Journal of Communication Disorders 62 (2016) 1–11

Contents lists available at ScienceDirect

Journal of Communication Disorders

Short-term and long-term test-retest reliability of the Nasality Severity Index 2.0

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ARTICLE INFO

Article history:
Received 12 August 2015
Received in revised form 18 December 2015
Accepted 1 May 2016
Available online 3 May 2016

Keywords:
Nasality Severity Index
Hypernasality
Reliability

ABSTRACT

Purpose: The Nasality Severity Index 2.0 (NSI 2.0) forms a new, multiparametric approach in the assessment of hypernasality. To enable clinical implementation of this index, the short- and long-term test-retest reliability of this index was explored.
Methods: In 40 normal-speaking adults (mean age 32y, SD 11, 18–56y) and 29 normal-speaking children (mean age 8y, SD 2, 4–12y), the acoustic parameters included in the NSI 2.0 (i.e. nasalance of the vowel /u/ and an oral text, and the voice low tone to high tone ratio (VLHR) of the vowel /i/) were obtained twice at the same test moment and during a second assessment two weeks later. After determination of the NSI 2.0, a comprehensive set of statistical measures was applied to determine its reliability.
Results: Long-term variability of the NSI 2.0 and its parameters was slightly higher compared to the short-term variability, both in adults and in children. Overall, a difference of 2.82 for adults and 2.68 for children between the results of two consecutive measurements can be interpreted as a genuine change. With an ICC of 0.84 in adults and 0.77 in children, the NSI 2.0 additionally shows an excellent relative consistency. No statistically significant difference was withheld in the reliability of test-retest measurements between adults and children.
Conclusion: Reliable test-retest measurements of the NSI 2.0 can be performed. Consequently, the NSI 2.0 can be applied in clinical practice, in which successive NSI 2.0 scores can be reliably compared and interpreted.
Learning outcomes: The reader will be able to describe and discuss both the short-term and long-term test-retest reliability of the Nasality Severity Index 2.0, a new multiparametric approach to hypernasality, and its parameters. Based on this information, the NSI 2.0 can be applied in clinical practice, in which successive NSI 2.0 scores, e.g. before and after surgery or speech therapy, can be compared and interpreted.

Abbreviations: NSI 2.0, Nasality Severity Index 2.0; MDT, maximum duration time; VLHR, voice low tone to high tone ratio; ICC, intraclass correlation coefficient; SEM, standard error of measurement; MDD, minimal detectable difference.

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http://dx.doi.org/10.1016/j.jcomdis.2016.05.001
0021-9924/

1. Introduction

To assess and diagnose hypernasality, speech-language pathologists as well as other clinicians mostly rely on a combination of perceptual and instrumental measurements. A perceptual assessment based on spontaneous speech, automatic speech and reading or repeating sentences and words remains the "gold" standard to determine resonance disturbance. However, perceptual measurements are subjective and therefore can be influenced by vocal quality (Kataoka, Warren, Zajac, Mayo, & Lutz, 2001) and articulation errors of the patient (Bzoch, 1997) or by experience of the examiner (Lewis, Watterson, & Houghton, 2003). To support the perceptual analysis, several instrumental measurements are available to determine the presence and amount of resonance disturbance (Bettens, Wuyts, & Van Lierde, 2014). However, contradictory results can emerge when the outcomes of different assessment techniques are compared. Acoustic analyses based on, for example nasometry or spectral analyses, do not always strongly correlate with perceptual judgments (Keuning, Wieneke, van Wijngaarden, & Dejonckere, 2002; Lewis et al., 2003; Nellis, Neiman, & Lehman, 1992; Prado-Oliveira, Marques, Souza, Souza-Brosco, & Dutka Jde, 2015; Watterson, McFarlane, & Wright, 1993) or are based on vowels only, which may limit their representativeness of spontaneous speech (Lee, Wang, & Fu, 2009; Rah, Ko, Lee, & Kim, 2001; Vijayalakshmi, Reddy, & O'Shaughnessy, 2007). Therefore, a combination of complementary test results into a multiparametric index can form a solution. In a pilot study, Van Lierde, Wuyts, Bonte, and Van Cauwenberge (2007) developed the Nasality Severity Index (NSI) based on a combination of five parameters, more specifically the nasalance value of the vowel /a/, an oral and oronasal text derived by the Nasometer (model 6200); the maximum duration time (MDT) of /s/; and the mirror-fogging test by Glätzel of /a/. The equation yielded NSI = −60.69 − (3.24 × nasalance oral text (%)) − (13.39 × Glätzel value /a/) + (0.244 × MDT (s)) − (0.558 × nasalance /a/ (%)) + (3.38 × nasalance oronasal text (%)). However, influence of personal and environmental variables due to the inclusion of MDT of /s/ and the use of the mirror-fogging test by Glätzel (Foy, 1910) was detected (Bettens, Wuyts, De Graef, Verhegge, & Van Lierde, 2013). Therefore, Bettens, Van Lierde, Corthals, Luyten, and Wuyts (2016) proposed an adaptation of the NSI based on the data of different instrumental measurement techniques and the optimal statistical discrimination between 50 children without resonance disturbance and 35 children with hypernasality, in a stepwise statistical approach, with sensitivity and specificity as the serving criteria. A weighted linear combination of three variables was established, more specifically the nasalance scores of the vowel /u/ and an oral text obtained with the Nasometer (model II 6450) and the voice low tone to high tone ratio (VLHR) of the vowel /i/ with a cutoff frequency of 4.47*F0Hz (originally described by Lee, Yang, and Kuo (2003)) (see Bettens et al. (2016) for more information about the rationale behind and the derivation of the formula). The formula of the adapted NSI yields NSI 2.0 = 13.20 − (0.0824 × nasalance /u/ (%)) − (0.260 × nasalance oral text (%)) − (0.242 × VLHR /i/ 4.47*F0Hz (dB)). The mean NSI 2.0 value of patients with perceived hypernasality was −6.82 (SD 5.14), whereas the mean NSI 2.0 value of the control children with normal resonance was +4.08 (SD 1.59). With a cutoff score of zero, the NSI 2.0 discriminated patients with hypernasality from persons with normal resonance with a sensitivity of 92% and a specificity of 100%, in which patients with perceived hypernasality had scores below zero. The validity of this new index was proven to be high by application of the parameter results of an independent patient and control group on the derived formula (sensitivity 88%, specificity 89%), in which all patients were perceptually judged with hypernasality and all control children with normal resonance.

However, before the NSI 2.0 can be implemented in daily clinical practice, the reliability of this new index has to be verified. According to literature, several sources can affect the stability of instrumental measurements (Lewis, Watterson, & Blanton, 2008). More specifically, instrumental variance (e.g. microphone and sound cart characteristics, machine model), test procedure (e.g. distance from the microphone), subject performance (e.g. physiological factors, nasal patency) and the environment (e.g. air moisture and temperature) can influence the reliability of assessment techniques. Similarly, the components of the NSI 2.0 are susceptible to these sources of variation.

Two of the three parameters included in the index are obtained by the Nasometer. This device, originally developed by Fletcher and Bishop (1970) and manufactured by KayPentax (KayPentax, NJ, Lincoln Park), determines the amount of nasal resonance based on an acoustic analysis of both a nasal and oral signal, and is considered an indirect measure of nasality. The signals are obtained by two microphones divided by a sound separation plate which is positioned between the nose and the upper lip of the participant. After filtering the signals using a band pass filter with a center frequency of 500 Hz and a bandwidth of 300 Hz, the ratio of the nasal signal to the (nasal + oral) signal, multiplied by 100, yields the nasalance score in a percentage. Several authors state that, although based on similar acoustic analyses of nasal and oral signals, nasalance scores of different instruments, such as the Nasometer, NasalView and OroNasal System, are not interchangeable (Awan, Omlor, & Watts, 2011; Bressmann, 2005; Bressmann, Klaiman, & Fischbach, 2006; Lewis & Watterson, 2003). Additionally, scores obtained with different models of the same instrument can also vary significantly (Awan et al., 2011; Awan & Virani, 2013; de Boer & Bressmann, 2014; Watterson & Lewis, 2006). Even results determined with different devices of the same model may differ due to the characteristics of the nasal and oral microphone (Zajac, Lutz, & Mayo, 1996). When the same device is used, replacement of the headgear can introduce a second source of variability (Watterson, Lewis, & Brancamp, 2005; Watterson & Lewis, 2006), although Lewis et al. (2008) and Kavanagh, Fee, Kalinowski, Doyle, and Leeper (1994) found only small differences between the condition of no change of the headgear and headgear change between two successive measurements. Next to instrumental and procedure variation, personal variation also has an influence on the reliability of the test results. Extensive research focused on between-subject variability, more specifically the influence of age (Brunnegard & van Doorn, 2009; Luyten et al., 2012; Prathanee, Thanaviratananich, Pongjunyakul, & Rengpatanakij, 2003; Van der Heijden, Hobbel, Van der Laan, Korsten-Meijer, & Goorhuis-Brouwer, 2011; van Doorn & Purcell, 1998), gender