Original Article

The Construction and Development of the Thai Simplified Nasometric Assessment Procedures (Thai SNAP Test) for Children Aged 4 to 6 Years

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Objective: To construct and develop the Thai Simplified Nasometric Assessment Procedures [Thai SNAP Test] for children aged 4 to 6 years and assess the validity and reliability of the test.

Materials and Methods: After the Thai SNAP Test was constructed, the test content validity was assessed by three professional speech and language pathologists and the reliability was determined using the test-retest reliability method. Fifty-one normal Thai children aged 4 to 6 years were asked to produce 25 speech stimuli. The first and second nasalance scores of each speech stimulus were obtained using a Nasometer II Model 6450.

Results: The Thai SNAP Test is composed of two subtests: 20 items in Syllable Repetition/Prolonged Sound Subtest I, and 5 items in Picture-Cued Subtest II. All items showed an excellent level of expert agreement (I-CVI = 1.00). Correlation coefficients for the test-retest nasalance scores showed moderate to very strong positive linear relationships ranging from 0.63 to 1.00 ($p<0.05$).

Conclusion: The Thai SNAP Test could potentially be used as a part of a clinical nasalance assessment process for children aged 4 to 6 years, including children with illiteracy, limited attention span, lack of cooperation, or limited phonological competence. The examiner can select the most appropriate items needed to measure the nasalance scores depending on the phonological competence of the subject.

Keywords: Thai SNAP Test, Nasalance score, Nasometer, Thai children

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A Nasometer is a computer-based instrument that provides objective data regarding nasal acoustic energy when a subject produces the speech stimulus passages. The ratio of nasal acoustic energy to oral plus nasal acoustic energy is calculated in term of percentage and is called the 'nasalance score'. This score can be used to evaluate velopharyngeal dysfunction[1,2], upper airway obstruction[2,3], and surgical as well as speech therapy outcomes. For the nasalance score assessment, the subject is asked to read or repeat the speech stimuli[4,5].

In Thailand, the speech stimuli passages were developed for objective assessment and normative nasalance score collection[6-8]. These speech stimuli were approximately 34 to 170 syllables in length. Some sentences were semantically and syntactically complicated, making the passages difficult to read or even repeat correctly, especially for children aged 4 to

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6 years who cannot read accurately, have a limited attention span and incomplete phonological acquisition[9,10]. Thus, when the phonetic heterogeneity passage is produced with articulation substitution, the nasalance score loses some validity[11].

MacKay and Kummer[12] designed and developed an appropriate nasalance protocol known as "the MacKay-Kummer SNAP Test-R Simplified Nasometric Assessment Procedures Revised 2005", which is used with young children and individuals with reading difficulties or illiteracy. The SNAP Test-R consists of three separate subtests: Syllable Repetition/ Prolong Sound Subtest, Picture-Cued Subtest, and Reading Passages Subtest. Researchers can select the appropriate items in the test for use in the assessment, depending on the phonological competence of the subject and the diagnostic goals of the assessment. The SNAP Test-R has many advantages but is not readily available in Thai language. Thus, construction and development of the Thai SNAP Test is an interesting and beneficial undertaking.

Objective

To construct and develop the Thai SNAP Test for children aged 4 to 6 years and assess the validity and reliability of the test.

Materials and Methods

Subjects

The study was conducted on 51 normal Thai children aged 4 to 6 years who were Central Thai speakers with no trace of a foreign accent. They had normal resonance, voice, and age-appropriateness with speech and language development. These characteristics were screened by using the Universal Parameter for Reporting Speech Outcomes in Individuals with Cleft Palate[13], perceptual assessment of voice, screening of language development[14] and articulation[15], respectively. Speech samples were taken from five general situations at their schools by using a digital voice recorder (SONY UX series model ICD-UX512F/L). The subjects had no history of neuromotor dysfunction, craniofacial abnormalities, tonsillectomy, adenoidectomy, hearing loss, mental retardation or attention deficit hyperactivity disorders. In addition, subjects with upper respiratory infection or/and nasal obstruction on the day of assessment were excluded from the study.

Construction of Thai SNAP test

The Thai Simplified Nasometric Assessment Procedures [Thai SNAP test] was constructed following approval from the Ethical Committee of Ramathibodi Hospital. The protocol number of the Documentary Proof of Ethical Clearance is 02-58-24. The test is based on the MacKay-Kummer SNAP Test-R Simplified Nasometric Assessment Procedures Revised 2005[12], and is composed of two subtests, namely the Syllable Repetition/Prolonged Sound Subtest I and Picture-Cued Subtest II.

The first subtest was designed to measure the nasality of a subject's speech. The subtest had 20 items and is divided into two parts. The first part, the Syllable Repetition Subtest, comprises 16 consonant-vowel (CV) syllables that contain high oral pressure-sensitive (/pʰ/, /tʰ/, /kʰ/, /s/, and /tɕʰ/) and nasal Thai consonants (/m/, /n/, and /ŋ/) combined with either a low vowel /a:/ or a high vowel /i:/. The second part, the Prolonged Sound Subtest, comprises two prolonged vowels /a:/ and /i:/ and two prolonged consonants /s/, and /m/.

The second subtest was also designed to assess the presence of hypernasality or hyponasality in a subject's speech. The subtest is composed of five picture-cued sentences that are essential phonetically homogeneous, focusing on bilabial plosives: /pʰ/, /p/, /b/, lingual-alveolar plosives: /tʰ/, /t/, /d/, velar plosives: /kʰ/, /k/, sibilant fricatives: /s/, and nasals: /m/, /n/, and /ŋ/.

The vocabulary in each sentence were chosen from speech samples of Thai children aged 4 to 6 years, which delivered from 10-minute conversation in five general situations (learning session, milk-break session, lunch session, playing session, and in the classroom before going home) at school. The speech samples were recorded by using a digital voice recorder. The selected vocabulary from all speech samples were then applied to the creation of the Picture-Cued Subtest. Each picture-cued sentence was constructed as a short sentence composed of a same simple leading phrase followed by three simple pictures (one picture represents one word). The picture-cued sentences for bilabial plosives were /pʰîːpʰóp puː/, /pʰîːpʰóp pʰát/ and /pʰîːpʰóp boː/; lingual-alveolar plosives were /ta: duː daːw/, /ta: duː tûː/ and /ta: duː tʰáːw/; velar plosives were /kʰăw kʰăːj kʰàj/, /kʰăw kʰăj kàj/ and /kʰăw kʰăːj kʰék/, sibilant fricatives were /sŭːa sàj sûːa/, /sŭːa sàj sôː/ and /sŭːa sàj sóːj/ while nasals were /mêː mɔːŋ măː/, /mêː mɔːŋ ŋuː/ and /mêː mɔːŋ nŭː/. The Picture-Cued Subtest consists of 15 black and white pictures that are presented on a computer screen during the collection of data.

Validity and reliability assessment

After the test was constructed, three professional speech and language pathologists [SLPs] with more than 20 years of experience in working with the cleft palate patients analysed the validity of the constructed test by using the content validity method[16]. The SLPs' qualifications are shown in Table 1.

These SLPs evaluated the consonants and vowels of each item and the selected vocabulary. A 4-point rating scale was used to evaluate the degree of content relevance: 1 = not relevant, 2 = somewhat relevant, 3 = quite relevant, 4 = highly relevant[16-18]. A rating of 1 or 2 is considered to be of low relevance, while a rating of 3 or 4 is considered to be of high relevance. The item-level content index [I-CVI] was computed based on the number of professional SLPs given a rating of either 3 or 4 divided by the total number of professional SLPs. The item-level content validity index [I-CVI] was at least 0.8. If the CVI was less than 0.8, then the author would have revised the test until the required level of validity was reached.

After all item-level content validity indices had reached 0.8, fifteen pictures for the five picture-cued sentences in Subtest II were assessed by 20 normal children aged 4 to 6 years who were not included in the main research study. Each picture was identified correctly by the children at least 80 percent of the time. If identification was less than 80 percent, that picture was then redrawn until 80 percent was reached.

After the validity of the Thai SNAP test was established, it was continuously evaluated by using test-retest reliability[19]. Fifty-one subjects who passed the screening processes and met the criteria were invited to visit the speech clinic at Ramathibodi Hospital. Prior to data collection, a Nasometer II Model 6450 was calibrated at the beginning of the test day. The subject practiced producing the speech sounds according to the test a single time. In the Syllable Repetition/Prolonged Sounds Subtest, the subjects were asked to say the syllable or sound that they could pronounce clearly. The researcher asked the subject to repeat the syllable correctly at a normal speed of approximately 6 to 10 syllables per 2 seconds[12] and to prolong the sounds clearly for at least 3 seconds. In the Picture-Cued Subtest, the subjects were asked to say the sentences that they could pronounce clearly. He or she pronounced a simple leading phrase with a single picture name in order to elicit a sentence. The set of three sentences was spoken twice; thus, there were six sentences produced for each passage[12]. Young children who had reading difficulties or literacy issues were asked to repeat the sentences following the researcher.

In actual testing, the researcher informed the subject instructions and the test methods for each task by speaking at a normal pitch and volume. The subjects performed the test that matched their articulation abilities. The order of the stimulus subtests was randomised for each person by using a table of random numbers[20]. If the subject made an error, such as repeating a word or spontaneously coughing, he or she was asked to repeat the test item. The headgear was fixed and checked to ensure it was at the same placement. The first and second nasalance scores of each subject were analysed for reliability. The strength of the linear relationship between the first and second nasalance scores of each speech stimulus was at least 0.8.

Table 1. SLPs' qualifications

SLP number	Academic degree	SLPs' experience in working with the cleft palate patients (years)
1	PhD	35
2	PhD	25
3	PhD	22

Results

Validity assessment for the test

Statistical analysis was completed by using IBM SPSS Statistics Package Version 22. The twenty-five items of the constructed test that were rated 3 or 4 were considered as relevant. The results showed that all items of the test had an I-CVIs of 1.00.

After all I-CVIs had reached 0.80, the illustrations were drawn for the 15 pictures in subtest II. The data analysis revealed that more than 80 percent of 20 subjects named all of the pictures correctly, except picture of /sûː a/ and /mă:/. These pictures were then redrawn and brought to the same subjects to be reassessed. This time, these two pictures were named correctly more than 80 percent.

Reliability assessment for the test

The test-retest nasalance scores of each item of 51 subjects were used to evaluate the normal distribution by using the test of normality. The test-retest nasalance scores of Syllable Repetition Subtest: /pʰi:/, /tʰi:/, /tɕʰi:/, /ma:/, /na:/, Picture-Cued Subtest:

bilabial plosives, alveolar plosives, sibilant fricatives, and velar plosives items were normally distributed. Following this, the Pearson's correlation coefficient was calculated to determine the relationship between the first and the second nasalance scores of each speech stimulus. The correlation coefficients for nine pairs of these items are shown in Table 2.

The other 16 test-retest nasalance scores of the Syllable Repetition Subtest: /pʰa:/, /tʰa:/, /kʰa:/, /sa:/, /tUʰa:/, /kʰi:/, /si:/, /ŋa:/, /mi:/, /ni:/, /ŋi:/, /a:/, /i:/, /s/, /m/, and Picture-Cued Subtest: nasals items were not normally distributed. Therefore, the Spearman's rank correlation coefficient was computed to determine the relationship between the first and the second nasalance scores of each speech stimulus. The correlation coefficients for 16 pairs of these items are shown in Table 3.

Table 2. Pearson's correlation coefficients for nine pairs of items of the Thai SNAP Test

Pairs of items	r
Subtest 1: Syllable Repetition/ Prolonged Sound Subtest	
/pʰi:/	0.84*
/tʰi:/	0.85*
/tUʰi:/	0.80*
/ma:/	0.91*
/na:/	0.92*
Subtest 2: Picture-Cued Subtest	
Bilabial plosives	0.80*
Alveolar plosives	0.87*
Velar plosives	0.86*
Sibilant fricatives	0.86*

* Correlation is significant at $p<0.05$ (2-tailed)

Table 3. Spearman's rank correlation coefficients for 16 pairs of items of the Thai SNAP Test

Pairs of items	r
Syllable Repetition/Prolonged Sound Subtest	
/pʰa:/	0.63*
/tʰa:/	0.70*
/kʰa:/	0.68*
/sa:/	0.74*
/tUʰa:/	0.73*
/kʰi:/	0.86*
/si:/	0.82*
/Ka:/	0.94*
/mi:/	0.90*
/ni:/	0.87*
/Ki:/	0.92*
/a:/	0.79*
/i:/	0.90*
/s/	1.00
/m/	0.67*
Picture-Cued Subtest	
Nasals	0.93*

* Correlation is significant at $p<0.05$ (2-tailed)

Discussion

Construction of Thai SNAP test

For subtest I, the high oral pressure sensitive consonants were selected based on the results of Moon et al[21], Seaver et al[22], and Flowers et al[23]. These researchers reported that the high oral pressure consonants (plosives, affricates, and fricative), especially voiceless sounds, had the greatest height of velar contact and firmest velopharyngeal closure. Furthermore, the velopharyngeal closure was maintained while producing these high oral pressure sensitive consonant-vowel items. Hence, it was appropriate for the evaluation of the velopharyngeal closure. Moreover, /pʰ/, /tʰ/, and /kʰ/ are the consonants that normal Thai children aged 4 to 6 years produced clearly[9,10]. Children can produce the sound /tɕʰ/ and /s/ clearly at an age of 4.6 to 5 years[9,10], respectively. However, the selected consonants differed from the results of the study of Cassassolles et al[24], which reported that hypernasality did not affect voiceless consonants because these phonemes were not voiced. The selection of the nasal consonants agreed with those of Fletcher[25], Pracharitpukdee et al[7], Buakanok et al[6], and Prathanee et al[8], in which the nasalance score rose with an increasing proportion of nasal consonants in the speech stimuli because the velopharyngeal valve opened to permit the sound energy into the nasal cavity during the production of the nasal sounds. In addition, /m/, /n/, and /ŋ/ were shown to be consonants that normal Thai children aged 4 to 6 years produce clearly[9,10].

The comparison of the vowels /i:/ and /a:/ in the studies of Kummer[12] and Abou-Elsaad et al[4] reflected a possible compensatory function of the tongue. During the /a:/ phonation, the tongue was laid deep and the size of the oral cavity was large, so the oral resonance was produced more strongly. As the tongue was positioned higher close to the velum in the phonation of the vowel /i:/, the air pressure was directed toward the nasal cavity and led to higher nasalance values. In addition, /a:/ and /i:/ were shown

to be vowels that normal Thai children aged 4 to 6 years produce clearly[9,10].

The study of Abou-Elsaad et al[4] reported that the prolonged fricative sound /s/ showed a zero nasalance score. This indicates that this sound is purely an oral sound and its nasalance score should be considered as an abnormal resonance. Moreover, /s/ was shown to be a consonant that normal Thai children aged about 5 years produce clearly[9,10]. Kummer[12] reported the prolonged nasal sound /m/ could be used to assess hyponasality. The /m/ sound is a nasal that is produced with air movement through the nose.

For subtest II, the researcher used the concept of speech sound groups (bilabial plosives, alveolar plosives, velar plosives, sibilant fricatives, and nasals) similar to the concept of the test items in subtest I. The vocabulary used in this subtest were selected from a speech sample of normal Thai children aged 4 to 6 years and were also considered to be found within the speech and language development of children in this age group[26]. In addition, the researcher designed each picture in black and white because it encourages the children to focus on the picture[27]. In addition, the researcher found that the picture-cued items motivate children to complete the test, as most children respond to the picture-cued items more attentively and cooperatively[28].

Validity assessment for the test

The Thai SNAP Test was assessed for validity by using the content validity method[16,29]. The consonants and/or vowels for each item and the selected vocabulary words were evaluated by three professional speech and language pathologists [SLPs] with more than 20 years of experience in working with cleft palate patients. All items in the Thai SNAP test had an I-CVI of 1.00 Lyn[16], Polit et al[17], and Waltz et al[18] described that an I-CVI of 1.00 firmly demonstrates an excellent level of expert agreement.

Reliability assessment for the test

For the findings of the test, 18 out of 25 were show correlation coefficients reliability. In the Syllable Repetition Subtest: /pʰi:/, / tʰi:/, /kʰi:/, /si:/, /tɕʰi:/, /ma:/, /na:/, /ŋa:/, /mi:/, /ni:/, /ŋi:/, /i:/, /s/, and Picture-Cued Subtest: bilabial plosives, alveolar plosives, velar plosives, sibilant fricatives, and nasals were shown exceeded 0.80. Moreover, the other correlation coefficients reliability for seven test-retest nasalance scores of the Syllable Repetition Subtest: /pʰa:/, /tʰa:/, /kʰa:/, /sa:/, /tɕʰa:/, /a:/, and /m/ were in the range from 0.63 to 0.73. This range is in agreement with the studies of Evans[30] and Dancey et al[31], who described that the range of correlation coefficients between 0.60 to 0.79, have a strong positive correlation. However, Hinkle et al[32] and Rumsey[33] argued that the correlation coefficients under 0.70 were in the level of moderate positive correlation. Likewise, in the results of the present study, three correlation coefficients of the test-retest nasalance scores of the Syllable Repetition items: /pʰa:/, /kʰa:/, and prolonged sound /m/ were 0.63, 0.68, and 0.67, respectively. It might be possible that the researcher randomized the order of the two subtests instead of using all items that would affect the first data collection. When Subtest I was assigned to each subject as the first order, the Syllable Repetition items of /pʰa:/ and /kʰa:/ were the first and third speech sounds for the nasalance score assessment. In addition, all subjects were unfamiliar with the headgear; as a result, they felt uncomfortable and nervous. Because of these two reasons, the subjects might have produced these sounds softly. The result was similar to the study of Van Lierde et al[34], in that speaking in a soft voice revealed significantly higher nasalance scores in the oronasal passage in normal subjects. In contrast, the results of the study of Watterson et al's study[35] indicated that there was no significant difference in nasalance scores across soft, conversational, and loud voice for Zoo Passage (oral passage) and Nasal Sentences. One additional factor that should be taken into consideration is that the subjects in the present study might have produced the speech stimuli at an abnormal speaking rate, which would affect the relationship between the first and second nasalance scores. This result was similar to those of Fletcher et al[36] and Whitney[37], in that speaking rate can influence nasalance scores. Thus, the random ordering of all speech stimuli for each subject, a volume unit [VU] meter for vocal loudness monitoring, and control of speaking rate should be considered in further study. The correlation coefficient of the first and second nasalance scores of the prolonged sound item /m/ was 0.67. It may be possible that some subjects sustained /ʔɯ:m/ instead of /m/ in the first or the second order of the nasalance assessment. Moreover, the sound /ʔ/ is a plosive sound in which the air pressure is directed toward the oral cavity, which would lead to a lower nasalance score.

Conclusion

The Thai SNAP test was found to be sufficiently valid and reliable as a nasalance assessment

tool. Therefore, the test can be used as a part of a clinical nasalance assessment process for children aged 4 to 6 years, including children with illiteracy, limited attention span, lack of cooperation, or limited phonological competence. The examiner is able to select the appropriate items to measure the nasalance scores, depending on the phonological competence of the subject or the diagnostic goals of the assessment.

What is already known on this topic?

In Thailand, there are three sets of speech stimuli to determine the nasalance scores of cleft palate children and adults aged 6 to 44 years.

What this study adds?

The Thai SNAP Test was constructed and developed to measure the nasalance scores of children aged 4 to 6 years. The test is appropriate for young children because it includes repeated syllables or sentences, and thus reduces the possible of production errors, and also contains simple pictures for the subjects to identify.

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Potential conflicts of interest

The authors no declare conflicts of interest.

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