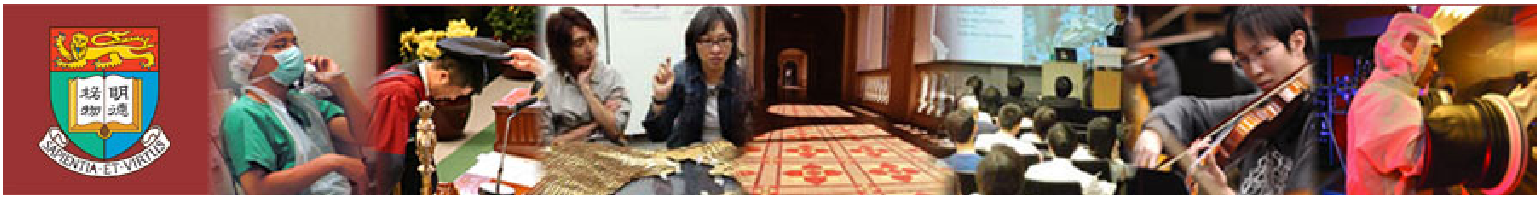

Predictability of Speech Performance at Age 2 for Speech Ability at Age 3 in Cantonese-speaking Children

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Abstract

This study investigated the predictability of children's early speech profiles at age 2 in terms of (1) the Percent Consonant Correct (PCC), (2) the total number of atypical errors, and (3) the total number of errors for the speech performance at age 3 in 38 Cantonese-speaking children. Children's speech sound production ability was assessed using a standardized test at ages 2 and 3. Candidacy for speech sound intervention at age 3 was the outcome measure. Hierarchical multiple regression analyses showed that the PCC, the total number of atypical errors and the total number of errors demonstrated high specificity but low sensitivity after controlling the individual contribution of gender, maternal education, and language performance at age 2. These three measures at age 2 correctly identified 84% to 88% of the typical children without intervention needs but only 31% to 46% of children with intervention needs at age 3. In conclusion, speech screening at early years solely based on the speech profiles at age 2 may not be an effective way in identifying children who are at risk of speech sound disorders at age 3. Other factors may play a role in shaping the trajectory of speech sound development.

Speech sound disorder (SSD) is defined as the presence of speech sound production difficulties of a language (Bernthal, Bankson, & Flipsen, 2009). SSD is a prevalent childhood communication disorder comprising the largest caseload of speech language pathologists (McKinnon, McLeod, & Reilly, 2007). SSD is a heterogeneous group. Shriberg, Paul, and Flipsen (2010) classified SSD into two subtypes, speech delay (SD) and speech errors (SE). SE refers to the group of children with speech sound distortion errors which do not affect the intelligibility. Shriberg et al. (2010) estimated that about 15% to 16% of 3-year-old children with SSD belong to the subtype of SD. Most children in this group would normalize the non adult-like speech patterns with or without therapy. However, about 9% of children with SD would have persistent speech problems after age 18 and would even be observed throughout the lifetime (Shriberg et al., 2010). The persisting problem was not only observed in their speech performance, but also in reading and literacy skills. In a single-case study, Weiner (1974) followed a 4-year-old child having non-developmental or atypical speech errors for 12 years. The child performed relatively weak in reading, spelling and phonological awareness during adolescence (Weiner, 1974). Related findings were observed in a more recent group study. Lewis, Freebairn, and Taylor (2000) examined the academic outcomes of children with history of SSD and/or language impairment (LI). They found that 18% of the young children with history of SSD but no LI demonstrated reading difficulties in mid-elementary school comparing the 75% of young children with history of both SSD and LI. Bishop, Price, Dale, and Plomin (2003) also suggested that children with persistent SSD showed greater difficulties in phonological awareness and literacy skills than those who had SSD resolved by age 5; 6. These studies pointed to the fact that SSD could result in broad impacts in later speech and language development and hence academic performance. The findings also highlighted the necessity of early identification and intervention, if possible. These can potentially minimize the impacts of SSD on an individual and the involved families as well as reduce the social and economic costs and burden to the limited clinical resources (Dodd, 2005; Law, Boyle, Harris, Karkness, & Nye, 2000).

A number of studies have investigated the risk factors for SSD. Campbell et al. (2003) reported three risk factors that best predict SD were being male, lower educational level of mother, and a familial history of SD. Harrison and McLeod (2010) reported that risk factors for SD at 3-year-old included being male, reactive temperament and recurring hearing problems. They also mentioned that the protective factors for SD included maternal well-being and sociable character of children. Nelson, Nygren, Walker, and Panoscha (2006) in their systematic review pointed out that the mostly investigated risk factors were being male, perinatal factors, and family history of speech and language delay. Yet, their contribution in screening was still unknown (Nelson et al., 2006). These studies revealed that the risk factors might vary among populations and research methods.

Most of these studies reviewed examined children speaking Indo-European languages and focused on child's demographic information, child's factors, parents' factors, family and community variables (Harrison & McLeod, 2010). Even among the child's factors, most research studies emphasized on the psychosocial aspects such as medical conditions after birth (Brookhouser, Hixson, & Matkin, 1979; Campbell et al., 2003; Choudhury & Benasich, 2003; Fox, Dodd, & Howard, 2002; Peters, Grievink, Wim H J van, John H L van den, & Schilder, 1997), hearing status (Singer et al., 2001; Yliherva, Olsen, Maki-Torkko, Koiranen, & Jarvelin, 2001), and temperament (Hauner, Shriberg, Kwiatkowski, & Allen, 2005; Prior et al., 2008). Only a small number of longitudinal studies used children's actual speech performance at a younger age as a predictor for the later speech sound production ability. For example, Roulstone, Miller, Wren, and Peters (2009) conducted a large-scale longitudinal study investigating the natural history of children with and without speech problems. The study aimed to investigate the speech error patterns of children at ages 2 and 5 who had persistent speech impairment at age 8. The demographic and speech data of 741 children at ages 2, 5 and 8 were collected respectively through parental questionnaires, single word object naming, narration, and speech samples from picture and sequence description. Roulstone et al. (2009) undertook multiple logistic regressions with adjustment of potential covariates including gender and socioeconomic status. They concluded that the proportion of speech errors at age 5 was predictive to the continuous speech errors at age 8. Carson, Klee, Carson, and Hime (2003) conducted a study to investigate if the phonetic or phonological data obtained at age 2 predicted the intervention recommendations made at age 3. The language and phonological development of a group of 28 children aged 2 were screened by the Language Development Survey (Rescorla, 1989) and speech samples analyzing a 20-minute parent-child play interaction respectively. Six measures were computed including the number of different consonants in the inventory, the percentage of closed syllables, the number of different initial and final consonants, and the number of different initial and final consonant clusters (Carson et al., 2003). Thirteen of these children were reassessed with reference to their language ability at age 3 to determine whether they needed intervention or only required monitoring recommendations while the other 15 children were dropped and not reassessed at age 3. Carson et al. (2003) concluded that the more the phonological developmental delay at age 2, the higher the risk of continuous speech and language problems at age 3. However, both studies mainly made use of brief and non-standardized assessments as a reference for children's speech performances. Roulstone et al. (2009) obtained the speech samples at ages 2 and 5 by asking the children to name 16 and 20 objects respectively while Carson et al. (2003) collected speech samples through a 20-minute parent-child free play interaction. The small number of trials and non-standardized assessment procedures might limit the type of specific analysis that could be carried out concerning the children's speech sound profile. McIntosh and Dodd (2008) conducted a longitudinal study which aimed to develop normative data and investigate the feasibility of early identification of children's speech problems at age 2. The speech ability of ten English-speaking children in Brisbane area was assessed at three time points respectively: at age 2, between age 2 and 3 and at age 3. The Toddler Phonology Test (McIntosh & Dodd, 2008) containing words derived from the Diagnostic Evaluation of Articulation and Phonology (DEAP; Dodd, Zhu, Crosbie, Holm, & Ozanne, 2002) was administered in the first two time points while the Screening Test and Phonology sections of the DEAP were used in the last time point. McIntosh and Dodd (2008) concluded that qualitative measurements in terms of the atypical error patterns could reliably predict the presence of SSD at age 3 but quantitative measurements including the Percent Consonant Correct (PCC), the Percent Vowel Correct (PVC) and the Percent Phoneme Correct (PPC) were not useful predictors for the children's speech ability at age 3. McIntosh and Dodd (2008) also argued that direct formal phonological assessment at age 2 was feasible.

Yet, using risk factors as a guide for selective screening and early identification of at-risk children was not supported due to the inconsistently identified risk factors across studies and there was only limited evidence from the small scales studies about the accuracy of such a screening procedure (Nelson et al., 2006). It would be difficult to apply the screening results at an individual level from a public health perspective.

Aim

Building on the McIntosh and Dodd's findings, this study aims to identify which characteristics of speech profile at age 2 have the potential to predict the speech performance at age 3 in Cantonese-speaking children. The speech profile of age 2 was measured in terms of (1) the PCC, (2) the total number of atypical errors, and (3) the total number of errors using a standardized speech assessment, Hong Kong Cantonese Articulation Test (HKCAT, Cheung, Ng, & To, 2006). Potential confounding factors on speech performance including gender, maternal education level, and children's language ability at age 2 were also included in the analysis to control their effects. The identified predictors would be evaluated at an individual level to examine the diagnostic accuracy of using these variables as the predictors.

Method

Participants

The participants in the present study were drawn from a previous study investigating how the maternal mental health problems affect the offspring's speech development (Wong, 2012). A total of 38 children who were assessed the speech performance at age 2 participated in the present study. These children included 27 girls and 11 boys aged between 2; 11 and 3; 3 in the current study (Mean (*M*) = 37.04 months, Standard deviation (*SD*) = 1.20). Children's demographic information including gender and maternal education levels was collected using a parental questionnaire at age 2. Twelve of the mothers had finished secondary education while the other 26 mothers had finished tertiary or above education.

Measures

Speech performance. Speech samples were collected from each child using the standardized assessment, HKCAT (Cheung, Ng, & To, 2006) at both ages 2 and 3. At age 2, the PCC, the total number of atypical errors and the total number of errors were computed. PCC was obtained by multiplying 100% and the quotient resulted from the division of the number of correct consonants by the total number of consonants produced. Atypical errors were defined as the error patterns used by less than 5% of the children in the population (To, Cheung, & McLeod, 2013). The total number of errors was calculated as the sum of all errors, including (1) atypical errors, (2) age-inappropriate developmental errors which exhibited by more than 10% of the children at the younger cohorts and those exhibited by less than 5% of the age-peers, and (3) age-appropriate errors which exhibited by more than 5% of the age peers. At age 3, intervention candidacy was used as the outcome measure. Children at age 3 who were considered to be a candidate for speech sound intervention showed the following characteristics: (1) HKCAT standard scores below -1.25 *SD*, and/or (2) presence of three or more age-inappropriate developmental errors or atypical errors. Children showed any of these characteristics were regarded as having intervention needs.

Language ability at age 2. The language performances of children at age 2 were obtained from the database. The parents filled in a form named Cantonese Communicative Developmental Inventory: Words and Sentences (CCDI/WS; Fenson, 1993). There were two parts assessing the word vocabulary production, and morphological and syntactic development. The CCDI percentile scores were computed from the raw scores obtained.

Demographic information. The demographic information was obtained from the database of a previous study by Wong (2012) in which the parents filled in questionnaires including information of the date of birth, gender and maternal education level.

Procedures

The mothers in previous project's database were contacted by telephone and were invited to participate in this study. For parents who agreed to participate in the project, appointment was made to have assessment either at home or at the Child Language Laboratory at the Division of Speech and Hearing Sciences of the University of Hong Kong. The assessors were blinded to the speech ability of the children at age 2 at the time of testing to avoid any potential bias affecting the validity of results.

Written parental consent was obtained before the assessment. Following rapport establishment, the HKCAT (Cheung et al., 2006) was administered. Binary choices were given if the child could not name the target upon verbal instructions. If binary choices could not elicit the child's production of the target, a model was given for imitation. The assessment took approximately 5-15 minutes to complete. Audio-recorded speech samples on a Sony digital recorder ICD-PX820 were used for transcriptions and reliability checking at a later stage. The investigators transcribing the speech samples and performing the reliability checking were also blinded to the speech ability of the children at age 2.

Reliability

Both inter- and intra-rater reliability were examined in terms of transcription agreement. For inter-rater reliability, four randomly selected recordings (around 10% of the samples) were re-transcribed independently by a trained transcriber who was a final year student at the Division of Speech and Hearing Sciences. For intra-rater reliability, four randomly selected recordings (around 10% of the samples) were re-transcribed by the investigator one to two months after initial transcription.

The reliability was computed by multiplying 100% and the quotient resulted from the division of the number of agreed phonemes by the total number of phonemes produced. The inter-rater reliability was 90% with a range of 80% to 96% and the intra-rater reliability was 98% with a range of 95% to 99% which were regarded as satisfactory. The original assessor's transcriptions were used for analysis.

Statistical Analysis

General information about participants' background and speech and language performances at age 2 were presented in terms of descriptive statistics. Three hierarchical logistic regression analyses with covariates of gender, maternal education and CCDI percentile were conducted to investigate the power of the three speech performance variables at age 2 in predicting the intervention candidacy at age 3.

Intervention candidacy was used as the dependent outcome variable with "0" representing intervention not required and "1" representing intervention required. The variables of speech performance, namely, the PCC, the total number of atypical errors and the total number of errors were the independent variables and were subject to logistic regression analyses independently. Any of the three target predictor variables was entered in the first step followed by CCDI percentile in the second, gender in the third and maternal education in the last step.

Odds ratios were computed to investigate the change in odds when the predictors change. The odds ratio larger than one means the odds of an outcome increases when the predictor increases while the odds ratio smaller than one means the odds of an outcome decreases when the predictor increases (Field, 2009). Operationally, odds ratio is an indicator of the likelihood of an outcome to occur with a condition present compared to the condition absent. Sensitivity and specificity were also examined to determine the classification accuracy of the predictive variables. Sensitivity refers to the competency of a model in identifying subjects having a disorder while specificity refers to the competency of a model in identifying subjects not having a disorder (Field, 2009).

Results

Descriptive Analysis

Means and standard deviations of the PCC, the total number of atypical errors, the total number of errors and the CCDI percentile at age 2 in both genders are summarized in Table 1. On average, the boys demonstrated lower PCC and CCDI percentile but larger total number of atypical errors and total number of errors than girls at age 2. At age 3, 13 out of 38 were identified with intervention needs. Table 2 summarized the PCC, the total number of atypical errors, the total number of errors and the CCDI percentile at age 2 of the children with and without intervention needs at age 3. Among the 38 children aged 3, two were identified as impaired by the HKCAT, 13 demonstrated three or more atypical errors and 11 showed three or more developmental errors.

Table 1

The Percent Consonant Correct, the Total Number of Atypical Errors, the Total Number of Errors and the CCDI Percentile (M and (SD)) of the Children at Age 2.

	Boys (*n* = 11)	Girls (*n* = 27)	Total (*n* = 38)
PCC	74.1 (10.5)	78.4 (13.7)	77.2 (12.8)
Atypical errors	8.5 (6.0)	5.2 (5.4)	6.2 (5.7)
Total errors	18.7 (8.0)	15.9 (12.0)	16.7 (10.9)
CCDI percentile	44.1 (24.0)	55.07 (28.1)	51.9 (27.1)

Table 2

The Percent Consonant Correct, the Total Number of Atypical Errors, the Total Number of Errors and the CCDI Percentile (M and (SD)) at Age 2 of Children Stratified According to Intervention Needs at Age 3.

	With intervention needs at age 3 (*n* = 13)	Without intervention needs at age 3 (*n* = 25)
PCC at age 2	80.1 (8.7)	85.0 (9.7)
Atypical errors at age 2	8.9 (6.8)	4.7 (4.5)
Total errors at age 2	24.5 (11.2)	12.7 (8.4)
CCDI at age 2	40.4 (27.7)	57.9 (25.3)

Hierarchical Logistic Regression Analyses

PCC. The results of logistic regression for PCC at age 2 were shown in Table 3. Significant predictability of PCC at age 2 for intervention candidacy at age 3 was observed (p = .038). However, the model became insignificant when CCDI percentile, gender and maternal education were added (p = .079). The odds of a child identified with intervention needs at age 3 decreased when the PCC at age 2 increased. That means, one unit increase in the PCC at age 2 resulted in .938 times of probability of having intervention needs than without intervention needs at age 3. This model correctly predicted 38.5% of children who needed intervention at age 3 and 84% of children who did not.

Total number of atypical errors. Table 4 displayed the results of logistic regression for total number of atypical errors at age 2. Significant predictability of total number of atypical errors at age 2 for intervention candidacy at age 3 was observed (p = .041).

However, the overall model became insignificant when CCDI percentile, gender and maternal education were added (*p* = .068) which also resulted in a reduced sensitivity and overall percentage correct. The odds of a child identified with intervention needs at age 3 increased when the total number of atypical errors at age 2 increased. That means, one unit increase in the total number of atypical errors at age 2 resulted in 1.144 times of probability of having intervention needs than without intervention needs at age 3. The model correctly predicted 30.8% of children who needed intervention at age 3 and 84% of children who did not.

Total number of errors. The results of logistic regression for total number of errors at age 2 were shown in Table 5. Significant predictability of total number of errors at age 2 for intervention candidacy at age 3 was observed (*p* = .006). In addition, the model remained significant when CCDI percentile, gender and maternal education were added (*p* = .011). The odds of a child identified with intervention needs at age 3 increased when the total number of errors at age 2 increased. That means, one unit increase in the total number of errors at age 2 resulted in 1. 135 times of probability of having intervention needs than without intervention needs at age 3. This model correctly predicted 46.2% of children who needed intervention and 88% of children who did not.

Generally, the models with independent variables PCC, the total number of atypical errors and the total number of errors at age 2 showed better specificity than sensitivity that they had better performance in correctly predicting children who do not need intervention than predicting children who need intervention at age 3. Among these three target predictive variables, the total number of errors at age 2 demonstrated the highest classification accuracy.

Table 3

The Predictive Power of PCC at Age 2 and Other Covariates (CCDI Percentile, Gender, Maternal Education) to the Intervention Candidacy at Age 3.

Predictor Variables	B (SE)	Odds Ratio	Confidence Level Lower	Confidence Level Upper	Sensitivity %	Specificity %	Overall Classification accuracy
Step 1*					38.5 (5/13)	92.0 (23/25)	73.7 (28/38)
PCC*	-.064(.031)	.938	.883	.997			
Step 2					46.2 (6/13)	92.0 (23/25)	76.3 (29/38)
PCC	-.048(.036)	.953	.888	1.024			
CCDI percentile	.014(.018)	.986	.953	1.020			
Step 3					46.2 (6/13)	88.0 (22/25)	73.7 (28/38)
PCC	-.047(.036)	.954	.890	1.024			
CCDI percentile	.013(.018)	.987	.953	1.021			
Gender	.455(.786)	1.576	.338	7.354			
Step 4					38.5 (5/13)	84.0 (21/25)	68.4 (26/38)
PCC	-.044(.037)	.957	.889	1.029			
CCDI percentile	.013(.018)	.987	.953	1.023			
Gender	.567(.827)	1.762	.348	8.913			
Maternal education	1.305 (.920)	3.688	.608	22.374			

* for $p < .05$

Table 4

The Predictive Power of Total Number of Atypical Errors at Age 2 and Other Covariates (CCDI Percentile, Gender, Maternal Education) to the Intervention Candidacy at Age 3.

Predictor Variables	B (SE)	Odds Ratio	Confidence Level Lower	Confidence Level Upper	Sensitivity %	Specificity %	Overall Classification accuracy
Step 1*					38.5 (5/13)	88.0 (22/25)	71.1 (27/38)
Atypical error no.*	.134(.066)	1.144	1.005	1.301			
Step 2					38.5 (5/13)	92.0 (23/25)	73.7 (28/38)
Atypical error no.	.100(.073)	1.105	.957	1.277			
CCDI percentile	-.017 (.016)	.983	.952	1.015			
Step 3					38.5 (5/13)	92.0 (23/25)	73.7 (28/38)
Atypical error no.	.095(.074)	1.099	.950	1.272			
CCDI percentile	-.017 (.016)	.983	.952	1.015			
Gender	.291(.805)	1.338	.276	6.485			
Step 4					30.8 (4/13)	84.0 (21/25)	65.8 (25/38)
Atypical error no.	.107(.080)	1.113	.952	1.303			
CCDI percentile	-.014(.017)	.986	.954	1.019			
Gender	.429(.849)	1.536	.291	8.116			
Maternal education	1.472(.957)	4.360	.669	28.426			

* for $p < .05$

Table 5

The Predictive Power of Total Number of Errors at Age 2 and Other Covariates (CCDI Percentile, Gender, Maternal Education) to the Intervention Candidacy at Age 3.

Predictor Variables	B (SE)	Odds Ratio	Confidence Level Lower	Confidence Level Upper	Sensitivity %	Specificity %	Overall Classification accuracy
Step 1***					46.2 (6/13)	88.0 (22/25)	73.7 (28/38)
Total error no.**	.127(.046)	1.135	1.037	1.242			
Step 2**					46.2 (6/13)	88.0 (22/25)	73.7 (28/38)
Total error no.*	.121(.051)	1.128	1.022	1.246			
CCDI percentile	-.005(.017)	.995	.963	1.029			
Step 3*					53.8 (7/13)	88.0 (22/25)	76.3 (29/38)
Total error no.*	.119(.050)	1.127	1.022	1.243			
CCDI percentile	-.004(.017)	.996	.964	1.030			
Gender	-.496(.846)	1.643	.313	8.626			
Step 4*					46.2 (6/13)	88.0 (22/25)	73.7 (28/38)
Total error no.	.115(.052)	1.121	1.013	1.241			
CCDI percentile	-.004(.018)	.996	.962	1.031			
Gender	.552(.877)	1.737	.312	9.681			
Maternal education	1.116 (.958)	3.052	.467	19.934			

*** for $p < .005$, ** for $p < .01$, * for $p < .05$

Discussion

The study investigated the predictive power of the PCC, the total number of errors and the total number of atypical errors for the speech ability at age 3 as represented by the intervention candidacy. The three variables all demonstrated significant predictability for the 3-year-old intervention candidacy. It is clear that children's early speech performance at age 2 is an important factor on their later speech performance at age 3. The total number of errors gave the highest classification accuracy in the step one of the model (78.9%) suggesting it had the strongest predictive power to the intervention candidacy at age 3 when compared to the other two target variables (PCC: 73.7%, the total number of atypical errors: 71.1%). In addition, both classification accuracies of the PCC and the total number of errors were higher than that of the total number of atypical errors. The results were somewhat different from McIntosh and Dodd (2008) who found that the qualitative measure by error types could more reliably predict the presence of speech sound disorder at age 3 than the quantitative measures by PCC, PVC and PPC. Nevertheless, the classification accuracies of the three variables were close to each other that they could all predict the outcome with satisfactory reliability if only the overall accuracy is considered.

When the overall accuracy is considered with reference to sensitivity and specificity, the three models showed acceptable specificity. That means a 3-year child with typical speech development is likely that his or her speech ability at age 2 was good too. Only a small number of children with speech problems at age 2 resolved the problems and performed normally at age 3. This is generally consistent with Carson et al. (2003) who suggested that the more phonologically delayed a child at age 2, the higher the risk of continuous speech and language problem at age 3.

Despite the satisfactory specificity of the three variables, their models generally showed low values of sensitivity which were 38.5%, 30.8% and 46.2%. False-negative and false-positive errors were examined in which they refer to the children having a disorder being wrongly identified as normal and those with normal speech being wrongly identified as having a disorder respectively. Among the 13 children identified with intervention needs at age 2, the number of false-negatives in the models of the PCC, the total number of atypical errors and the total number of errors were eight, nine and seven respectively. That means, more than half of the children identified with intervention needs at age 3 could not be predicted based on the speech performance at age 2. In other words, some children at age 2 appeared to be on the right track might not progress as good as other typically developing peers and demonstrated speech concerns at age 3. This group of children posed the biggest challenge to clinicians for early identification. If the speech performance at a younger age was the sole factor to be considered for eligibility to receive treatment, this group of children was likely to be missed out from the referral system. Children's varying trajectory of speech development posed remarkable challenges to clinicians to accurately identify the at-risk cases at an early age (Law et al., 2000).

Other potential confounding variables including language performance at age 2, gender and maternal education were also included to control their effects on the outcome. In all the three models, CCDI percentile, gender and maternal education showed insignificant contribution ($p > 0.05$) in predicting speech performance at age 3 and their addition in the models generally resulted in reduced overall percentage correct of classification accuracy. These indicated that they were not contributable to the predictability for intervention candidacy at age 3. The results of insignificant predictability of gender for the intervention candidacy at age 3 corresponded to the studies by Fox et al. (2002), McIntosh and Dodd (2008), and Roulstone et al. (2009). In other words, being a girl was not observed as a protective factor of speech sound disorders at age 3. However, the insignificant predictability of maternal education was not consistent with the finding reported by Law et al. (2012) who provided support to the importance of maternal education in children's language ability. The mismatch might be attributed to the small sample size of the present study and most parents in the present study received at least secondary education.

In conclusion, universal screening has the potential to be a cost-effective way for early identification of children with speech problems. Early identification of SSD can minimize and reduce the possible impacts resulted from SSD to children, parents and social community in the long run. However, for the mass screening to be effective, the most important condition is the knowledge of accurate risk factors. The present study demonstrated that the three speech measures at age 2 showed satisfactory specificity, children with typical speech performance at age 3 are likely to have adequate speech ability at age 2. Only a small proportion of children at age 2 can outgrow the problems and perform typically at age 3. However, the current findings suggested that speech performance at age 2 had a compromised level of sensitivity to predict for speech performance at age 3. It may be possible that other factors are more important than early speech performance in predicting a child's later speech performance, such as stimulability.

Limitations and Future Study

There are some limitations of this study. Firstly, the small sample size of 38 children might not be well representative for the 3-year-old Cantonese-speaking population in Hong Kong. Larger sample should be employed to allow strong statistical power. Secondly, the study investigated limited variables that there are more parameters to examine among many measures. Therefore, future research should take other factors into consideration which were also looked into in foreign studies such as family history of SSD, perinatal events, number of siblings, stimulability, PVC, PPC and so on to find out which measures best predict later speech ability. Lastly, the study investigated that predictability of variables at age 2 for speech ability at age 3 only, follow-up of the study to older ages may give a more thorough understanding of the trajectory of speech sound development.

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