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A short-form version of the Australian English Communicative Development Inventory

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Abstract

Purpose: The Australian English Communicative Development Inventory (OZI) is a 558-item parent report tool for assessing language development at 12–30 months. Here, we introduce the short form (OZI-SF), a 100-item, picture-supported, online instrument with substantially lower time and literacy demands.
Method: In tool development (Study 1), 95 items were drawn from the OZI to match its item distribution by age of acquisition and semantic categories. Five items were added from four other semantic categories, plus 12 gestures and six games/routines. Simulations computed OZI-SF scores from existing long-form OZI norm data, and OZI and projected OZI-SF scores were correlated. In an independent norming sample (Study 2), parents ($n = 230$) completed the OZI-SF for their children aged 12–30 months. Child scores were analysed by age and sex.
Result: OZI-SF and OZI scores correlate highly across age and language development levels. Vocabulary scores (receptive, expressive) correlate with age and the median for girls is higher until 24 months. By 24 months, 50% of the sample combine words "often". The median time to OZI-SF completion was 12 minutes.
Conclusion: Fitted percentiles permit working guidelines for typical (median) performance and lower cut-offs for children who may be behind on age-based expectations and/or at risk for a communication difficulty. The OZI-SF is a short-form of the OZI that has promise for research and clinical/educational use with Australian families.

Keywords: *Vocabulary; gesture; assessment; parents; MacArthur-Bates; Australian English*

Introduction

The MacArthur-Bates Communicative Development Inventories (CDI) were developed as effective and cost-efficient parent-report checklists with a focus on early vocabulary (Fenson et al., 1994). CDIs are typically completed by parents/caregivers either independently or with a professional involved in the child's care (e.g. speech-language pathologists, doctors or child and family health nurses). The role of caregivers in accurate reporting of early communication skills is well-documented (Law & Roy, 2008; Miller et al., 2017; Sachse & von Suchodoletz, 2008). Caregivers' reporting of early vocabulary has been shown to predict early language outcomes and later literacy development (Lee, 2011; Snowling, 2004). Early identification of infant and toddler communication skills can support access to early intervention and has the potential to limit later difficulties

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(Larson, 2016; Paul & Roth, 2011). However, it is also well known that CDIs are most accurate when language and dialect-specific (for example British English – Hamilton et al., 2000; Australian English – Kalashnikova et al., 2016).

CDIs typically have two parts. The first section is a set list from which caregivers indicate the words their child understands or says. In the second section, additional information is recorded such as the child's longest utterance (M3LU), early symbolic and communicative gestures as well as the development of word combinations. Speech-language pathologists use CDIs to screen or assess early vocabulary development in addition to a method to monitor therapeutic change (Crais, 2011; Heilmann et al., 2005). In the current context, we propose that CDIs are a useful assessment in telehealth for infants and toddlers.

The Australian English Communicative Development Inventory (OZI) was developed in 2003 (Schwarz, 2007) as an adaptation of the CDI. The OZI assesses expressive (not receptive) vocabulary in infants and toddlers aged 12–30 months, includes sections on word forms, word endings, and mean length for the three longest sentences (M3L), and also collects information about date of birth, gender, exposure to languages other than English, ear infections or hearing loss, and gestation period in weeks.

The OZI was developed by combining, and adapting for Australian English, sections of the infant CDI "Words and Gestures" and the toddler CDI "Words and Sentences" into a single vocabulary list (for details see Kalashnikova et al., 2016). One of the original purposes for developing a single list for the age range 12–30 months was to produce an instrument suitable for longitudinal studies of Australian children (Schwarz, 2007). At 558 items over 15 vocabulary sections, the OZI is slightly shorter than the Words and Sentences form of the MacArthur-Bates CDI (680 items, 22 vocabulary sections). The CDI vocabulary sections which do not appear on the OZI are: words about time, pronouns, question words, prepositions and locations, quantifiers and articles, helping verbs, and connecting words. Additionally, CDI sections on gesture production or grammatical complexity are also excluded from the OZI.

The OZI is warranted for use with Australian children, normed, and has been used in research. Toddlers (24- and 30-month-olds) who are acquiring Australian English have higher scores on the OZI than on the American English MacArthur-Bates CDI (Kalashnikova et al., 2016). Expressive vocabulary norms have also been developed for the OZI for 12- to 30-month-old Australian infants and toddlers ($N = 1496$) and these norms are available on WordBank (http://wordbank.stanford.edu). In OZI norming, a large sample of Sydney children aged 12–30 months, 749 girls and 747 boys, with parent report of no sensory or cognitive deficits was recruited from a research register of study volunteers at MARCS BabyLab, an infant research laboratory at Western Sydney University. The sample comprised children from monolingual Australian English backgrounds (74% sample) as well as bilingual backgrounds (exposure to a second language ranging from 2 to 70 hours per week). Participants were recruited by phone and email and they completed a hardcopy OZI checklist, either on a visit to the lab or at home after receiving instructions over the phone. Participants' household incomes were estimated at the median for Sydney, and slightly higher than the median income for New South Wales and Australia overall (see Kalashnikova et al., 2016).

The OZI has been adopted in research and clinical practice by speech-language pathologists in Australia. In research, the OZI was already well used even prior to available norms. It has been used in studies of preterm infants (Crosbie & Holm, 2008), children with Down syndrome (Tang & Smith, 2010), infants at risk for dyslexia (Kalashnikova, Goswami, & Burnham, 2020), and in a range of other basic science studies (e.g. Hemsley et al., 2010, 2013; Kalashnikova et al., 2019; Lam & Kitamura, 2010; Masso et al., 2014; Mulak et al., 2013). No valid studies of the OZI have yet been done, nor have studies of the extent to which parents can specifically use the OZI to validly report their child's vocabulary. Studies with other CDIs have, however, been done, indicating that CDIs provide valid estimates of children's communication and that parents are able to report accurately using a CDI. Not surprisingly, parents are known to find it easier to report expressive rather than receptive vocabulary. Examples of key validity studies for CDIs include: Bleses et al. (2008), Dale (1991), Dale et al. (1989), Feldman et al. (2005), Pérez-Pereira and Resches (2011), and Reese and Read (2000).

Since the OZI was developed, short-form versions of the MacArthur-Bates CDIs have increasingly been developed and have proved popular in research and practical applications. Short forms have been developed for a range of languages including American English (Fenson et al., 2000), Bangla (Hamadani et al., 2010), British English (Atkinson et al., 2001; Eley et al., 2001), Danish (Vach et al., 2010), Galician (Pérez-Pereira & Resches, 2007), German (Sachse & von Suchodoletz, 2007), Austrian German (Marschik et al., 2007), Italian (Caselli et al., 2007), Mexican Spanish (Jackson-Maldonado & Martin del Campo, 2005), and Swedish (Eriksson et al., 2002). Even at 558 items, the OZI is a long-form; the OZI has been observed to take as long as 30–45 minutes to complete, even for parents with high literacy levels (i.e. university education background), and especially for older toddlers who are producing many words. In 2018, it was therefore decided to develop a short-form OZI for use where a shorter instrument was more practical, in clinical or educational contexts and in some research contexts (e.g. where a battery of tests is required and there is insufficient time available for the full OZI to be administered). It was also decided to create a short-form OZI that would allow measurement of both receptive and expressive vocabulary, since receptive vocabulary is an important predictor of communicative development, and to permit measurement of vocabulary development in young infants, who tend to obtain very low scores on the expressive CDI. Authorisation from the CDI Board was obtained in 2019 for developing and norming the OZI Short Form (OZI-SF).

Aim of the study

This article outlines the development of the Australian English CDI short form (OZI-SF), in two sub-studies. In the first sub-study, the aim is to describe in detail the development process, including ascertaining the relationship between (expressive) scores on the OZI and simulated expressive scores on the OZI-SF. In the second sub-study, the aim is to collect and descriptively analyse independent norming data (expressive and receptive) for the OZI-SF. This analysis is intended to inform initial guidelines suggested for clinical use and directions for future research in the final discussion sections.

The research questions addressed in this study are:

RQ1. What is the relationship between OZI scores and simulated OZI-SF scores? To what extent are they correlated, based on data from the OZI norming sample?

RQ2. How do child scores (receptive and expressive) on the OZI-SF pattern by child age and sex in an independent norming sample with a similar geographic and socioeconomic profile to the OZI norming sample?

Short form development

Method

Instrument development

This research received ethics approval from the Human Research Ethics Committee of Western Sydney University (H12120). The CDI Advisory Board provided advice on tool development and authorisation of the OZI-SF tool as a version of the CDI Words & Gestures form.

Procedures were developed to generate an OZI short-form alternative to the existing long-form, following the approach taken to develop other CDI short forms (Fenson et al., 2000; Jackson-Maldonado et al., 2013; Pérez-Pereira & Resches, 2011; Rinaldi et al., 2019). This approach contrasts with constructing a form designed for language screening at a particular age. For example, the Danish short form CDI was carefully designed to produce a left-skewed distribution at 3 years of age so that the lower percentiles would be well spaced (Vach et al., 2010).

Following the guidelines for the creation of a short-form vocabulary inventory described in Fenson et al. (2000), the list of items selected to make the OZI-SF was drawn from the full form of the Australian English Communicative Development Inventory (OZI: Kalashnikova et al., 2016). It was decided in advance of item selection that the short form would comprise 100 words, a length previously been chosen as an upper limit for other short-form CDIs, and would assess both expressive and receptive vocabulary. Additionally, a small set of gestures and games/routines, a question about word-combining, and a measure of sentence length were included. These inclusions make the OZI-SF more comparable in content to other CDIs, permitting assessment of preverbal communication as well as early syntactic development, key milestones in communication development. Items were excluded from the list if (a) their meaning or semantic category was ambiguous (could fall into more than one category), (b) they were highly culturally specific, or (c) they referred to a concept for which a child may produce a different word.

A set of 95 vocabulary items were first drawn from the OZI. We ensured that the distribution of words on OZI-SF was equivalent or comparable to the OZI for each *semantic category* (see Table I) and *age of acquisition* (see Table II for list comparison, and Table III for OZI-SF item-by-item age of acquisition according to the OZI long-form norms). To make the OZI-SF closer to original American CDIs in semantic category coverage, an additional five vocabulary items were included into the OZI-SF from the following semantic categories (that were not included in the OZI): words about time, pronouns, prepositions, and question words. This change makes the OZI-SF more comparable in content with other CDIs and brings the number of semantic sections on the OZI-SF to 19. (Note that in Table III these five words appear without age of acquisition data since these words were not included in the OZI.) The selection of target words was thus driven by overall

Table I. Distribution of items according to semantic categories.

Semantic category	*n* OZI	% OZI	% OZI-SF	*n* OZI-SF
Sounds	12	2.15	2.04	3
Animals	42	7.53	7.15	7
Vehicles	14	2.51	2.38	2
Toys	17	3.05	2.89	3
Food/Drink	63	11.29	10.73	11
Clothing	24	4.30	4.09	4
Body parts	27	4.84	4.60	5
Small items	49	8.78	8.34	8
Furniture	30	5.38	5.11	5
Outside	32	5.73	5.45	6
Places to go	21	3.76	3.58	4
People	29	5.20	4.94	5
Games/Routines	24	4.30	4.09	4
Action words	108	19.35	18.39	17
Descriptive words	66	11.83	11.24	11
	558	100.00	95.02	95

Table II. Distribution of items according to Age of Acquisition.

Age (months)	n OZI	% OZI	% OZI-SF	n OZI-SF
13	3	0.54	0.51	1
14	1	0.18	0.17	1
15	1	0.18	0.17	1
16	7	1.26	1.19	1
17	9	1.62	1.54	3
18	14	2.51	2.39	2
19	25	4.49	4.26	4
20	18	3.23	3.07	3
21	14	2.51	2.39	2
22	91	16.34	15.52	16
23	37	6.64	6.31	6
24	26	4.67	4.43	4
25	35	6.28	5.97	6
26	79	14.18	13.47	13
27	80	14.36	13.64	13
28	8	1.44	1.36	1
29	20	3.59	3.41	3
30	15	2.69	2.56	3
31	74	13.29	12.62	12
	557*	100.00	95.00	95

*This sums to 557 (not 558) because the item "own name" is not included in AoA data.

Table III. OZI-SF items with Age of Acquisition (months) from the OZI long-form norms.

Baa Baa	17	Hat	19	Tree	22	Pull	26
Uh oh	15	Necklace	28	Pool	22	Shake	27
Ouch	19	Shoe	17	Flag	29	Run	22
Kangaroo	23	Coat	29	Shop	22	Think	30
Bird	17	Lips	26	House/home	22	Wish	30+
Cat	18	Toes	21	Beach	25	Look	23
Bear	22	Leg	22	School	24	Big	23
Sheep	22	Chin	22	Mummy	13	Gentle	26
Spider	22	Tongue	24	Grandma/nanna	14	Careful	26
Penguin	26	Glass	27	Person	30+	Dirty	22
Airplane	19	Clock	22	Friend	27	Fine	30+
Boat	20	Mop	30+	Doctor	26	Mad	30+
Game	27	Comb	27	Lunch	25	Noisy	30+
Puzzle	25	Towel	23	Call	25	Slow	30
Present	25	Glass	27	Thank you	18	Happy	26
Pasta	25	Keys	19	Night-night	21	Tiny	30+
Beans	27	Picture	26	Carry	26	Drop	26
Meat	27	Chair	20	Chase	27	Build	27
Peas	24	Bed	20	Dump	30+	Black	26
Salt	30+	Oven	27	Finish	24	No	16
Yoghurt	22	Stairs	23	Fit	27	*Today	
Cereal	27	Bench	30+	Hug	22	*She/he	
Custard	30	Cloud	26	Listen	29	*Does	
Carrot	23	Swing	22	Like	26	*Down	
Pudding	30+	Sun	22	Pretend	30+	*In	

The order of items in Table III reflects CDI semantic categories.
*Indicates the five added items on time, pronouns, prepositions, and question words that were not in the OZI long-form inventory (hence they lack OZI age norms).

comparability with the OZI and other CDIs, and then consensus on the word selection was reached across the research team.

In addition to the 100 vocabulary items, 12 gestures and six games/routines were also included; gestures and routines were chosen based on consensus agreement among the research team about their familiarity with many Australian children and potential usefulness in practical contexts as indices of early communication. The resulting, complete OZI-SF inventory is provided as a supplementary file.

Simulation sampling

Sets of item-by-item scores were extracted from the OZI for the 95 vocabulary items on the OZI-SF. These scores were used for three separate simulations. Simulation 1 compares the OZI and OZI-SF in a sample balanced for infant age. A total of 50 children were selected from the norming dataset for the OZI long-form with $n = 5$ for each of the following age groups: 12, 14, 16, 18, 20, 22, 24, 26, 28, and 30 months. Sampling of children was done by selecting the first children located in the dataset who met the age criteria. A correlation was obtained for OZI and OZI-SF scores for this group. It is important for the OZI-SF to be valid at all ages and at all levels of language development, especially perhaps at the lower levels of language development, in the event it becomes used as a screener in some speech-language pathology contexts. The intended age range for the OZI is also relatively wide (12–30 months) for a single CDI form; most short-form and long-form CDIs have two separate forms (infant and toddler versions) to cater to this age range. Therefore, we split the Simulation 1 dataset into three subsamples (three age groups: 12–18, 20–24, and 26–30 months of age) and obtained separate correlations between OZI and OZI-SF scores.

Simulation 2 compares OZI and OZI-SF scores for a sample of children who differ systematically in percentile rank. Simulation 2 was run by using the full OZI norming sample (Kalashnikova et al., 2016). (The same data are publically available on WordBank (wordbank.stanford.edu – Frank et al., 2017), permitting replication if desired.) For Simulation 2, a total of 58 children were selected from the OZI norming sample to represent both the extremes and the middle of the range of language level: $n = 20$ scored in the 10^{th} percentile of the sample, $n = 19$ scored in the 50^{th} percentile, and $n = 19$ scored in the 90^{th} percentile. Children were sampled by selecting the first children located in the dataset who met the percentile rank criteria. As a check on the validity of the OZI-SF for younger and older children, correlations were also obtained separately for three subsamples of children within Simulation 2 (three levels of language: 10^{th}, 50^{th}, and 90^{th} percentiles). Simulation 3 compares OZI-SF and OZI scores using all children ($N = 1521$) who participated in the normative sample for the OZI and assesses for gender effects.

Result

For each of the three simulations, Pearson's product-moment correlations were obtained between scores on the OZI (from the norming sample data) and simulated scores on the OZI-SF, for the 95 words drawn from the OZI. Partial correlations were also obtained to control for the effects of age.

Simulation 1: infant age

For the sample balanced by infant age, the correlation between OZI and OZI-SF scores was $r(50) = 0.995$, $p < 0.001$ ($r(50) = 0.988$, $p < 0.001$ after age was partial out). Table IV provides separate correlations between OZI and OZI-SF scores for subsamples

Table IV. Correlations between OZI and OZI-SF scores for subsamples.

Subsample	Correlation	Correlation after age partialed out
Simulation 1: aged 12–18 months	$r(20) = 0.945, p < 0.001$	$r(20) = 0.914, p < 0.001$
Simulation 1: aged 20–24 months	$r(15) = 0.987, p < 0.001$	$r(15) = 0.988, p < 0.001$
Simulation 1: aged 26–30 months	$r(15) = 0.990, p < 0.001$	$r(15) = 0.988, p < 0.001$
Simulation 2: 10^{th} percentile	$r(20) = 0.980, p < 0.001$	$r(20) = 0.865, p < 0.001$
Simulation 2: 50^{th} percentile	$r(19) = 0.996, p < 0.001$	$r(19) = 0.996, p < 0.001$
Simulation 2: 90^{th} percentile	$r(19) = 0.995, p < 0.001$	$r(19) = 0.899, p < 0.001$

within this simulation sample (ages 12–18, 20–24, and 26–30 months).

Simulation 2: percentile rank

For the sample drawn from percentile ranks 10, 50, and 90, the correlation between OZI and OZI-SF scores was $r(58) = 0.996$, $p < 0.001$ ($r(58) = 0.995$, $p < 0.001$ after age was partial out). Table IV provides separate correlations between OZI and OZI-SF scores for subsamples within this simulation sample (10^{th}, $50^{th,}$ and 90^{th} percentiles).

Simulation 3: full OZI sample

For the simulation involving the full OZI norming sample, the correlation between OZI and OZI-SF scores was $r(1521) = 0.996$, $p < 0.001$ ($r(1521) = 0.992$, $p < 0.001$ after age was partial out). Figure 1 shows the distribution of scores on OZI in relation to simulated scores on OZI-SF. Girls obtained higher scores on average than boys on the OZI-SF, $t(1515) = 4.625$, $p < 0.001$, as on the OZI (Kalashnikova et al., 2016), but gender only accounted for 1.3% of the variance in OZI-SF scores (just as it accounted for only about 1% of the variance in OZI scores – Kalashnikova et al., 2016, p. 419).

Correlations were also obtained between OZI-SF scores and children's M3L (mean length of the three longest sentences produced by the child) only for children 16 months or older. The correlation was $r(1099) = 0.754$, $p < 0.001$ ($r(1099) = 0.585$, $p < 0.001$ after age was partial out).

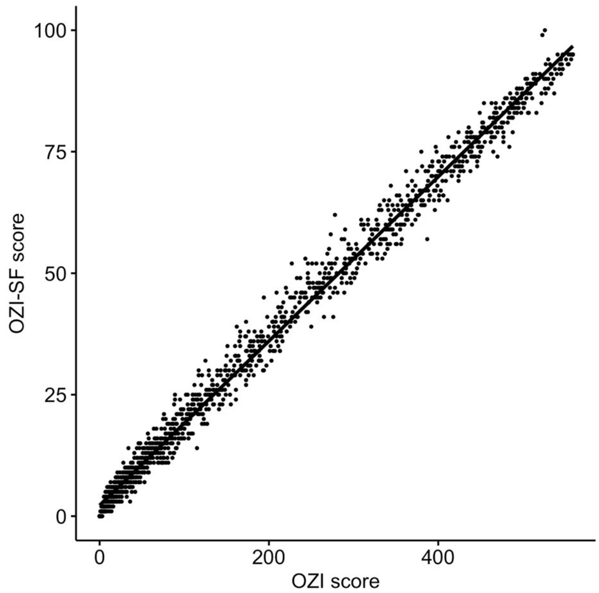

Figure 1. Correlations between OZI scores and simulated OZI-SF scores, for the OZI norming sample.

Discussion

The first substudy has offered an account of the development of the OZI-SF as an alternative to the OZI (Schwarz, 2007; Kalashnikova et al., 2016). Following procedures for other short-form CDI development (e.g. Fenson et al., 2000) the first 95 items on the OZI-SF were drawn from the OZI, to match its distribution by productive age of acquisition and semantic categories. Correlations were then obtained between OZI scores and OZI-SF simulated scores (based on the norming sample, Kalashnikova et al., 2016), in three simulations. The correlations were high (> 0.90) for all comparisons. Correlations were also obtained between simulated OZI-SF vocabulary scores and M3L. Even though those vocabulary-grammar correlations were weaker than the correlations between vocabulary scores, the pattern is consistent with previous research into correlations between the vocabulary and grammar scores on the complete CDI forms (Fenson et al., 1994). Taken together, the present results suggest that the OZI-SF can potentially meet the intended goal of a shorter alternative to the OZI across the relatively wide age range of the single-form OZI (12–30 months). Next, we turn to the independent norming study on the OZI-SF.

Why is a separate norming study warranted for the OZI-SF, when the OZI is already normed? Structurally, the OZI-SF departs slightly from the OZI in that it includes five items that were not drawn from the original OZI, plus twelve gestures, and six games/routines. A shorter form may also induce a different reporting pattern, and so an independent sample is required. A norming study provides full norms for the 100-item vocabulary list on the OZI-SF, and also allows us to examine for the first time the pattern of parent report on receptive vocabulary (since the OZI norms are only for expressive vocabulary). The new section on gestures and games/routines on the OZI-SF is not anticipated to have good reliability (based on the psychometric analysis of a set smaller than 40 items, see Fenson et al., 2000, p. 98). So we do not attempt norms. We have included this section, however, in case it proves useful to educators, clinicians, and parents in starting conversations with each other about early communication, to monitor development, and guide advice on fuller assessments and referrals to speech-language pathology, or other educational and social supports for child and family. The norming sample for the OZI-SF also permits the assessment of whether separate norms for boys and girls are warranted. Based on the results of substudy 1, separate norms may be required since the OZI-SF simulated results in the first part of this paper show that scores for girls are slightly higher than for boys at the same age.

Independent norming data for OZI-SF

Method

This research received ethics approval from the Human Research Ethics Committee of Western Sydney University (H13693).

Participants, recruitment and procedure

Participants were parents of children ($N = 230$) aged approximately 12–30 months, the same age range as for the norming of the long-form OZI. Parents were recruited via social media through the MARCS Institute BabyLab infant research facility, from the facility's register, and via social media (e.g. StoryPark) posts from participating early childhood centres in western Sydney.

Each parent completed the OZI-SF online in the form of a Qualtrics survey, by using their computer, tablet or smartphone to visit a link: tinyurl.com/y7t2ceyw. (Each parent used an internet browser, they did not need to have a Qualtrics account or to have Qualtrics installed). The survey was introduced with simple instructions on how to answer the questions about "says" and "understands", for example, to count "says" only if the child says the word spontaneously not just in imitation, to count incomplete pronunciations (like "sketti" instead of "spaghetti"), and to count an item if known in English or any language, for a bilingual/multilingual child. (See the link above.) As exemplified with the screenshot in Figure 2, each vocabulary item was picture-supported by a clear and colourful drawing to increase enjoyment and accessibility. Parents completed the OZI-SF items (100 vocabulary items selecting "Says" and/or "Understands" – plus the gestures and games/routines) as well as demographic information (child's sex, date of birth, parent education). The median time to completion was 12 minutes (according to automatic survey analysis in Qualtrics). A report on the child's results on the OZI-SF, including the parent's "says" and/or "understands" responses for each item, item images, and total scores was automatically emailed to the parent at the conclusion of the Qualtrics survey.

Sample construction and data processing

Online data collection occurred between February 2019 and April 2020, when the sample goal of age by sex (6×2) stratified sample of children was reached.

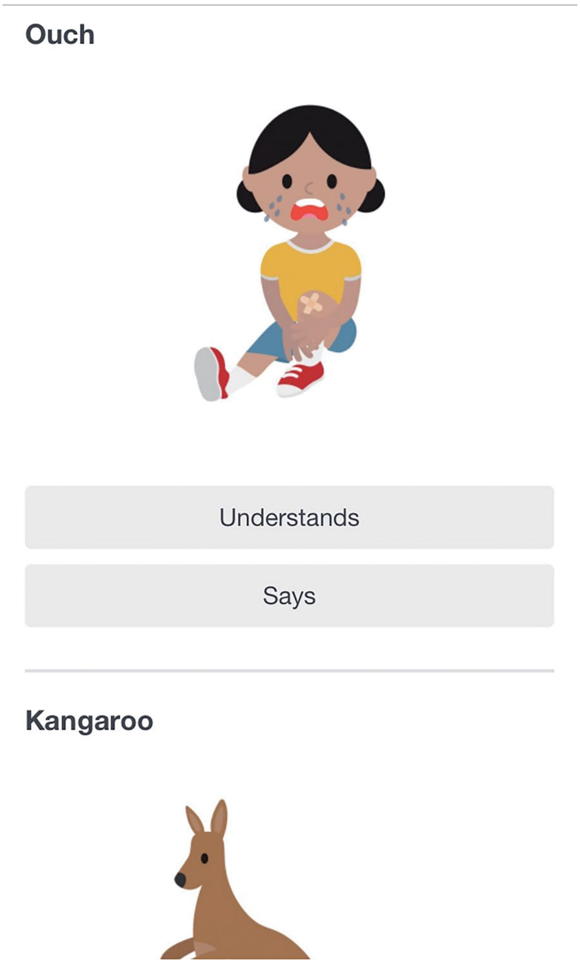

Figure 2. Screenshot of the online OZI-SF interface showing response choices and supporting images.

A Python script identified unique children using a combination of name, date of birth and gender, and assigned to each unique child an ID, as some children were reported on more than once (different ages). The script also converted the data into standard formats (e.g. converting Male, male, and m to M), and calculated total scores for each child: expressive score (/100), receptive score (/100), gesture score (/12) and games/routine score (/6).

The data collected were then subsetted into the desired sample, based on the following inclusion/exclusion criteria. There was a minimum of 10 boys and 10 girls per age group, with age bins centred on ages 12, 15, 18, 21, 24, 27, and 30 months (with a window of up to 1.5 months on either side of the centre point). Each child included was born full-term (at greater than or equal to 37 weeks). Hearing status varied freely in the sample and included children who had had grommets. One parent must have completed tertiary education (technical/vocational certificate or diploma, or university degree), to ensure the norming sample was similar to the middle-class norming sample for the OZI (Kalashnikova et al., 2016). For parents who completed the OZI-SF more than once for the same child, only data from the first visit were included. GPS location data (where available)

Table V. Descriptive statistics for child age by sex within each age group.

Age group (months)	Sex	Mean age	Standard deviation	Standard error	*n*
10.5–13.4	F	11.70	0.85	0.19	19
	M	11.76	0.91	0.20	21
13.5–16.4	F	14.97	0.98	0.33	9
	M	14.76	0.87	0.26	11
16.5–19.4	F	18.07	0.85	0.22	15
	M	18.14	0.87	0.21	17
19.5–22.4	F	21.10	0.69	0.18	15
	M	21.12	0.83	0.02	17
22.5–25.4	F	23.63	0.73	0.19	15
	M	23.90	0.80	0.17	23
25.5–28.4	F	26.83	0.85	0.20	18
	M	27.18	0.87	0.22	16
28.5–31.4	F	29.73	0.75	0.16	20
	M	29.97	0.57	0.17	12

confirmed Australian data source. Using all these criteria we excluded a total of 122 entries. This yielded a total sample of data for 230 children (117 male and 113 female). These data, in an anonymised format, are available for further analysis: doi:10.26183/2ha1-jd64.

The age and sex characteristics of the final sample are shown in Table V. For several age × sex groups, the sampling exceeded the minimum of 10 boys and 10 girls (with the exception of girls aged 13.5–16.4 months, for which only 9 data points proved possible within a reasonable timeframe). Participating families were predominantly monolingual in English (156 or 67.8%) although a substantial minority reported using more than one language at home (74 or 32.2%). Participants' geographical locations were assessed by GPS coordinates (approximated for privacy reasons to 11 × 11 km square region or 1 decimal place) and determined to be in Greater Sydney area (142 participants), non-Sydney areas of Australia (57 participants), or no location available (31 participants).

Data analysis

The OZI-SF norming sample data were analysed descriptively by age and sex, across the OZI-SF measures of vocabulary scores (receptive, expressive), word combination, and scores for gestures and games/routines. RStudio (version 3.6.3) was used to analyse scores as a function of demographic variables and to fit percentiles (R Core Team, 2020). For the percentile fitting, the Quantile Regression (quantregGrowth, v5.55) R package was used (Muggeo et al., 2013). All other graphs were plotted using the ggplot2 package (v3.3.0; Wickham, 2016).

Result

How do scores on the OZI-SF differ by child age?

There was a strong positive correlation between receptive scores and age ($r(228) = 0.74$, $p < 0.001$), and between expressive scores and age ($r(228) = 0.73$, $p < 0.001$). (See Supplementary Materials for scatterplots of receptive and expressive scores by child age and sex).

The 10th, 25th, 50th, 75th, and 90th percentile estimates and their confidence intervals for receptive and expressive vocabulary, respectively, are shown in Figures 3(a,b). The receptive scores follow a generally logarithmic pattern, with the exception of the 10th percentile; the values in the graph increase rapidly early on but begin to level off after the 18-month mark. Children in the 90th percentile are estimated to reach the maximum possible score of 100 shortly after 24 months of age, with those in the 75th percentile also reaching 100 by 31.4 months.

By comparison, the expressive scores in Figure 3(b) follow a more exponential pattern. This is particularly so for the 10–50th percentiles, where the percentile curves begin at or close to zero at 10.5 months and noticeably steepen after the 21-month mark. The percentile fitting on this cross-sectional norming dataset allows us to describe typical scores by age (e.g. the 50th percentile), in addition to describing scores indicating a child may be below age-based expectations and/or at risk of a communication difficulty (e.g. the 10th percentile or below). See the supplementary file for tables of the actual and estimated data from the percentile analyses.

How do scores on the OZI-SF differ by sex?

Up to 24 months of age, the median score for girls is higher than the median score for boys, for both receptive and expressive vocabulary, but above 24 months of age, this sex difference no longer holds. (See Supplementary materials for boxplots of scores by age and sex.)

How does the emergence of word combinations depend on age and sex?

Children are increasingly reported to combine words "often" from age 16.5 months. By 22.5–25.4 months, over 50% of children were reported to combine words "often". At this age, less than 25% of children were reported to not yet combine words, and this group comprised more boys than girls. (See Supplementary materials for response proportions by child age and sex.)

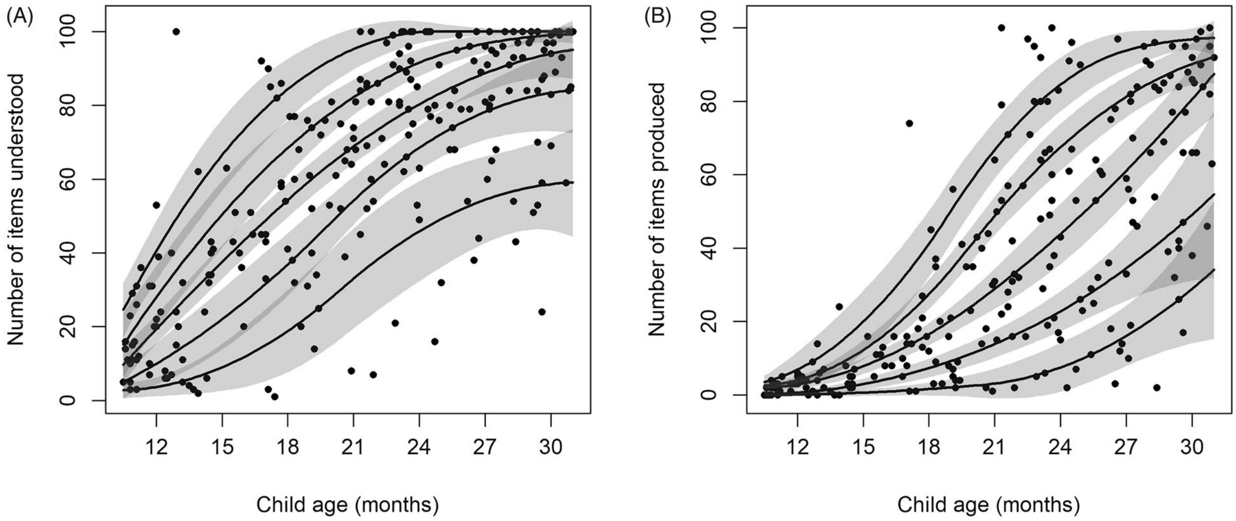

Figure 3. (A) Receptive scores by percentiles (10th, 25th, 50th, 75th, and 90th), on OZI-SF (independent norming sample). (B) Expressive scores by percentiles (10th, 25th, 50th, 75th, and 90th), on OZI-SF (independent norming sample).

Table VI. Gesture development by age.

Age used	Gesture
12 months	Extending the arms to show the caregiver the child is holding something
	Extending the arm upward to signal a wish to be picked up
	Reaching out to give the caregiver a toy or some object that the child has
	Pointing with the arm and index finger at some interesting object or event
18 months	Blowing kisses from a distance
	Shrugging to indicate "all gone" or "where'd it go?"
	Gesturing "hush" by placing the finger to lips
	Nodding the head "yes"

How do scores for gestures and for games/routines differ by age?

Table VI summarises the development of gesture use in the OZI-SF norming data. Four gestures are early acquired (produced by 12 months), and four are later acquired (by 18 months). These are the ages at which 50% of the sample uses these gestures "often".

Four other gestures were neither early- nor later-acquired. They are: requesting something by extending arm and opening and closing hand, shaking head "no" (both 50% "often" at 15 months), waving good-bye on his/her own when someone leaves (50% "often" at 12 months, and 75% "often" at 18 months), and smacking lips in "yum yum" gesture to indicate that something tastes good (a gesture with a high "sometimes" response across ages, with 50% "often" from 27 months).

Of the games/routines, children engaged in two early (75% by 12 months: dancing and peekaboo). Four appeared slightly later (75% by 15 months: playing chasing games, singing, and playing round and round the garden; then playing "twinkle, twinkle, little star" by 18 months).

Discussion

From the analysis, for the middle-class socioeconomic demographic reflected in the sample, several key observations emerged about typical patterns of development as measured by the OZI-SF. Using information based on the 50th percentile, it emerges that by age 12 months parents typically report that their children engage in two of the six games/routines (dancing and playing peekaboo), already understand approximately 16 words, and produce 2–3 words on the OZI-SF. At the same (50th) percentile, by age 24 months parents typically report that their children engage in all of the six games/routines, "often" use all or nearly all the 12 gestures, produce approximately 53 words on the OZI-SF, and have started combining words. By age 30 months, parents of children at the 50% percentile report that they are producing 83 words on the OZI-SF.

The information from children at or below the 25th percentile on the OZI-SF presents a quite different picture. At age 12 months, parents report that their children understand approximately 10 words and produce 1 word on the OZI-SF. At age 24 months, these children are producing approximately 23 words or fewer on the OZI-SF and are not yet combining words. At age 30 months, children at the 25th percentile are producing approximately 51 words or fewer on the OZI-SF. Future research can usefully deepen the data on early gestures and games/routines, and include validity studies to compare the OZI-SF scores with other measures of communication at ages 12–30 months. Until then, the normative data results just outlined for the 25th percentile may serve as a useful clinical heuristic in screening to prompt close monitoring of children's communicative development and a more comprehensive speech, language, and hearing assessment, if a professional and parent agree.

Expressive score trajectories on the OZI-SF can be compared to those for the OZI (see Figure 3, Kalashnikova et al., 2016). On the OZI-SF, the range of scores for the middle of the distribution (25^{th}–75^{th} percentiles) broadens from about 15–18 months and narrows again from 24-27 months. On the OZI the same percentiles also display increasing then decreasing variability in expressive scores over the 15–18 through 24–27 month age range. The trajectories for the 10^{th} and the 90^{th} percentiles are also very similar on the OZI-SF and OZI.

From a practical point of view, the OZI-SF at 100 vocabulary items appears to be a promising alternative tool to the OZI long-form. The median time to completion for the OZI-SF in the norming data (Section 2) is 12 minutes. This is considerably less time than needed for the full 558-item OZI (up to 40+ minutes for children over 18–24 months). The OZI-SF has other strengths: it is available for online completion, via a regular URL (no special software or account is needed); it has picture support promoting enjoyment for all and accessibility for parents who may have limited literacy in English, and a report with scores is automatically generated and emailed to the parent and/or professional. The OZI-SF can be completed by a parent on their own (e.g. prior to a clinical appointment, to save time) or completed as a conversation between parent and professional. Since the norming study was concluded an OZI-SF website has been set up and the parent/professional can visit with their child's scores to receive feedback and interpretation of those scores against the expected norms, including suggestions for referral for those children who are under the 10^{th} percentile, not combining words on time, and/or whose parents are concerned about their child's communication development. The website also links to useful resources for parents (on book reading, talking with children, playgroups, FAQs on bilingualism and screentime, and finding professionals, including Speech Pathology Australia's "find a speech-language pathologist" search function. See: westernsydney.edu.au/babylab/research/infant_vocabulary_checklist_OZI_SF/for_parents/understanding_what_the_results_mean

General discussion and future research

This paper has described the development of the OZI-SF, its simulated correlations with the long-form OZI, and the results of an independent norming sample for the OZI-SF. The percentile curves fitted to the OZI-SF norming data appear similar to those for the OZI, which would permit speech-language pathologists and researchers to use the OZI-SF as an alternative to the OZI where a shorter form is desired for practical reasons.

It will be important to sample more widely across socioeconomic backgrounds to ensure that the OZI-SF is widely applicable in research as well as in educational/clinical applications. Future research could document any differences in patterns of development and/or possible differences in parent reporting tendencies that might be found in a lower socioeconomic status group (e.g. parents who are early school leavers and/or living in poverty). In the current context, the OZI-SF has potential for use in the telepractice capacity and research exploration of this is warranted. Another major focus for future research, given Australia's multiculturalism, will be the applicability of the OZI-SF for families in which children are growing up with one or more additional languages or dialects, as well as Australian English. This would involve both quantitative research (e.g. comparison of scores achieved) as well as qualitative research (e.g. feedback from parents on the cultural and linguistic "translatability" of the items for games/routines, gestures, and vocabulary, to establish how feasible it is for a parent to report the item in any language and to use total conceptual vocabulary scoring). There is also considerable scope for future research to examine in detail the acquisition of the gestures and games/routines, for both mainstream and minority populations. Meanwhile, the OZI-SF is offered as a promising tool for measuring early communication in children aged 12–30 months, as an alternative to the OZI, with lesser time and literacy demands.

Declaration of interest

No potential conflict of interest was reported by the authors.

Supplementary material

Supplemental data for this article can be accessed at https://doi.org/10.1080/17549507.2021.1981446.

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