Running Head: **INTELLIGIBILITY IN CONTEXT SCALE**

Intelligibility in Context Scale: Cross-linguistic use, validity, and reliability

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Abstract

The Intelligibility in Context Scale (ICS) is a free parent-report screening tool that has been translated into over 60 languages. To date, there is cross-linguistic evidence regarding its validity and reliability reported in 18 studies of over 4,235 children from 14 countries (Australia, Croatia, Fiji, Germany, Hong Kong SAR China, Italy, Korea, Jamaica, The Netherlands, New Zealand, Portugal, Slovenia, Sweden, Viet Nam) speaking 14 languages (Cantonese, Croatian, Dutch, English, Fijian (Standard or dialects), Fiji-Hindi, German, Italian, Jamaican Creole, Korean, Portuguese, Slovenian, Swedish, Vietnamese). Cross-linguistic research provides support for the use of the ICS as a primary screening tool for young children to identify which children require additional assessment. Additional research has been undertaken to determine its relevance during assessment and intervention as a descriptive tool and outcome measure for children (and some adults) with speech sound disorders, cleft lip and palate, hearing loss, and autism spectrum disorder. The review concludes with an exploration of cross-linguistic possibilities of the ICS within implementation science.

Key words: Intelligibility in Context Scale, intelligibility, cross-linguistic, screening, outcome measure, validity, reliability

Intelligibility is "the degree to which the listener understands what the speaker says when the target is uncertain" (Camarata, 2010, p. 382). It is frequently considered by speech-language pathologists (SLPs) when determining: the presence of speech sound disorder, the need for intervention, and whether intervention has been successful (Baker, 2010; Mullen & Schooling, 2010). Intelligibility requires a two-way interaction between a speaker and a listener. It can be influenced by: (1) the speaker's age, sex, language/dialect, presence of speech sound disorder or other communication disability, (2) the listener's familiarity and relationship with the speaker, language/dialect, and communication disability, (3) the task, including measurement tool and response type, and (4) the context/environment, including the amount of background noise. There are three main methods for assessing intelligibility: single word measures, connected speech measures, and rating scales (Kent, Miolo, & Bloedel, 1994) and numerous measures exist. This paper examines the Intelligibility in Context Scale (ICS) (McLeod, Harrison & McCormack, 2012a), the only intelligibility rating scale created to consider intelligibility with different conversational partners that is available in over 60 languages.

Intelligibility in Context Scale (ICS): Description

The Intelligibility in Context Scale (ICS) (McLeod, Harrison & McCormack, 2012a) was developed as a parent-report screening tool to consider English-speaking preschool-aged children's intelligibility with seven different communication partners. In the past, the main communication partners (listeners) that have been examined include: family members, speech-language pathologists (SLPs), and strangers (Baudonck Buekers, Gillebert, & Lierde, 2009; Flipsen Jr., 1995; Kwiatkowski & Shriberg, 1992). The ICS examines intelligibility with seven conversational partners (parent, immediate family, extended family, friends, acquaintances, teachers, strangers), informed by the Environmental Context of the World Health Organization's International Classification of Functioning, Disability, and Health

(ICF-CY) (WHO, 2007). The seven questions are answered on a 5-point scale (5 = *always* to 1 = *never*) and summed order to create a score out of 35. The total score is then divided by 7 to reveal the total average score out of 5. The ICS can be downloaded in a useable .pdf format for free[1] from http://www.csu.edu.au/research/multilingual-speech/ics and the website also contains a brief administration manual.

A review of literature since 2012 illustrates that the ICS has been used in at least five ways. Firstly, the ICS has been used to describe intelligibility of children (Burton, Washington, & Samms-Vaughan, 2018; Hoàng, Trà, & Cao, 2014; McCormack, McLeod, & Crowe, 2019) and adults (Crowe, Marschark, & McLeod, 2019). For example, the ICS was used to compare parents and children's perspectives about talking (McCormack et al., 2019), Secondly, the ICS has been used as a screening tool (McLeod, Harrison, McAllister, & McCormack 2013). Thirdly, it has been used to compare children's intelligibility with different conversational partners (e.g., "Bob is more intelligible to family members, less intelligible to strangers") or between different languages "Bob achieved a higher average total score in Spanish than in English" (e.g., McLeod, Verdon, & International Expert Panel on Multilingual Children's Speech, 2017). Fourthly, the ICS has been used to compare perspectives about intelligibility (e.g., mothers and fathers: Piazzalunga, Salerni, Limarzi, Fassina, & Schindler, 2019; Washington, McDonald, McLeod, Crowe, & Devonish, 2017; parents and teachers: Tomić & Mildner, 2014); showing high correlations between adult raters. Finally, the ICS also has been used as an outcome measure in research with preschool children with speech sound disorders (McLeod, Baker, et al., 2017; McLeod, Davis et al., 2019), children with cleft lip and palate (Seifert, Wren, Davies, & McLeod, 2019), and adults who speak languages other than English (Blake, McLeod, & Verdon, 2019).

[1] The ICS is licenced under Creative Commons so users "are free to share … with appropriate attribution and acknowledgment of the source…may not use this work for commercial purposes, … [and] may not alter, transform, or build upon this work."

Validation in English. The ICS was initially validated on 120 Australian English-speaking children aged 3;11 to 5;8 years from the Sound Effects Study (McLeod, Harrison, & McCormack, 2012b). There were 109 participants with SSD and 11 typically developing participants in the sample. The internal reliability was high (α = 0.93) and there were moderate to high correlations (range r = .48 to r = .86, p < .01) when examining internal consistency. Validity was established by finding a significant difference in ICS mean scores between typically developing participants (M = 4.69) and children with SSD (M = 3.85). To establish criterion validity scores on the ICS were compared with the percentage correct scores on the Diagnostic Evaluation of Articulation and Phonology (DEAP; Dodd, Hua, Crosbie, Holm, & Ozanne, 2002). There were significant correlations for percentage of phonemes correct (PPC) (r = .54), percentage of consonants correct (PCC) (r = .54), and percentage of vowels correct (PVC) (r =.36). The authors concluded: "The ICS is a promising new measure of functional intelligibility. These data provide initial support for the ICS as an easily administered, valid and reliable estimate of preschool children's intelligibility when speaking with people of varying levels of familiarity and authority" (McLeod et al., 2012b, p. 648).

Next, a larger study was undertaken with a new sample of 803 Australian children aged 4;0 to 5;5 from the Sound Start Study (McLeod, Crowe, & Shahaien, 2015) (Table 1). Overall, the mean average total score on the ICS was 4.4 (SD = 0.7); that is, the participants scored between "usually" (4) and "always" (5) intelligible. There were significant differences between ratings of intelligibility with different partners with parents receiving the highest mean score (M = 4.7) and strangers receiving the lowest mean score (M = 4.0). ICS scores were significantly different between children whose parents had concerns about "talking and making speech sounds" (M = 3.9) and no concerns (M = 4.6). Sensitivity of 0.82 and specificity of 0.58 was established using an adjusted cut-off of 4.6. Test-retest reliability for

140 participants revealed a strong correlation between the ICS mean score for parents' first (M = 3.9) and second (M = 3.8) completions of the ICS. The internal reliability of the ICS was high, there were moderate to high correlations when examining internal consistency, and the ICS mean score was positively correlated with PCC, PVC, and PPC (Table 1). The authors concluded the ICS could be used as a preschool screening tool due to its validity, reliability and that the mean score was not impacted by socio-economic status (SES) or the number of spoken languages.

Translation into 60+ languages. Subsequently, the ICS was translated and back translated into over 60 languages by speech-language pathologists, phoneticians, linguists and accredited translators (McLeod, 2015) available at https://www.csu.edu.au/research/multilingual-speech/ics. The South African translations of the ICS into Afrikaans, isiZulu, isiXhosa, Sepedi, English, Setswana, Sesotho, Xitsonga, siSwati, Tshivenda, and isiNdebele were undertaken by teams of speech-language pathologists using forward and back translation and community checking (Pascoe & McLeod, 2016).

Cross-linguistic Validation Studies

To date, researchers have published 18 validation/norming studies of the ICS (Table 1) of 4,235 children in 14 countries (Australia, Croatia, Fiji, Germany, Hong Kong SAR China, Italy, Korea, Jamaica, The Netherlands, New Zealand, Portugal, Slovenia, Sweden, Viet Nam) speaking 14 languages (Cantonese, Croatian, Dutch, English, Fijian (Standard or dialects), Fiji-Hindi, German, Italian, Jamaican Creole, Korean, Portuguese, Slovenian, Swedish, Vietnamese). Additional studies have been presented in theses (e.g., Croatia: Arlović, 2015; Iceland: Hauksdóttir, 2016; Philippines: Abellanosa, Garces, Montallana, Tan, & Valmores, 2018) and more research is underway. The 18 studies (Table 1), had an average of 235.3 participants (SD = 245.6; range = 30–803) with 2,606 identified as typically

developing, 839 identified as having atypical speech development (via direct speech assessment, speech-language pathology (SLP) referral, or parent/teacher concern) and the remainder unclassified. Participants ranged in age from 1;2 to 15 years; however, the majority were preschool-aged participants, aligning with the original intention of the ICS. Across the studies, the mean total scores ranged from 3.96 to 4.60, suggesting that overall participants were "usually" understood. Participants were described as most often understood by their parents and least often understood by strangers.

Reliability. Test-retest reliability was examined in six studies (Table 1), frequently with subgroups of participants, demonstrating "high test-retest reliability" (Neumann Rietz, & Stenneken, 2016; Piazzalunga et al., 2019; Washington et al., 2017) "strong" correlations (McLeod et al., 2015) and "satisfactory" results (Lee, 2019; Ng, To & McLeod, 2014). Internal reliability/consistency was examined in 10 studies to estimate "the extent to which a group of items measure the same overall construct" (McLeod, 2012, p. 149), and was found to be very high (α=0.91–0.98) for all but Hopf, McLeod, and McDonagh (2017) and Lagerberg, Hellström, Lundberg, and Hartelius (2019) who included older participants, up to 10 years of age (Table 1).

Validity. Construct validity was examined in nine studies to "demonstrate that the test measures the construct of interest from a number of perspectives" (McLeod, 2012, p. 150) and most studies reported "moderate to high correlations" (Phạm, McLeod, & Harrison, 2017, p. 677) (Table 1). Criterion validity, was examined in 11 studies "to consider the degree of overlap between the test and other standard speech sampling tools" (McLeod, 2012, p. 150). Table 1 demonstrates that across the studies, weak to moderate significant correlations were found between ICS mean scores and PCC on standardised testing (range=.299-.673), except for Hopf et al. (2017) who found no correlation for their school-aged children (5;3–10;5 years). Across six studies, weak to moderate correlations also were

found between ICS mean scores, PVC (range=.26-.588), and PPC (range=.34-.655). Three studies compared scores on the ICS with other clinical measures of intelligibility (Kim, Ballard, & McCann, 2016; Lagerberg et al., 2019 van Doornik, Gerrits, McLeod, & Terband, 2018) and found "weak but significant correlations" (Lagerberg et al., 2019, p. 1). Content validity was considered during the original creation of the tool aligning with the ICF and literature regarding factors influencing intelligibility (McLeod et al., 2012b).

Sensitivity and specificity. Participants achieved higher ICS total scores if they were identified with typical speech (range = 4.03–4.78) than children identified with atypical speech (range = 3.63–4.14)[2]. Five studies examined sensitivity and specificity (Table 1), reporting varying levels of accuracy. For example, Lousada et al. (2019) studied 76 preschool-aged children and reported sensitivity of 0.80, and sensitivity of 0.84, at a cut point of 4.36. Kok and To (2019) undertook a comprehensive analysis of data from 789 Cantonese-speaking children to determine that the ICS had best screening accuracy for children aged 4;0-4;5 years, with sensitivity of 0.80, and specificity of 0.84, at a cut point of 3.64, but was less accurate for children in other age groups.

Comparisons between groups. Significant correlations were found between children's ICS scores and age (e.g., McLeod et al., 2015; Neumann et al., 2016; Phạm et al., 2017). Some studies showed no significant difference between children's ICS scores and sex (Phạm et al., 2017); whereas, in McLeod et al. (2015) females were rated significantly higher than males ($p < .005$) with no significant interaction between sex and age. There was no significant difference in ICS scores between participants who spoke one or more than one language (McLeod et al., 2015). Some studies showed low but significant correlations with SES (Neumann et al, 2016); whereas, others did not (McLeod et al., 2015). In Vietnam, Phạm

[2] The study by Sprunt and Marella (2018) reported lower scores for the children with atypical speech since they removed the middle group of participants from their analysis (Table 1).

et al. (2017) demonstrated significant factors influencing ICS scores were parents' occupation level and mothers' (but not fathers') education level.

Learnings for Implementation Scientists

Implementation science documents and supports the application of research into clinical practice (Douglas & Burshnic, 2019). The ICS has incorporated elements of implementation science, such as collaboration between researchers and clinicians to facilitate appropriate "adaptation to local contexts" (Bauer et al., 2015, p. 5). Many ICS studies have used effectiveness research designs (e.g., based in real-world, heterogeneous contexts; Bauer et al., 2015). The ICS is available in languages that do not have standardised assessments and minimises participant response burden within resource-constrained settings, so it has been has been used both in research and clinical settings. For example, responses on the ICS were compared with the UNICEF/Washington Group Child Functioning Module (CFM) for 463 children in Fiji "to measure progress against the Sustainable Development Goals for children with disabilities" (Sprunt & Marella, 2018, p. 89). The uptake of the ICS into clinical practice was documented for 23 SLPs in South Africa over 3 weeks in seven languages who indicated "the ICS was user-friendly and … was useful to have a screening tool in the first language of speakers (e.g. isiXhosa)" (Pascoe & McLeod, 2016, p. 337). These SLPs indicated that audio-recorded versions may be useful for respondents who could not read; an adaptation successfully incorporated in the Jamaican context (Washington et al., 2017). Anecdotally, the uptake of the ICS into practice has been relatively swift (Charles Sturt University, 2017) considering research to practice has been documented to take an average of 17 years (Green et al., 2009). For example, it has been included in the American Psychological Association's PsycTESTS database (https://www.apa.org/pubs/databases/psyctests/) and the American Speech-Language-Hearing Association example of Functional Goal Writing Using ICF (http://www.asha.org/uploadedFiles/ICF-Speech-Sound-Disorder.pdf). The ICS has been

recommended in the International Consortium for Health Outcomes Measurement (ICHOM) core outcomes set for Craniofacial Microsomia (www.ichom.org/medical-conditions/craniofacial-microsomia/), used to determine the Timing of Primary Surgery for Cleft Palate (TOPS) in Sweden, Denmark and the UK (http://www.topstrial.org.uk/summary.html), as an assessment tool in the UK Cleft Collective Birth Cohort Study (http://www.speech-therapy.org.uk/projects/cleft-collective-speech-and-language-study), within hospital assessment protocols in Danderyds, Sweden (http://www.ds.se/talkliniken) and Ho Chi Minh City, Viet Nam (Hoàng, Trà, & Cao, 2014), and many other real-world clinical and educational settings to document children's intelligibility.

Limitations and Future Directions

Despite the value of the ICS, there are a number of limitations. The ICS is a simple and quick measure that relies on reporter judgment, rather than direct assessment; thus, is influenced by the interdependence between the listener and speaker. At times, the person completing the ICS (usually the parent), may not be able to answer some of the ICS questions because the child does not interact with that person (e.g., a child who is too young to attend school will not speak with a teacher). Current work is underway to create an online version and a version of the ICS for teachers/children and spouses/adults. While it is promising to have validation data for 14 languages, additional validation and norming across languages, countries and with multilingual speakers would be of benefit. Further testing of the applications of the ICS (e.g., as an outcome measure) and the adoption of the ICS into clinical practice using implementation science is warranted.

Summary and Conclusions

Intelligibility is an important concept in SLP practice and requires consideration of the speaker, listener, task, and context/environment. The ICS is a promising parent-report

measure of intelligibility in over 60 languages. There is emerging evidence across languages that typically developing preschoolers are “usually” to “always” intelligible (mean score >4/5). There also is emerging evidence from 18 studies that it is a valid and reliable tool across languages and countries and that it is being implemented in clinical practice. To conclude with external commentary: The ICS “…permits one to gain inroads into what counts as a clinically, communicatively, as opposed to merely statistically significant change in intelligibility … in relation to given listeners, in given situations.” (Miller, 2013, p. 608).

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Table 1. *Summary and comparisons of the psychometric properties across 18 studies examining the Intelligibility in Context Scale (ICS) ordered alphabetically by language*

ICS language	**Participants' spoken language(s)**	**Participants' country**	**Author (year)**	**Age range (years)**	**Sample size *(N)***	**Typical *(n)***	**Atypical *(n)***	**Identification of atypical sample**	**ICS-Total *Mean (SD)***	**ICS-Typical *Mean (SD)***	**ICS-Atypical *Mean (SD)***	**Sensitivity/ Specificity (Optimal cut off score)**	**Test-retest reliability**	**Internal reliability/ consistency**	**Construct validity**	**Criterion validity (PCC)**	**Criterion validity (PVC, PPC)**
1. ICS: Traditional Chinese	Cantonese	Hong Kong, SAR China	Ng et al. (2014)	3;0-6;0	72	39	33	Speech assessment	.	4.56 (0.48)	4.14 (0.65)	0.58/ 0.72 (4.29)	"satisfactory" ICC range r = .67 to r = .87 Item-to-item agreement 71.40%	.	range r = .56 to r = .89, ps < .001	PICC r = .41, p < .001	.
2. ICS: Traditional Chinese	Cantonese	Hong Kong, SAR China	Kok & To (2019)	2;4-6;9	789	642	147	Speech assessment	3.96 (0.71)	4.03 (0.70)	3.63 (0.66)	4;0-4;5 years: 0.80/ 0.74 (3.64)	.	.	.	.	.
3. ICS: Croatian	Croatian	Croatia	Tomić & Mildner (2014)	1;2-7;3	486	.	.	.	Parents: 4.44 (0.59); Teachers: 4.52 (0.62)	.	.	.	.	α = .98	.	.	.
4. ICS: Dutch	Dutch	The Netherlands	van Doorni	4;0-6;11	67	48	19	Speech assessment	.	4.50 (0.44)	4.01 (0.56)	.	.	.	.	.	.

				k et al. (2018)													
5.	ICS: English	English	Australia	McLeod et al. (2012b)	3;11 - 5;8	120	11	109	Parent/ teacher concern	.	4.69 (0.51)	3.85 (0.49)	.	.	α = .93	range r = .48 to r = .86, ps < .001	r = .54, p < .01	PVC: r =.36, p < .01 PPC: r = .54, p < .01
6.	ICS: English	English	Australia	McLeod et al. (2015)	4;0 - 5;5	803	525	278	Parent concern	4.4 (0.7)	4.6	3.9	0.82/ 0.58 (4.6)	(n = 140) "strong correlation" Time 1 (M = 3.9) Time 2 (M = 3.8) r = .75, p < .001	.	.	.	.
7.	ICS: English	"Main language (ML)", Fiji English (FE)	Fiji	Hopf et al. (2017)	5;3 - 10;5	65	.	.	Speech assessment	ML: 4.6 (0.6); FE: 4.4 (0.5)	.	.	.	.	ML: α = .83; FE: α = .79	ML: r = .31 to .78, all ps < .05; FE: r = .29 to .68, all ps < .05	"no correlation" r = .1, p = 0.55	PVC: r = .26, p = 0.04 PPC: r = .1, p = .34
8.	ICS: English	English (E) + Jamaican	Jamaica	Washington et al. (2017)	3;3 - 6;3	145	145	.	Speech assessment	.	E: 4.43 (0.63) / JC:	.	.	(n = 12) "high" Time 1 (M = 4.41)	α = .91	range r = .42 to r = .81,	r = .39, p < .001	PVC: r = .28, p = .005 PPC: r

	Creole (JC)									4.50 (0.56)			and Time 2 (M = 4.47), ρ = .97, p < .001		*ps* < .001		= .39, *p* < .001
9. ICS: English, Fijian, Fiji-Hindi	Not reported	Fiji	Sprunt & Marella (2018)	5 – 15 years	463	257	71	Parent/ teacher concern	.	4.0-5.0	1.0-2.43*	.	.	.	.	.	.
10. ICS: German	German	Germany	Neumann et al. (2016)	3;0-5;11	181	151	30	SLP referral and speech assessment	4.40 (0.76)	4.49 (0.47)	3.97 (0.63)	.	(n = 36) "high" r = .998, p < .001	α = .94	r = .71 to r = .93 ps < .001	r = .42, p < .001	PVC: r = .62, p < .001 PPC: r = .47, p < .001
11. ICS: Italian	Italian	Italy	Piazzalunga et al. (2019)	3;0-5;11	364	356	8	Parent report	Mothers: 4.51 (0.47) Fathers: 4.46 (0.50)	.	.	.	(n = 127) "high" Mothers: rs=.781, p<.01; 276 ICC=.887, 95%CI =.839-.920), and Fathers: rs=.778,	Mothers: α = .918 Fathers: α = .917	Mothers: *r*=.409 to *r*=.847 Fathers: *r*=.465 and *r*=.871	"moderate correlation" *r*s=.432, *p*<.01	PVC: "weak correlation" *r*s=.327, *p*<.01 PPC: "moderate correlation" *r*s=.435, *p*<.01

													p<.01; ICC=.881, 95%CI=.829-.917				
12. ICS: Korean	Korean	Korea	Lee (2018)	4;0 – 6;9	78	55	23	Speech assessment	.	.	.	.	.	.	.	SSD: *r* = 0.673, *p* <.001 Typical: *r* = 0.299, *p* <.05	.
13. ICS: Korean	Korean	Korea	Lee (2019)	2;6-6;5	178	145	33	Speech assessment	4.46 (0.59)	4.64 (0.41)	3.67 (0.62)	0.91/ 0.78	"satisfactory" *r* = 0.853, *p* <.001	α = .945 range *r* = .541 to *r* = .827	range *r* = .656 to *r* = .943, ps < .001	r = 0.627, p < .001	.
14. ICS: Korean	Korean	New Zealand	Kim et al. (2016)	3;0-5;11	33	33	.	.	4.44 (0.42)	4.44 (0.42)	.	.	.	.	.	.	.
15. ICS: European Portuguese	Portuguese (Europe)	Portugal	Lousada et al. (2019)	3;11-6;2	76	51	25	Parent/ teacher concern	4.50 (0.60)	4.78 (0.36)	3.91 (0.59)	0.80/ 0.84 (4.36)	.	α = 0.96	.	*r* = .654	PVC: *r* = .588 PPC: *r* = .655
16. ICS: Slovenian	Slovenian	Slovenia	Kogovšek & Ozbič (2013)	1;6 – 6;6	104	.	.	.	4.56 (0.51)	.	.	.	.	.	.	.	.

17. ICS: Swedish	Swedish	Sweden	Lagerberg et al. (2019)	4;1-10;1	30	.	30	SLP referral	.	.	3.99 (0.64)	.	.	"moderate to strong" r = .56-.90	*r* = .40, *p* < .05	.	.
18. ICS: Vietnamese	Vietnamese	Viet Nam	Phạm et al. (2017)	2;0-5;11	181	148	33	Parent concern	4.43 (0.62	4.63 (0.67)	3.96 (0.70)	.	.	α = .94	range *r* = .54 to *r* = .88, *p*s < .001	*r* = .42, *p* < .01	.

Note. PCC = percentage of consonants correct, PICC = percentage of initial consonants correct, PVC = percentage of vowels correct, PPC = percentage of phonemes correct, PICC = percentage of initial consonants correct, SSD = speech sound disorders. *Removed the middle group of participants from analysis.