited to word-length phonological units, as in recognizing the two parts of the compound word *cowboy*. Next, they become aware of syllables within words, as in recognizing each syllable of the two-syllable word *seven*. Eventually, awareness proceeds within the syllable to recognition of onsets and rimes. For example, for the first syllable of the word *seven*, the onset is the sound of the initial 's,' and the rime is the sound of the vowel and remaining consonant 'ev.' Eventually, awareness is demonstrated for individual phonemes within syllables. Awareness occurs for individual phonemes within rimes, as when recognizing the sounds represented by the letters 'e' and 'm' in the word *stem*. Subsequently, awareness of individual phonemes within consonant clusters occurs, as when recognizing the sounds represented by the letters 's' and 't' in *stem*.

An important reason for assessing phonological awareness is that clear implications for intervention exist. Many children who are weak in phonological awareness show improved reading performance after being given intervention designed to improve their phonological awareness (Ball & Blachman, 1991; Brady, Fowler, Stone, & Winbury, 1994; Bradley & Bryant, 1985; Cunningham, 1990; Lundberg et al., 1988; Torgesen, Morgan, & Davis, 1992). In general, reading approaches that feature systematic, explicit instruction in phonological awareness and phonetic decoding skills produce stronger reading growth in children who are weak in phonological awareness compared with reading approaches that do not teach these skills explicitly (I. S. Brown & Felton, 1990; Felton, 1993; Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998; Hatcher, Hulme, & Ellis, 1994; Lovett, Borden, Lacerenza, Benson, & Brackstone, 1994; Torgesen, Wagner, & Rashotte, 1997; Torgesen et al., in press).

Phonological Memory. Phonological memory refers to coding information phonologically for temporary storage in working or short-term memory. When you

attempt to remember a phone number you have looked up as you make your way to the phone, you are storing the number temporarily in working memory. You probably do so not by storing a visual representation of the sequence of digits (although you may be able to do this if you try), but rather by storing a phonological representation of the sounds of the digit names.

The part of memory most involved in storing phonological information is called the phonological loop. The phonological loop provides a brief, verbatim storage of auditory information (Baddeley, 1986, 1992; Torgesen, 1996). The phonological loop consists of two parts working together. The first is a phonological store, which can be thought of as a tape recording loop that retains the most recent 2 seconds worth of auditory information that has been recorded. The second is an articulatory control process that provides input to the phonological loop initially and also can refresh information already in the loop so that it can be stored for longer than 2 seconds.

A deficient phonological memory does not appear to impair either reading or listening to a noticeable extent, providing the words involved are already in the individual's vocabulary. However, phonological memory impairments can constrain the ability to learn new written and spoken vocabulary (Gathercole & Baddeley, 1990; Gathercole, Willis, & Baddeley, 1991). One clear example is provided by study of an individual who, as an adult, suffered a brain injury that selectively impaired phonological memory (Baddeley, Papagno, & Vallar, 1988). This individual could converse and read relatively fluently provided the words were in his spoken and reading vocabularies. However, this native English speaker was unable to learn new words in the form of Spanish vocabulary. In fact he was unable to even repeat Spanish words accurately. In addition, when presented orally with brief two-syllable nonwords, his accuracy for repeating them was less than 50%. Studies of elementary school-age children also indicate that deficits in phonological memory result in impaired development of written and spoken vocabularies (Gathercole & Baddeley, 1990).

Perhaps the most comprehensive investigation of impaired phonological memory is a series of over 20 experiments that investigated the consequences of poor phonological memories for children with reading disabilities (Torgesen, 1988, 1996; Torgesen & Houck, 1980; Torgesen, Rashotte, & Greenstein, 1988). Early studies demonstrated that the origin of the memory deficit was a specific deficit in phonological coding of familiar verbal materials such as digits and words. Alternative explanations, such as inattention, anxiety, poor use of mnemonic strategies, or poor motivation, were ruled out. The children were not impaired in short-term memory for nonverbal material, long-term memory, or listening comprehension; however, they showed severe impairments in decoding visually presented nonsense syllables. When followed up approximately a decade later, over half of the individuals still had severe memory impairments, and those who did showed almost no improvement in reading skills. Finally, consistent with the studies of Gathercole and Baddeley (1990), individuals with impaired phonological

memories as children scored poorly on the Vocabulary subtest of the *Wechsler Adult Intelligence Scale* a decade later, yet performed adequately on nonverbal performance subtests such as Block Design.

Phonological coding in working memory may not be all that important for reading common known words, although some controversy exists about this assertion (Crowder & Wagner, 1991). It is clear, however, that phonological coding in working memory is potentially more useful when attempting to decode new words, particularly words that are long enough to decode bit by bit, as a means of storing intermediate sounds.

Rapid Naming. The third kind of phonological processing is rapid naming. Rapid naming of objects, colors, digits, or letters requires efficient retrieval of phonological information from long-term or permanent memory. When reading, young readers presumably retrieve (a) phonemes associated with letters or letter pairs, (b) pronunciations of common word segments, and (c) pronunciations of whole words. The efficiency with which children are able to retrieve phonological codes associated with individual phonemes, word segments, or entire words should influence the degree to which phonological information is useful in decoding printed words (Baddeley, 1986; Wolf, 1991).

Measures of rapid naming require speed and processing of visual as well as phonological information. Some researchers who study rapid naming suggest that rapid naming tasks assess the operation of a precise timing mechanism that is important for the developing knowledge of common letter patterns in printed words (Bowers & Wolf, 1993; Wolf, 1991). Consequently, individuals who show poor performance on rapid naming tasks are expected to have difficulty reading fluently. Individuals who have double deficits—that is, deficits in both rapid naming and phonological awareness—appear to have greater difficulty learning to read than do individuals with deficits in either rapid naming or phonological awareness alone (Bowers & Wolf, 1993).

The Model of Phonological Processing

The frame of reference described in the previous section can be depicted in a model of phonological processing (Wagner & McBride-Chang, 1996; Wagner et al., 1987; Wagner & Torgesen, 1987; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993; Wagner et al., 1994; Wagner et al., 1997). This model is presented in Figure 1.1.

Phonological awareness, phonological memory, and rapid naming represent three correlated yet distinct kinds of phonological processing abilities. These abilities are correlated rather than independent, in that confirmatory factor analytic studies reveal that the correlations between them are substantially greater than zero. They are distinct rather than undifferentiated, in that the correlations between them are less than one. In general, phonological awareness and phonological memory tend to be more highly cor-

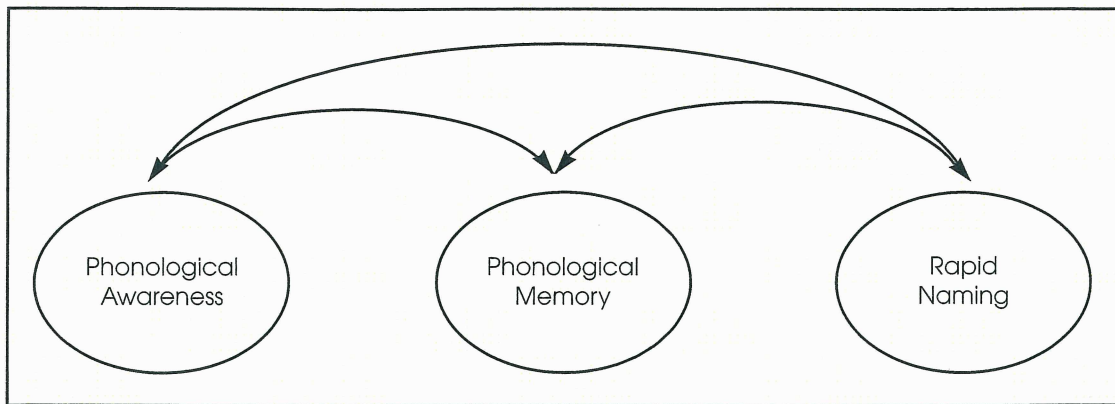


Figure 1.1. The model of phonological processing.

related with one another than with rapid naming. In addition, the three kinds of phonological processing abilities tend to become less correlated with development. For very young children, phonological awareness and phonological memory can be nearly perfectly correlated (Wagner et al., 1987; Wagner et al., 1993).

Overview of the CTOPP

The *Comprehensive Test of Phonological Processing* (CTOPP) assesses phonological awareness, phonological memory, and rapid naming. A deficit in one or more of these kinds of phonological processing abilities is viewed as the most common cause of learning disabilities in general, and of reading disabilities in particular. In addition to their role in learning to read, phonological processing abilities also support effective mathematical calculation, listening comprehension, and reading comprehension. The CTOPP was developed to aid in the identification of individuals from kindergarten through college who may profit from instructional activities to enhance their phonological skills. Because the test battery spans such a wide range of ages, it was necessary to develop two versions of the test. The first version, developed for individuals ages 5 and 6 years old, primarily kindergartners and first graders, contains seven core subtests and one supplemental test (see Table 3.1). The second version, for individuals ages 7 through 24, persons in second grade through college, contains six core subtests and six supplemental tests (see Table 3.2). In both versions the supplemental subtests are provided to allow the examiner to more carefully assess specific phonological strengths and weaknesses. Both versions are individually administered and require about 30 minutes for administration of the core subtests.

Uses of the Test

The CTOPP has four principal uses: to identify individuals who are significantly below their peers in important phonological abilities, to determine strengths and weaknesses among developed phonological processes, to document individuals' progress in phonological processing as a consequence of special intervention programs, and to serve as a measurement device in research studies investigating phonological processing.

First, the CTOPP can be used to obtain information that is helpful in identifying those children and young adults who are markedly deficient in phonological processing ability. Phonological processing abilities have been shown to be related to later success in reading in a large number of studies (Adams, 1990; Bradley & Bryant, 1985; Bryant, MacLean, Bradley, & Crossland, 1990; Byrne, Freebody, & Gates, 1992; Foorman, Francis, Novy, & Liberman, 1991; Fowler, 1991; Juel, Griffith, & Gough, 1986; Liberman, Shankweiler, & Liberman, 1989; Lundberg, Olofsson, & Wall, 1980; McBride-Chang, 1995b, 1996; Morais, 1991; Stahl & Murray, 1994; Stanovich, Cunningham, & Cramer, 1984; Treiman, 1991; Tunmer, Herriman, & Nesdale, 1988; Tunmer & Nesdale, 1985; Tunmer & Rohl, 1991; Vellutino & Scanlon, 1987; Wagner et al., 1994; Wagner et al., 1997). In addition, a deficit in one or more aspects of phonological processing is viewed as the primary cause of the majority of cases of learning disabilities (Ackerman & Dykman, 1993; Bruck, 1990; Bruck & Treiman, 1990; Catts, 1989; Elbro, Nielsen, & Petersen, 1994; Felton & Brown, 1990; Felton & Wood, 1990; McBride-Chang, 1995a; McBride-Chang & Manis, in press; Olson, Wise, Conners, Rack, & Fulker, 1989; Shankweiler & Liberman, 1989; Siegel & Ryan, 1988; Stanovich, 1988; Torgesen, 1991; Torgesen, Wagner, Simmons, & Laughon, 1990;

Tunmer, 1989; Wagner, 1986; Wolf & Obregon, 1992). The CTOPP can be used to verify or document a processing deficit that is suspected on the basis of an individual's performance on other measures, such as the *Wechsler Intelligence Scale for Children—Third Edition* (Wechsler, 1991). For this usage, one might administer subtests corresponding to one, two, or all three kinds of phonological processing, depending on one's purpose. A particularly valuable use of the CTOPP in this context is early identification of kindergarten and first-grade children whose deficiencies in phonological processing leave them at risk for reading failure. Early identification coupled with early intervention designed to promote phonological awareness appear to be promising approaches to reducing the incidence of reading failure.

Second, the results of the CTOPP are useful to inventory a person's relative strengths and weaknesses (i.e., they are helpful in conducting an intraindividual assessment of phonological processing assets and deficits). Not only can examiners analyze performance across the contents of the subtests, but they can investigate a person's status relative to the constructs incorporated into the test (i.e., composite quotients). By considering the CTOPP's composite scores, examiners can contrast aspects pertaining to phonological awareness, phonological memory, and rapid naming abilities.

Third, examiners can use the CTOPP to provide a means for evaluating an individual's progress in prescribed remedial programs. The monitoring of an individual's progress is an important component of special instruction and is often required by law or by school policy. Periodic assessment is desirable even when it is not required because it provides educators with evidence that the instructional program is appropriate to meet an individual's needs.

Fourth, the CTOPP has value as a research tool, especially for investigators who wish to study phonological processing using standardized instruments. Its results can be used to test the adequacy of various theories of phonological processing; to measure the relationship of certain abilities to reading proficiency, to successful everyday living skills, and so forth; and to determine the effectiveness of various intervention programs on test performance.

Tests that are used for these four purposes should satisfy rigorous technical adequacy criteria. In fact, many state agencies and several professional organizations, most notably the American Psychological Association (1985), have set up criteria that all good tests should satisfy. These standards generally relate to reliability, validity, normative data, and methods for reporting scores. The CTOPP was constructed with these requirements clearly in mind in order to better meet the purposes for testing.