Journal of Communication Disorders 51 (2014) 51–63

Contents lists available at ScienceDirect

Journal of Communication Disorders

Construct-related validity of the *TOCS* measures: Comparison of intelligibility and speaking rate scores in children with and without speech disorders

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ARTICLE INFO

Article history:
Received 14 April 2014
Received in revised form 8 June 2014
Accepted 30 June 2014
Available online 12 July 2014

Keywords:
Intelligibility
Children
Cerebral palsy
Dysarthria
Speech sound disorders
Speaking rate

ABSTRACT

This study evaluated construct-related validity of the *Test of Children's Speech* (*TOCS*). Intelligibility scores obtained using open-set word identification tasks (orthographic transcription) for the *TOCS* word and sentence tests and rate scores for the *TOCS* sentence test (words per minute or WPM and intelligible words per minute or IWPM) were compared for a group of 15 adults (18–30 years of age) with normal speech production and three groups of children: 48 3–6 year-olds with typical speech development and neurological histories (TDS), 48 3–6 year-olds with a speech sound disorder of unknown origin and no identified neurological impairment (SSD-UNK), and 22 3–10 year-olds with dysarthria and cerebral palsy (DYS). As expected, mean intelligibility scores and rates increased with age in the TDS group. However, word test intelligibility, WPM and IWPM scores for the 6 year-olds in the TDS group were significantly lower than those for the adults. The DYS group had significantly lower word and sentence test intelligibility and WPM and IWPM scores than the TDS and SSD-UNK groups. Compared to the TDS group, the SSD-UNK group also had significantly lower intelligibility scores for the word and sentence tests, and significantly lower IWPM, but not WPM scores on the sentence test. The results support the construct-related validity of *TOCS* as a tool for obtaining intelligibility and rate scores that are sensitive to group differences in 3–6 year-old children, with and without speech sound disorders, and to 3+ year-old children with speech disorders, with and without dysarthria.
Learning outcomes: Readers will describe the word and sentence intelligibility and speaking rate performance of children with typically developing speech at age levels of 3, 4, 5 and 6 years, as measured by the Test of Children's Speech, and how these compare with adult speakers and two groups of children with speech disorders. They will also recognize what measures on this test differentiate children with speech sound disorders of unknown origin from children with cerebral palsy and dysarthria.

1. Introduction

The ability to produce spoken language that is understandable to others is typically achieved by age four years; by this age most children can use speech successfully in their daily communication interactions. For example, Coplan and Gleason (1988)

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http://dx.doi.org/10.1016/j.jcomdis.2014.06.007
0021-9924/

reported the following ages at which 90% of parents assigned a given level of intelligibility to their child when asked "How much of your child's speech can a stranger understand?" 50% at 22 months, 75% at 37 months, and 100% at 48 months. These findings are consistent with the guideline provided by Flipsen (2006), who suggested the following formula: age (years)/4 × 100 = % of conversational speech that is intelligible to unfamiliar adults (i.e., age 1 year = 25%, 2 years = 50% intelligible, 3 years = 75% and 4 years = 100%). Weiss (1982) reported the following developmental milestones for speech intelligibility, based on the mean of word identification scores obtained from a 200-word orthographic transcription of a spontaneous speech sample and from a set of 25 single words, when audio recordings of the speech samples and words were judged by an unfamiliar adult: 25% by 18 months, 50% by 2 years, 64% by 2.5 years, 80% by 3 years, 92% by 3.5 years and 100% by 4 years. More recently, Rice et al. (2010) reported the percentage of intelligible utterances calculated from spontaneous speech samples using the SALT software (Miller & Chapman, 1991) for 176 children in their control group (unaffected by specific language impairment) at 6-month age intervals from 2.5 to 9.0 years. As expected, mean scores increased with age; the lowest score (74%) was reported for the 2.6–2.11 age interval and the highest score (94%) was reported for the 8.6–8.11 age interval. Children aged 3.6 to 4.11 had scores between 84% and 87% and children 5.0 and older had scores greater than 90%.

Children with moderate or more severe developmental speech delays and/or disorders often have reduced intelligibility that may persist beyond the preschool years. Gordon-Brannan and Hodson (2000) reported intelligibility scores for imitated single words on the *Children's Speech Intelligibility Measure* (*CSIM*) (Wilcox & Morris, 1999), a sentence repetition task, and a 100-word spontaneous speech sample for children between 4.0 and 5.6 years with varying levels of phonological proficiency (adult-like to severe involvement). No child in their study had known neuromotor involvement that might affect speech production and all children had age-appropriate receptive language. Children in the "adult-like" subgroup obtained high mean scores in the three conditions (84% on the *CSIM*, 96% on the imitated sentences, 95% on the spontaneous sample). Mean scores of the children with the most severe phonological impairment were 35% on the CSIM, 44% on the imitated sentences, and 48% on the spontaneous sample. Flipsen (2006) compared several different versions of the Intelligibility Index (Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997), based on spontaneous speech samples, for children between 3.0 and 8.11 with normal (or normalized speech) and with speech delay. All age means in the group with normal speech were above 95.5% and increased to a maximum of 99.5%, as age increased. Age means in the group with speech delay ranged from 80.8% for the 3 year-olds to 95.3% for the 8 year-olds.

Children with cerebral palsy (CP) and developmental dysarthria have a chronic neuromuscular impairment underlying their speech disorder that often delays early speech learning and reduces speech intelligibility. CP is defined as a group of disorders of movement and posture that limit activity and are attributed to non-progressive disturbances in the fetal or infant brain (Bax, Goldstein, Rosenbaum, Leviton, & Paneth, 2005). The impact of CP on a child's motor control for speech production may impair the strength, speed, accuracy, coordination and endurance of the muscle groups used to speak (Workinger, 2005). These impairments constrain development of differentiated, precise, dynamic actions of the oral articulators and their coordination with the respiratory–phonatory system to produce clear, efficient speech patterns, which can limit the success of spoken interactions (Hodge, 2010; Pennington, 2008). Pennington, Roelant, Thompson, Robson, Steen, and Miller (2013) reported intelligibility scores for the *CSIM* and word identification of connected speech samples (combination of imitated and spontaneous utterances) for 15 five to eleven year-old children with CP who underwent an experimental speech therapy procedure. Mean intelligibility scores obtained six weeks prior to treatment, based on three unfamiliar listeners, were 46.8% (SD 18.7) for the *CSIM* and 43.7% (SD 24.7) for the connected speech sample. These results indicate significant intelligibility deficits for the group as a whole, compared to what is expected for similar-aged peers without speech disorders, and are most similar to the mean scores of the children with the most severe phonological impairment (without dysarthria) reported by Gordon-Brannan and Hodson (2000).

Speech intelligibility measures are desirable to estimate the severity of a child's speech disorder, which is used to determine the need for and nature of intervention and to potentially discriminate between children with and without speech disability (Hodson, 2004). Increasing intelligibility is often a primary therapeutic goal for young children with speech disorders, regardless of the underlying reason for the intelligibility deficit; intelligibility has been identified an important outcome measure to evaluate change in a child's ability to make his or her speech understandable to others, (e.g., McLeod, Harrison, & McCormack, 2012; Pennington, Miller, Robson, & Steen, 2010; Pennington et al., 2013). However, assessment of intelligibility remains a challenge because of differences in how narrowly or broadly it is defined and the multiple factors that can affect its measurement (Flipsen, 2006; Hodge & Whitehill, 2010; Kent, Miolo, & Bloedel, 1994; Miller, 2013). These include variables related to the talker, the speaking task and environment, phonetic and linguistic characteristics of the spoken material, listener characteristics, judging task and listening environment. This is particularly the case for pre-literate children, children at younger ages developmentally, and/or children with central nervous system impairment, where additional factors related to language competence and ability to attend to, and perform the speaking task, may further complicate intelligibility assessment.

2. Brief summary of the Test of Children's Speech (*TOCS*)

TOCS (Hodge, Daniels, & Gotzke, 2009) was developed to provide a standard protocol for obtaining intelligibility and speaking rate measures from children with developmental language ages as young as three years. The impetus for developing *TOCS* was to provide a means to obtain reliable and valid intelligibility measures from English-speaking children with dysarthria. *TOCS* measures are based on a narrow definition of intelligibility, that is, the extent to which listeners who