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TABLE OF CONTENTS

TABLE DES MATIÈRES

Effects of stimulus rate and noise on speech-evoked auditory brainstem responses

Les effets du rythme de présentation et du bruit sur les potentiels évoqués auditifs du tronc cérébral obtenus à l'aide de stimuli verbaux

KEY WORDS

SPEECH-EVOKED ABR

STIMULUS RATE

NOISE

AUDITORY STRESSORS

DISSOCIATION OF NEURAL RESPONSES

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Abstract

Objective: To evaluate the effects of two auditory stressors, fast stimulus rate and/or addition of white noise, on auditory processing of speech in normal hearing subjects.

Design: Speech-evoked auditory brainstem responses (ABR) were collected using a 300 ms formant-synthesized /a/ vowel presented in four conditions: slow stimulus rate of 1.6/s in quiet, fast stimulus rate of 3.1/s in quiet, slow stimulus rate of 1.6/s with continuous white noise, fast stimulus rate of 3.1/s with continuous white noise.

Study sample: Twelve subjects (25 to 35 years old) with normal hearing thresholds.

Results: A fast stimulus rate in quiet reduced amplitude response corresponding to F1 but not to F0. The addition of white noise at the slow stimulus rate reduced amplitude of wave V and response amplitude at F1 but increased response amplitude at F0. Changing from quiet-slow to noise-fast increased response amplitude at F0 by 2.9 dB ($p<0.05$), and decreased response amplitude at F1 and amplitude of wave V by 5.1 dB ($p<0.01$) and 4.7 dB ($p<0.05$) respectively. The interaction of fast stimulus rate with the addition of white noise demonstrated facilitative effects for response amplitude at F0, but occlusive or reversal effects for response amplitude at F1 and wave V amplitude.

Conclusions: This is the first study to investigate the interaction of fast stimulus rate and addition of white noise on speech-evoked ABR in human subjects. The results indicate a clear dissociation in the speech-evoked ABR between the steady-state response at F0, and that at F1 or the transient wave V. The findings advance our understanding of the complex interaction of perceptual stressors in young normal-hearing adults.

Abrégé

Objectif : Évaluer les effets de deux facteurs de stress auditifs, soit un rythme rapide de présentation avec ou sans l'ajout de bruit blanc, sur le traitement auditif de la parole chez des sujets ayant une audition normale.

Devis : Des potentiels évoqués auditifs du tronc cérébral (PÉATC) obtenus à l'aide de stimuli verbaux furent recueillis en utilisant un stimulus d'une durée de 300 ms, correspondant à la voyelle /a/ synthétisée par formants, présenté dans quatre conditions : un rythme lent de présentation de 1,6/s dans le silence, un rythme rapide de présentation de 3,1/s dans le silence, un rythme lent de présentation de 1,6/s avec un bruit blanc continu et un rythme rapide de présentation de 3,1/s avec un bruit blanc continu.

Échantillon : Douze sujets (entre 25 et 35 ans) avec des seuils d'audition normaux.

Résultats : Un rythme rapide de présentation dans le silence a réduit l'amplitude de la réponse correspondant au F1, mais pas à la F0. L'ajout de bruit blanc sur le rythme lent de présentation a réduit l'amplitude de l'onde V et l'amplitude de la réponse au F1, mais a augmenté l'amplitude de la réponse de la F0. Le changement de la condition silence-lent à celle bruit-rapide a augmenté l'amplitude de la réponse de la F0 de 2,9 dB ($p<0,05$), en plus de diminuer l'amplitude de la réponse du F1 et l'amplitude de l'onde V de 5,1 dB ($p<0,01$) et 4,7 dB ($p<0,05$), respectivement. L'interaction entre le rythme rapide de présentation et l'ajout de bruit blanc a démontré des effets facilitants pour l'amplitude de la réponse de la F0, mais des effets d'occlusion ou de renversement pour l'amplitude de la réponse du F1 et pour l'amplitude de l'onde V.

Conclusion : Il s'agit de la première étude qui explore l'interaction entre le rythme rapide de présentation et l'ajout d'un bruit blanc sur le PÉATC obtenus à l'aide de stimuli verbaux chez des sujets humains. Les résultats indiquent une dissociation évidente sur les PÉATC obtenus à l'aide de stimuli verbaux entre la réponse *auditory steady-state* de la F0 et la réponse du F1 ou l'onde transitoire V. Les découvertes font avancer notre compréhension de l'interaction complexe des facteurs de stress perceptuels chez les jeunes adultes ayant une audition normale.

Introduction

The human auditory system interprets the sounds of speech via sensory and cognitive processes, but understanding speech is not a simple task. Difficult listening conditions, such as the presence of noise, reverberation, or fast speech rate, may result in perceptual stressing of the auditory system, especially in individuals with hearing loss. The mechanisms under which the auditory system responds to these stressors and maintains robust speech representations are still not well understood (Tzounopoulos & Kraus, 2009), especially under conditions of combined or multiple auditory stressors. The present paper is concerned with the interaction of two types of auditory stressors: stimulus rate and noise.

Several authors have studied the interaction of stressors on speech perception (e.g. Adams, Gordon-Hickey, Morlas, & Moore, 2012; Adams & Moore, 2009; Raju & Alwan, 2013; Tun, 1998). Tun (1998) evaluated speech perception with sentences presented at various speech rates and different signal-to-noise ratios (SNRs) in young and older adults with normal hearing. The older group had greater difficulty than the young group in processing fast speech, especially at low SNRs. Adams et al (2012) investigated the effects of three speaking rates (slow, average, and fast) on speech perception in noise with older adults with normal hearing (ONH) and hearing impairment (OHI). The authors reported poorer speech perception for both groups of participants when the target speech was presented at a faster rate compared to the average and slower speaking rates. At all three speech rates, speech perception was significantly better for the ONH group than for the group with hearing impairment. Raju and Alwan (2013) evaluated the effects of presentation rate on the perception of consonant-vowel-consonants (CVC) in noise. The authors reported different results depending on the vowel identity. Speaking rate had the most pronounced effect on the /CuC/ stimuli, with fast speech rate being more intelligible than slow speech in noise. However, with the /CiC/ and /CaC/ stimuli, more intelligible speech in noise was found at the slow presentation rate.

Perceptual studies, such as described above, reflect the activity of the whole auditory system to speech stimuli, which involves the complex interaction of sensory, linguistic, cognitive, contextual cues, and other factors (Houtgast & Festen, 2008), in response to multiple stressors such as fast presentation rates and noise. However, they provide limited information about the internal representation of the different elements of speech, such as fundamental frequency and formants, within the auditory system, and on their contribution to CVC discrimination and/or sentence perception. Electrophysiological studies, in contrast, provide an objective measure of the processing that occurs between the stimulus and a response from the generator site, making it possible to probe intermediate stages of the auditory pathway and the specific elements of speech being affected by a particular experimental manipulation.

Speech stimuli evoke both transient and steady-state electrophysiological responses at the level of the brainstem. In electrophysiological studies, the transient brainstem response is typically analyzed in the time domain, which involves measuring amplitudes and latencies of various peaks in the response. Apart from potentially being a neural marker of the start of a speech segment, the transient response has been shown to encode the acoustic structure at the start of the voiced consonant–vowel stop syllables /ga/, /da/, /ba/ (Johnson et al, 2008). The steady-state brainstem response, on the other hand, is typically analyzed in the frequency domain and can be categorized into the envelope-following response (EFR) and the fine structure frequency-following response (FFR). The EFR spectral components are generated primarily as a result of the non-linearities that are introduced by the rectification process of the speech envelope within the cochlea (Aiken & Picton, 2008; Cebulla, Stürzebecher, & Elberling, 2006). The EFR is commonly used to extract the evoked response that is phase-locked to the envelope of the speech stimulus which is modulated at the fundamental frequency F0. On the other hand, the FFR spectral content is generated as a result of auditory neural phase-locking that follows the fine structure of the speech stimulus. The FFR is used to extract the evoked response in the region of the first formant F1, and possibly the second formant F2 if it is sufficiently low in frequency to allow neural phase-locking (Aiken & Picton, 2008; Prévost, Laroche, Marcoux, & Dajani, 2013).

Krizman, Skoe, and Kraus (2010) explored the effects of a single stressor, increasing stimulus rate, on auditory brainstem responses. They used both a click and a CV monosyllable (/da/) stimulus presented at three rates (6.9/s, 10.9/s, and 15.4/s). For the speech-evoked auditory brainstem response (ABR), they reported that the latency of peaks III, V, and A systematically increased in response to increasing stimulus presentation rates while latency of later peaks corresponding to the steady-state response were stable across the three presentation rates. Furthermore, they reported that the increased stimulus rate affected elements of the steady-state speech-evoked response differently; with higher frequencies (notably the F1) being rate sensitive while lower frequencies (notably the F0) remained rate resistant.

Some studies (e.g., Prévost et al, 2013; Russo, Nicol, Musacchia, & Kraus, 2004) explored the effects of another single stressor, background noise, using speech-evoked ABR. Prévost et al (2013) investigated the effects of different SNRs (+5, 0, -5, and -10 dB) on the transient and steady-state components of the ABR evoked by a vowel stimulus in white noise. They reported that in the presence of noise, transient response waves V and A were delayed when compared to those evoked in quiet, and the amplitude of waves V and A were strongly reduced. On the other hand, an increase in the speech-evoked ABR amplitude at F0 (but not F1) was found at all SNRs compared to the quiet condition. Similarly, Russo et al (2004) reported that the amplitude at F0 was more resistant to noise than the amplitude at F1. These results indicate that the different elements of speech may not be affected in the same direction under adverse conditions.

Several other studies (Johnson, Nicol, & Kraus, 2005; Wible, Nicol, & Kraus, 2004) have also reported a response dissociation at F0 and F1. These studies have reported that the response at F1 is diminished or delayed in children with language-based learning problems compared to normal children despite normal F0 encoding. This dissociation is also consistent with Bidelman and Krishnan (2010), who found that responses at F0 and F1 in the steady-state component of the speech-evoked ABR were affected differently under the influence of reverberation. They reported that reverberation had a minimal effect on the speech-evoked ABR at F0, but a large effect on the speech-evoked ABR at higher frequencies (notably the F1).

Using an animal model, the guinea pig, Cunningham, Nicol, King, Zecker, and Kraus (2002) evaluated the effects of multiple stressors at the level of the inferior colliculus (IC), medial geniculate body (MGB), and primary auditory cortex (AC) in response to a synthetic /ada/. Two speech rates, conversational and clear, were used in quiet and in noise. The authors reported that the onset and formant transition in the electrophysiological response were significantly degraded by the conversational rate compared to the clear rate, in noise at the IC, MGB, and AC levels. However, they found no difference across rates for the steady-state component of the response, corresponding to the vowel /a/ in the /da/ syllable, at the IC and MGB levels. They indicated that this response is conserved due to the phase-locking mechanism, which is pronounced for frequencies below 1 kHz (Assmann & Summerfield, 2004; Greenberg & Ainsworth, 2004).

To date, none of the speech-evoked ABR studies on humans have investigated the effects of multiple stressors. Of interest, however, Burkard and Hecox (1983) investigated the effects of two stressors (noise and increased stimulus rate) using click-evoked ABR as a function of stimulus rate (15/s, 40/s, 65/s, and 90/s) and noise level (-40, 0, 10, 20, 30, and 40 dBEM), where dBEM (Effective Masking) was defined as the level of broadband noise which is just sufficient to perceptually mask a signal of the same nominal dBnHL. The authors studied the effects on wave V of the click-evoked ABR and reported that a higher noise level or a higher stimulus rate increases wave V latency. However, the combined effects were described as being occlusive, indicating that, at low noise levels, rate increases the latency of wave V but as noise level rises, the rate effect becomes less pronounced. These results raise the question as to whether the occlusive interaction found between presentation rate and noise level in the ABR response for click stimuli would also be present in the ABR transient and/or steady-state responses for speech stimuli.

The aim of this study is to investigate the interaction of two types of perceptual stressors (1) noise and (2) stimulus presentation rate on speech-evoked ABR. Responses to a synthetic vowel /a/ stimulus were recorded at two presentation rates, 3.1/s and 1.6/s, in quiet and continuous white noise conditions. For the transient response, we hypothesized that the amplitude of waves V and A would be reduced while latency of waves V and A would be increased under the effects of these two perceptual stressors. This hypothesis is consistent with single stressor studies (Prévost et al, 2013; Russo et al, 2004). For the steady-state response, we hypothesized that the combined effects of the two perceptual stressors would be different for the response amplitude at F0 and F1, as found for single stressor studies (Bidelman & Krishnan, 2010; Prévost et al, 2013; Russo et al, 2004), and that by extension, this dissociation would lead to differences in the interaction effect from the two stressors upon F0 and F1. Results from this study could therefore provide a window into subcortical processing of speech under the effects of noise and rate stressors.

SUBJECTS AND METHODS

Subjects

Twelve subjects (7 males and 5 females) participated in the study. The age of participants ranged from 25 to 35 years (mean = 29.4). All subjects had normal hearing thresholds, defined as ≤15 dB HL bilaterally at 0.25, 0.5, 0.75, 1, 2, and 4 kHz, and none of the subjects had a history of hearing difficulties. All subjects were compensated for their participation and provided their informed consent in compliance with a protocol approved by the University of Ottawa Research Ethics Board.

Stimuli

A synthetic vowel /a/ was generated using formant synthesis (F0 = 0.1 kHz, F1 = 0.7 kHz, F2 = 1.22 kHz, F3 = 2.6 kHz) based on a simplified version of the Klatt synthesizer (Klatt, 1980; Laroche, Dajani, Prévost, & Marcoux, 2013). This vowel was presented at 76.9 dB SPL, as measured in an ear simulator (IEC 60318-4, G.R.A.S. RA0045), in quiet or in noise, at a sampling frequency of 48 kHz and with 16-bit resolution. The vowel time-domain waveform, Hilbert envelope, and amplitude spectrum are presented in Figure 1.

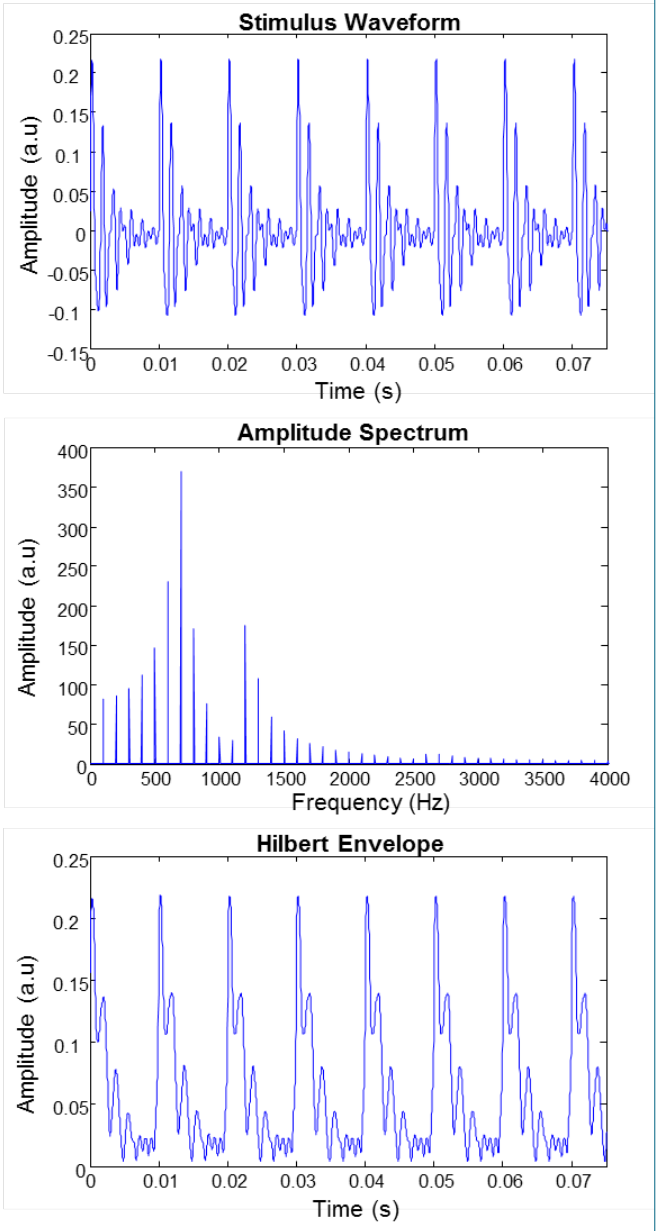

Figure 1. Time domain representation of the 300 ms /a/ vowel and its corresponding spectrum and Hilbert envelope.

The stimuli were delivered using the Bio-logic insert-earphone of the BioMARK v.7.0.2 system (Biological Marker of Auditory Processing, Biologic Systems Corp., Mundelein, IL). In the noisy condition, continuous white noise was added to the vowel and presented continuously at an SNR of 0 dB. The choice of the 0 dB SNR was based on Prévost et al (2013) who evaluated speech-evoked ABR in response to the same vowel /a/.

The study comprised four experimental conditions, in which the speech stimuli were delivered in the right ear of subjects at two different presentation rates (slow and fast) for each of two listening backgrounds (quiet and noise) (Table 1). The duration of the speech stimulus was 300 ms for both rates, but the inter-stimulus interval (ISI) was different. At the slow presentation rate (1.6/s), the ISI was 325 ms, while at the fast presentation rate (3.1/s), the ISI was 22.5 ms. Experimental conditions were presented in a pseudo-randomized order. The responses for the speech-evoked ABR were based on coherent averaging of responses to 1500 stimulus presentations in alternating polarities.

ABR recording

Measurements were performed in a shielded audiometric room with dim lighting. In order to minimize artifacts, the subjects were instructed to remain relaxed and to avoid abrupt movements while sitting in a comfortable reclining chair and watching a muted movie with subtitles. None of the subjects reported to have fallen asleep. Also, recorded sweeps in which the response exceeded 23.8 μV were discarded. In addition, we followed the recommendations of the manufacturer of BioMARK™ regarding the environmental electromagnetic noise reduction such as turning off fluorescent lights when operating the equipment, and making sure all the devices are connected with the iso-transformer provided with the system. The evoked potentials were recorded with a vertical one-channel electrode set-up. A recording electrode was placed at the vertex (Cz) and a reference electrode was placed on the right ear lobe. The ground electrode was placed on the left ear lobe. All electrode impedances were below 5 kOhm at 10 Hz. The response was amplified and filtered using an amplifier with a gain of 10,000 and a filter bandwidth extending from 30 to 1000 Hz. The evoked potentials were recorded using the BioMARK™ system over 319.8-ms epochs (1024 points/epoch corresponding to a sampling frequency of approximately 3202 Hz).

In order to ensure the absence of electromagnetic leakage contaminating the recorded responses, we replicated the ABR recording on one subject's scalp with

Table 1. The four listening conditions.

Conditions	Stimulus	Stressors
1	Quiet-slow	None
2	Quiet-fast	Rate
3	Noise-slow	Noise
4	Noise-fast	Combined

1. Slow stimulus rate of 1.6/s in quiet, 2. Fast stimulus rate of 3.1/s in quiet, 3. Slow stimulus rate of 1.6/s in continuous white noise at 0 dB SNR, 4. Fast stimulus rate of 3.1/s in continuous white noise at 0 dB SNR

the sole exception that instead of placing the foam insert earphone in the subject's right ear, it was inserted into an ear simulator (IEC 60318-4, G.R.A.S. RA0045), which presents approximately the same acoustic load to the electro-acoustic transducer as if the earphones were inserted in the ear. Spectral analysis of the recorded signal coherently averaged over 3000 trials showed that components at F0 in the EFR and at F1 in the FFR did not visually exceed the background noise, indicating no electromagnetic leakage from the sound-generating equipment to the electrodes.

Data Analysis

We analyzed both the transient and the steady-state responses to the speech stimulus. We use the terminology of Envelope Following Response or EFR (response at F0 and its early harmonics) and Frequency Following Response or FFR (response at F1) to distinguish between the responses that follow the envelope and those that follow the higher frequency fine structure. The time-domain EFR was computed by averaging the auditory brainstem responses to the original stimulus and to the inverted polarity stimulus, while the time-domain FFR was computed by averaging the responses to the original stimulus and the negative of the response to the inverted polarity stimulus (Aiken & Picton, 2008; Aiken & Purcell, 2013).

For the transient response, we followed the criteria from Skoe and Kraus (2010) for identifying peak latency and amplitude. The peak latency and amplitude were visually extracted from the time-domain EFR waveforms. The absolute peak amplitude was larger than the baseline activity recorded before the onset of the stimulus. The onset response "V" in quiet conditions started 6–10 ms following the stimulus, reflecting the time delay to the auditory brainstem, followed by negative wave "A" (Chandrasekaran & Kraus, 2010). An allowance for an increase in wave V latency was made when background noise was present. After the peak latency and amplitude were identified, another rater who was blind to the experiment, visually extracted the peak latency and amplitude. No discrepancies were found between the peaks that were identified by us and ones that were identified by the blind rater.

For the steady-state response, the time-domain EFR and FFR waveforms were subjected to discrete Fourier transform with Matlab v.7.9 (MathWorks. Natick, MA) to extract the signal amplitude at F0 and F1 in order to evaluate the representation of speech under the effects of noise and/or stimulus rate. The signal amplitudes at F0 and F1 correspond to the height of the peak in the EFR and FFR root-mean-square (RMS) amplitude spectrum (in μV) at the frequencies of 100 Hz and 700 Hz, respectively. This was done in accordance with Aiken and Picton (2008). Examples of EFR and FFR from one subject in time and frequency domains in each condition are presented in Figures 2 and 3.

The differences in the amplitude of the EFR at F0 and FFR at F1, and in the amplitude and latency of waves V and A, across experimental conditions (Table 1), were evaluated separately with two-way repeated measures ANOVAs using SPSS, version 18.0 (SPSS Inc., Chicago, IL).

RESULTS

Results for the amplitudes and latencies corresponding to waves V and A are presented in Table 2 across all four experimental conditions. Results from the ANOVA are presented in Table 3. A background effect was observed for the amplitude of wave V ($p < .01$) and the latency of waves V ($P < .001$) and A ($p < .001$), but not for the amplitude of wave A. No rate effect was observed for the amplitude and latency of waves V and A. The interaction between background and stimulus rate showed a significant effect on the wave V amplitude only ($p < .05$).

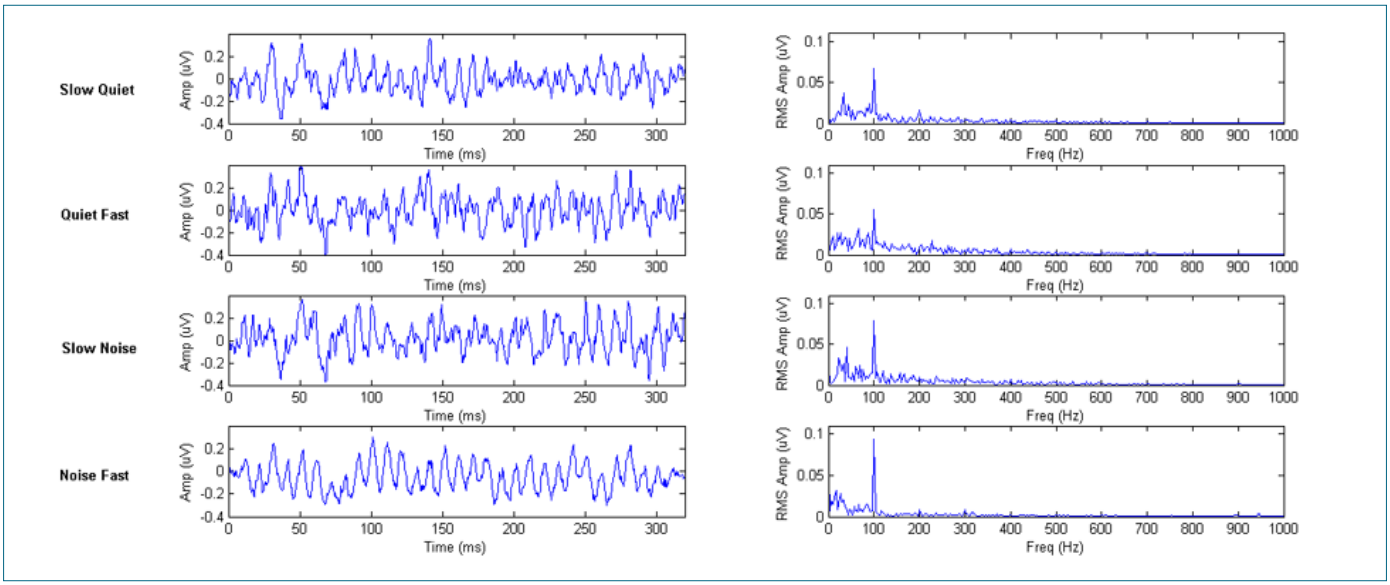

Figure 2. An example Envelope Following Response (EFR) from subject 4 in time and frequency domains in each condition. The signal amplitude at F0 corresponds to the height of the peak at 100 Hz.

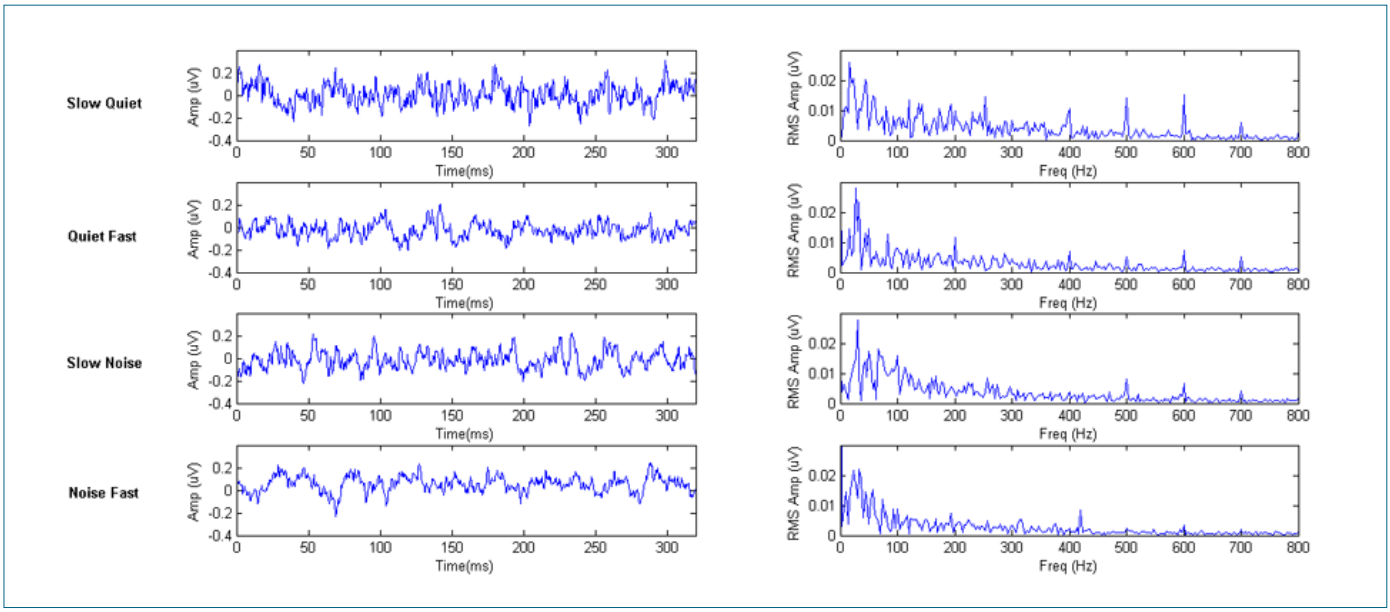

Figure 3. An example Frequency Following Response (FFR) from subject 4 in time and frequency domains in each condition. The signal amplitude at F1 corresponds to the height of the peak at 700 Hz.

Table 2. Mean (standard error) for the latency and amplitude of waves V and A over all subjects in each condition.

	Wave V latency [ms]	Wave A latency [ms]	Wave V amplitude [uV]	Wave A amplitude [uv]
Quiet-slow	7.42 (0.23)	9.16 (0.32)	0.31 (0.05)	-0.08 (0.02)
Quiet-fast	7.73 (0.82)	9.52 (0.84)	0.25 (0.03)	-0.1 (0.04)
Noise-slow	10.07 (0.42)	11.76 (0.42)	0.11 (0.02)	-0.08 (0.03)
Noise-fast	10.28 (0.49)	12.28 (0.59)	0.18 (0.03)	-0.04 (0.02)

Table 3. Statistical results from two-way repeated measures ANOVA for latency and amplitudes of waves V and A, and for amplitudes EFR and FFR.

	F	p
V (latency)		
Background (Quiet vs Noisy)	59.895	0.000 ***
Rate (Slow vs Fast)	0.559	0.470
Interaction (Background x Rate)	0.024	0.881
A (latency)		
Background (Quiet vs Noisy)	70.463	0.000 ***
Rate (Slow vs Fast)	0.94	0.353
Interaction (Background x Rate)	4.485	0.834
V (amplitude)		
Background (Quiet vs Noisy)	17.144	0.002 **
Rate (Slow vs Fast)	0.059	0.813
Interaction (Background x Rate)	8.311	0.015 *
A (amplitude)		
Background (Quiet vs Noisy)	2.222	0.164
Rate (Slow vs Fast)	0.039	0.847
Interaction (Background x Rate)	3.098	0.106
EFR (amplitude)		
Background (Quiet vs Noisy)	1.519	0.058 +
Rate (Slow vs Fast)	4.47	0.243
Interaction (Background x Rate)	5.173	0.044 *
FFR (amplitude)		
Background (Quiet vs Noisy)	22.535	0.001 **
Rate (Slow vs Fast)	0.777	0.397
Interaction (Background x Rate)	12.96	0.004 **

***p < 0.001; **p < 0.01; *p < 0.05; +p < 0.1. The degree of freedom is (3, 20).

The interaction of stressors found for wave V amplitude was further explored using post-hoc pairwise t-tests between experimental conditions. The results are found in Table 4, where the significance of changes in amplitude for single and multiple stressor conditions are reported. The effect sizes are expressed in dB as 20 times the logarithm of the amplitude ratio of the two conditions under test. This was calculated from the mean amplitude values listed in Table 2. For single stressors Quiet (slow to fast) and Slow (quiet to noise), the wave V amplitude trends towards a significant decrease by 1.9 dB and significantly decreases by 9.0 dB, respectively. For multiple stressors Fast (quiet to noise), Noise (slow to fast), and quiet-slow to noise-fast, the wave V amplitude changes correspond to a significant 2.9 dB decrease, a significant 4.3 dB increase, and a significant 4.7 dB decrease, respectively.

The amplitudes corresponding to F0 (labeled as EFR amplitude) and to F1 (labeled as FFR amplitude) across all experimental conditions are presented in Figure 4. Results from the ANOVA are presented in Table 3. A background effect or trend was observed for the EFR amplitude ($p = .058$) and the FFR amplitude ($p = .001$). On the other hand, no rate effect was observed for the EFR and FFR amplitudes. A significant interaction between background and stimulus rate was found for both the EFR amplitude ($P < .05$) and the FFR amplitude ($p < .01$).

The interaction of stressors found for EFR and FFR amplitudes was further explored using post-hoc pairwise t-tests between experimental conditions. The results are found in Table 4, where the significance of changes in amplitude for single and multiple stressors are reported. These changes were derived from Figure 4. For single stressor situations, the EFR amplitude shows a non-significant decrease by 0.3 dB for Quiet (slow to fast) and a non-significant increase by 1.3 dB for Slow (quiet to noise). On the other hand, the FFR amplitude significantly decreases by 2.3 dB for Quiet (slow to fast) and by 6.7 dB for Slow (quiet to noise). For multiple stressors, the EFR amplitude significantly increases by 3.3 dB for Fast (quiet to noise), significantly increases by 1.6 dB for Noise (slow to fast), and significantly increases by 2.9 dB for quiet-slow to noise-fast. In contrast, the FFR amplitude significantly decreases by 2.8 dB for Fast (quiet to noise) and by 5.1 dB for quiet-slow to noise-fast while it shows a non-significant increase by 1.6 dB for Noise (slow to fast) (Table 4).

DISCUSSION

The ability to communicate in the presence of auditory stressors is an important task for successful participation in educational, social, and vocational environments. In this study, we explored the effects of two stressors, namely noise and fast stimulus rate, on the brainstem electrophysiological response to speech. These stressors were evaluated separately (effects of fast stimulus rate or noise) as well as jointly (combined effects of stimulus rate and noise). Although these stressors are fundamentally different, they represent realistic forms of signal degradation (Krizman et al, 2010; Prévost et al, 2013). Moreover, these stressors can differentially affect the processing of the different elements of speech such as fundamental frequency and formants. Results from this study could therefore provide a window into subcortical processing of speech under the effects of these stressors.

Single stressors

Quiet (slow-to-fast):

The EFR amplitude decreased by only 0.3 dB as a result of going from slow to fast stimulus rate conditions while the FFR amplitude decreased by 2.3 dB, as shown in Table 4. These results indicate a dissociation between responses at F0 and F1 with increasing stimulus rate in quiet. Such dissociation between responses at F0 and F1 was also reported by Krizman et al (2010). They indicated that the amplitude corresponding to F1 decreased systematically with the rate increase while the amplitude corresponding to F0 remained stable. They also found an increase in the wave V latency with increasing rate. In our study, the change in latency was very small, but the wave V amplitude decreased by 1.9 dB.

Slow (quiet-to-noise):

The EFR amplitude increased by 1.3 dB as a result of going from quiet to noise conditions while the FFR amplitude decreased by 6.7 dB, as shown in Table 4. These results again show a dissociation between responses at F0 and F1, this time with added noise. Such dissociation between responses corresponding to F0 and F1 is consistent with previous studies. Johnson et al (2005), Kraus and Nicol (2005), Prévost et al (2013), and Russo et al (2004) also reported a dissociation between F0 and F1 with the addition of noise, where the higher frequencies (including F1) were diminished despite normal - or in the case of Prévost et al (2013) enhanced - F0 encoding. Furthermore, in our study, the wave V amplitude decreased by 9 dB. This result is consistent with Russo et al (2004) and Prévost et al (2013) who reported a degradation of the transient response waves in the presence of noise.

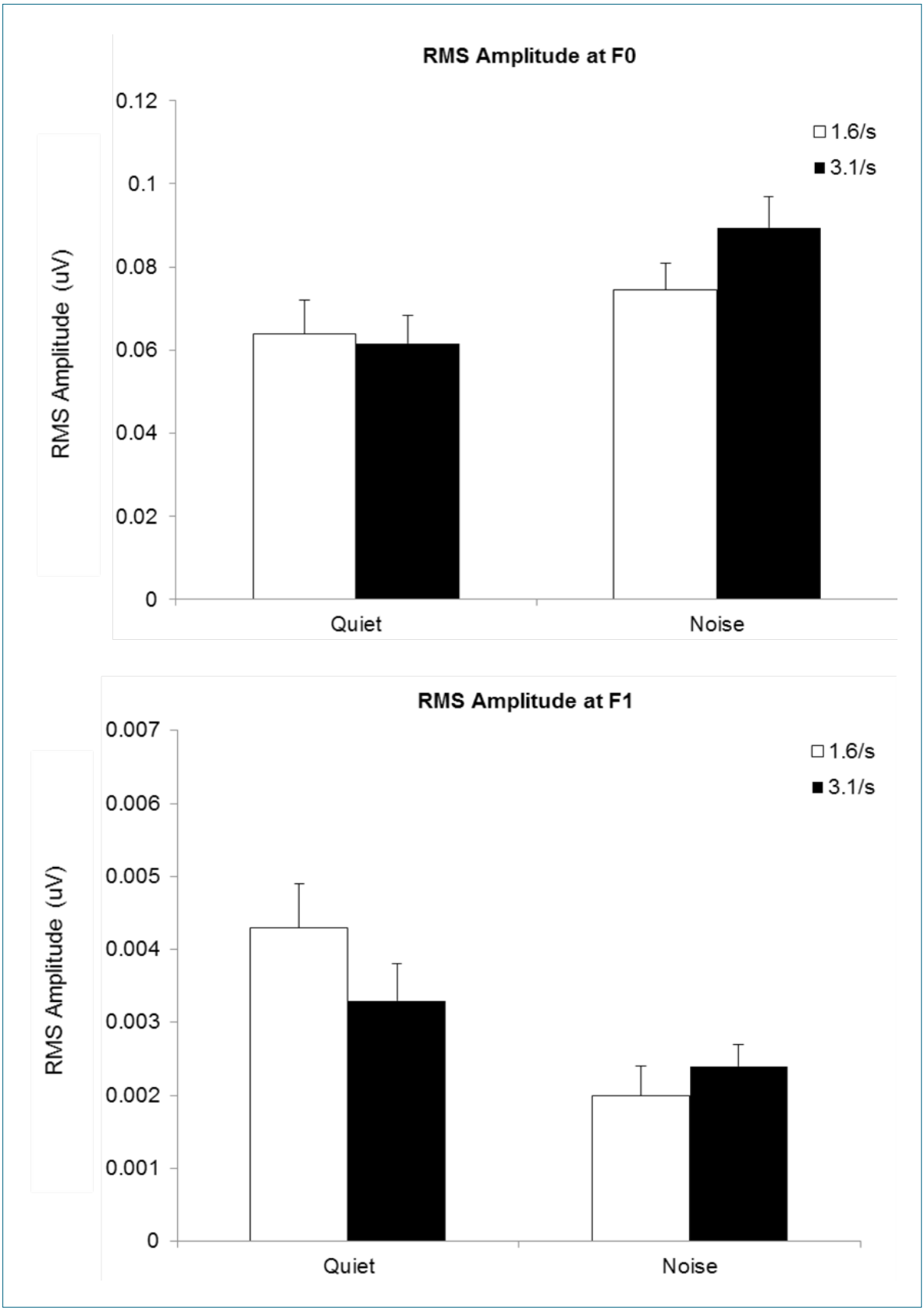

Figure 4. Comparison of response amplitudes in μV (mean and standard error) at F0 and at F1 for the two presentation rates (1.6/s and 3.1/s) in quiet and in noise.

Table 4. Mean change (standard error) of the transient response of wave V amplitude and EFR and FFR amplitudes over all subjects, and p-values obtained with post-hoc pairwise t-test comparisons between conditions. The type of effect (Facilitative, Reversal, Occlusive) is also indicated.

		V Amplitude change [dB]	F0 Amplitude change [dB]	F1 Amplitude change [dB]
Single Stressor	Quiet (slow to fast)	-1.9 (0.9) +	-0.3 (0.4)	-2.3 (0.6) *
	Slow (quiet to noise)	-9.0 (2.1) ***	1.3 (0.6)	-6.7 (1.3) ***
Multiple Stressors	Fast (quiet to noise)	-2.9 (0.26) * OE	3.3 (0.1) ** FE	-2.8 (1.3) * OE
	Noise (slow to fast)	4.3 (1) * RE	1.6 (0.3) ** FE	1.6 (0.6) RE
	Quiet-slow to Noise-fast	-4.7 (1.1) ** OE	2.9 (0.2) + FE	-5.1 (1.9) ** OE

FE denotes Facilitative Effect. RE denotes Reversal Effect. OE denotes Occlusive Effect.***p < 0.001; **p < 0.01; *p < 0.05; +p < 0.1.

Multiple stressors

Fast (quiet to noise):

The wave V amplitude and the FFR amplitude showed a lesser decrease at the fast rate compared to the slow rate as a result of going from quiet to noise, (-2.9 dB vs. -9.0 dB) and (-2.8 dB vs. -6.7 dB), respectively. These results indicate that the effect of the baseline stressor (fast rate) provided an occlusive effect in the presence of the added stressor (noise). On the other hand, the EFR amplitude showed an increase by 3.3 dB. This increase is somewhat surprising in that the effect of going from quiet to noise is larger with fast rate than with slow rate for F0 amplitude (3.3 dB vs. 1.3 dB). This result indicates that the baseline stressor (fast rate) provided a facilitative effect in the presence of the added stressor (noise). The facilitative effect at F0 and occlusive effect at F1 and wave V of the baseline stressor (fast rate) are presented in Table 4.

Noise (slow to fast):

The wave V amplitude and the FFR amplitude showed a reversal in the direction of the effect in noise compared to quiet as a result of going from a slow to fast stimulus rate (4.3 dB vs. -1.9 dB) and (1.6 dB vs. -2.3 dB), respectively. On the other hand, the EFR amplitude showed an increase by 1.6 dB. This increase is again somewhat surprising in that the effect of increasing the stimulus rate is larger in noise than in quiet (1.6 dB vs. -0.3 dB). These results indicate that the baseline stressor (noise) produced a facilitative effect in the presence of the added stressor (fast rate). The facilitative effect at F0, reversal effect at F1 and wave V are presented in Table 4.

Quiet-slow to Noise-fast:

The wave V amplitude and the FFR amplitude showed a lesser decrease in comparison to the combined effects of the two single stressors (Quiet (slow to fast) and Slow (quiet to noise)), with changes of (-4.7 dB vs. -10.9 dB) and (-5.1 dB vs. -9 dB), respectively. These results indicate that the two stressors interacted in an occlusive fashion. On the other hand, the EFR amplitude showed a higher increase in comparison to the combined effects of the two single stressors (Quiet (slow to fast) and Slow (quiet to noise)), with changes of 2.9 dB vs. 1 dB. This result indicates that the two stressors (noise and fast rate) interacted in a facilitative fashion, resulting in an increase in the F0 response. The facilitative effect for F0 and occlusive effect for F1 and wave V amplitude are reported in Table 4.

Overall, the results for the multiple stressors show an essential dissociation between EFR and FFR amplitude changes (facilitative effect for EFR vs. occlusive or reversal effect for FFR). The results also show an association between FFR and wave V amplitudes changes (occlusive or reversal effect for both responses).

Relationship to other studies

The dissociation between responses corresponding to F0 on the one hand and responses corresponding to F1 and wave V of the transient response on the other hand might be explained in terms of a source and filter model of auditory processing of speech. Johnson et al (2005) suggested that specific components of the brainstem response reflect source (i.e., F0 and harmonics of the envelope) and filter (i.e., formants) stimulus

characteristics separately and along two separate neural streams. Results from Bidelman and Krishnan (2010) also supported this hypothesis. The authors reported that the neural representation of the filter related components are significantly degraded with reverberation while the neural representation of the source information remained relatively unchanged under the same conditions. However, this two-stream model has not been firmly established and the exact neural mechanisms are unclear.

Krizman et al (2010) reported a differential effect of increasing stimulus rate on the responses that correspond to F1 compared to those that correspond to F0, and concluded that these results support the involvement of different neural streams. The authors also proposed that this differential effect likely reflects an interaction of neural adaptation, neural fatigue, and refractory properties of individual nerve fibers, resulting in a desynchronization of the response at high stimulus rates (Hall, 1992).

Auditory brainstem responses to speech sounds are shaped by both the acoustic characteristics of the incoming speech signal and cognitive processes such as attention and memory (Galbraith, Bhuta, Choate, Kitahara, & Mullen, 1998). Specifically, auditory selective attention helps to extract relevant signal elements from competing background noise and stores them in working memory (Johnson & Zatorre, 2005). These steps enable top-down effects, thus enhancing the brainstem encoding of relevant and predictable features (pitch, timing, and harmonics) (Chandrasekaran & Kraus, 2010). Speech processing is related to a reliable transmission of speech in the brainstem (Parbery-Clark, Skoe, & Kraus, 2009) and to cognitive functions such as auditory attention that, although they are thought to take place in the cortex, may have top-down effects on brainstem processing (Anderson & Kraus, 2010).

Accordingly, the facilitative effect on the EFR amplitude when the two stressors are present could depend on active mechanisms that include top-down feedback, which in turn is "interrupted" with the longer inter-stimulus gaps found at the slower stimulus rate (i.e., 1.6/s). Hocherman and Gilat (1981) investigated the effects of inter-stimulus gaps using responses of single units in the primary auditory cortex. The durations of the stimulus and the ISI were varied (50-ms stimuli were presented at intervals of either 550 ms or 900 ms, while 100-ms stimuli were presented at intervals of either 900 ms or 1,600 ms). The authors reported that varying the ISI from 550 ms to 900 ms for the 50-ms stimuli or from 900 ms to 1,600 ms for the 100-ms stimuli resulted in a similar increase in evoked activity (67.5% and 67.1 %, respectively). Furthermore, they reported that randomly mixing two ISIs (550 and 900 ms) for the 50-ms stimuli or (900 ms and 1,600 ms) for the 100-ms stimuli caused a reduction in evoked activity in 29% of the units and an increase in 14%. The remaining 57 % of the units did not follow a consistent reduction or increase in evoked activity. The authors speculated that the responses to varying the ISI could relate to cortical mechanisms that enable an evoked activity to such changes by some attentive mechanisms.

The neural basis of top-down attentional control of auditory processing at lower levels, such as the auditory brainstem and cochlea, was also investigated by Rinne et al (2008) using functional magnetic resonance imaging (fMRI). The authors suggested that auditory processing at the brainstem level is top-down modulated via selective attention. As reported in Du, Kong, Wang, Wu, and Li (2011), attentional top-down control of auditory processing is performed through enhancing synchronous phase-locked activities of brainstem neurons to behaviorally relevant stimulus. In our experiment we did not control for selective attention, but based on the reports in the literature (Anderson & Kraus, 2010; Bidelman & Krishnan, 2010), speech-evoked auditory brainstem responses may be useful measures for investigating how perceptual/cognitive cues can assist in selectively targeting a speech signal and improving recognition in the presence of multiple auditory stressors. To improve recognition, the processing at the level of the brainstem could involve internal noise suppression, signal enhancement, or a combination of both (Prévost et al, 2013).

Enhancement of the subcortical response that follows the envelope has been found in normal listeners who undergo auditory training for pitch discrimination (Carcagno & Plack, 2011) and for speech recognition in noise (Song, Skoe, Banai, & Kraus, 2012). Moreover, long-term experience with music or a tonal language has been found to correspond to a more robust subcortical representation of the pitch frequency (Bidelman, Gandour, & Krishnan , 2011; Wong, Skoe, Russo, Dees, & Kraus, 2007). The gain in the envelope-following evoked responses that we observed with multiple stressors could provide an electrophysiological substrate underlying noise robustness of normal hearing listeners with conversational speech. Furthermore, the strength of the subcortical representation of the envelope in normal listeners has been suggested to be a primary contributor to speech perception in noise (Song et al, 2012; Swaminathan & Heinz, 2012).

In hearing-impaired listeners, on the other hand, enhancement of the response at F0 appears to be associated with a degraded perceptual ability. Anderson,

Parbery-Clark, White-Schwoch, Drehobl, and Kraus (2013) have evaluated the effects of sensorineural hearing loss (SNHL) on older adults using speech-evoked ABR and have reported a greater spectral representation for the response that follows the envelope in the SNHL group compared to an aged matched normal hearing group, and equivalent representation for the response corresponding to the temporal fine structure in the signal. The authors suggested that the perceptual deficit in the SNHL group might be related to an imbalanced subcortical representation of speech, with dominance of the neural activity that follows the signal envelope relative to the activity that follows the rapidly-varying temporal fine structure. Another plausible explanation may be related to hearing impaired listeners having widened auditory filters (Sharma & Chaudhari, 2013). As such, unlike in normal listeners, their auditory filters (particularly the lower frequency narrow filters) pass complex signals which are modulated at F0 because they combine multiple (instead of individual) harmonics of the fundamental, resulting in a stronger response at F0.

The effects of the multiple stressors on waves V amplitude and FFR amplitude showed an occlusive or reversal effect in the present study. For Fast (quiet to noise) and Quiet-slow to Noise-fast, both the wave V amplitude and the FFR amplitude showed an occlusive effect. This result is similar to what Burkard and Hecox (1983) found, where the effect of increased rate and addition of noise on wave V of the click-evoked response was purely occlusive. On the other hand, the Noise (slow to fast) effect on wave V amplitude and FFR amplitude showed a reversal effect. This result may be due to mechanisms similar to those proposed above for the facilitative effect with EFR.

The combined effects of fast rate and noise are complex, resulting in an interaction, rather than a summation. The neural mechanisms for such interaction are not fully defined yet. Further studies are required to reveal the neurophysiologic and cognitive processes involved in encoding speech stimuli under effects of perceptual stressors such as fast rate and noise.

CONCLUSION

This is the first study to investigate the interaction of auditory stressors such as fast stimulus rate and/or addition of white noise on the auditory system in humans using speech-evoked ABR. Perceptual studies have investigated the combined effects of these stressors. Such studies characterize the response of the whole auditory system, which involves the complex interaction of sensory, linguistic, cognitive, aging, contextual cues, and other factors. In our study, speech-evoked ABR provided an objective means to assess processing at an intermediate level of the auditory system and probe into the neural representation of specific elements of speech.

For single stressors, our findings are consistent with previous studies that found a dissociation between responses corresponding to F0 and F1 under effects of either noise or increased stimulus rate. What differentiates this study from preceding work is the evaluation of how multiple stressors can interact together. This study has shown an essential dissociation between responses corresponding to F0 on the one hand and responses corresponding to F1 and wave V on the other hand. The two stressors have shown facilitative effects on the responses corresponding to F0, while they have shown occlusive or reversal effects on the responses corresponding to F1 and wave V. The facilitative effect found for F0 is particularly interesting and unexpected. However, the current study cannot determine whether this effect corresponds to a natural mechanism in normal listeners that underlies robustness in difficult environments, or whether it is an indicator of a degradation in the sub-cortical representation of a speech as found in studies with hearing impaired listeners in single stressor situations.

The encoding of the neural responses corresponding to F0 and F1 is important for both recognizing the speech content and identifying the speaker and voice emotion. Therefore, the recording of speech-evoked ABR with multiple stressors could be useful for investigating the neural mechanisms underlying how speech perception and recognition is achieved under difficult acoustic conditions. Further investigation into the effects of other auditory stressors will help reveal the physiological mechanisms that are selectively enhanced or diminished. Future work needs to evaluate the effects of age (younger vs. older adults) and hearing status (normal vs. impaired) on the interaction of rate and noise as well as the interaction between other auditory stressors.

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Declaration of Interest

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Speech-Language Pathologists' Role in Inclusive Education: A Survey of Clinicians' Perceptions of Universal Design for Learning

Le rôle de l'orthophoniste dans l'inclusion scolaire : un sondage recueillant la perception des cliniciens sur la conception universelle des apprentissages

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KEY WORDS

UNIVERSAL DESIGN FOR LEARNING
UDL
COLLABORATION
INCLUSIVE EDUCATION
SCHOOL-BASED SPEECH-LANGUAGE PATHOLOGY

Abstract

Background: Increasingly, Canadian schools are prioritizing full inclusion in which students with disabilities are educated alongside their peers in general education classrooms. Universal design for learning (UDL) is a framework that supports inclusion and offers a common foundation from which educators and S-LPs can collaborate to meaningfully embed speech, language, and communication support into the classroom.

Purpose: To determine the extent to which S-LPs working in Canadian schools perceived that they were knowledgeable about UDL, their belief that they had the skills needed to implement UDL, and the ease or difficulty with which they were able to implement UDL as part of their current position.

Method: Ninety-one school-based S-LPs completed a 25-minute online anonymous survey. The survey covered a range of topics relevant to school-based practice, including questions specific to UDL.

Results: A majority of S-LPs were familiar with the term and definition of UDL and did not perceive general knowledge about UDL to be a major barrier to implementation. Respondents were less certain about their competency in specific skills needed to implement UDL at the classroom level. With respect to other factors, most S-LPs identified: time, opportunities to collaborate with school personnel, and administrative support as key barriers to implementing UDL. Open-ended survey responses reinforced these factors as barriers and identified additional ones as well.

Conclusion: S-LPs reported many challenges to implementing UDL. While S-LPs would benefit from professional development to support specific skills related to implementation, systemic change also is required to support S-LPs' involvement in collaboratively implementing UDL. Additionally, high quality research is required to examine the effectiveness of UDL-based S-LP services.

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Contexte : Les écoles canadiennes priorisent de plus en plus l'inclusion complète des élèves avec handicaps afin qu'ils reçoivent leur éducation aux côtés de leurs pairs dans les classes régulières. La conception universelle des apprentissages (CUA) est un cadre qui soutient l'inclusion et qui offre une base commune sur laquelle les éducateurs et les orthophonistes peuvent s'appuyer pour collaborer et intégrer un moyen de soutenir la parole, le langage et la communication dans la classe.

Objectif : Déterminer comment les orthophonistes qui travaillent dans les écoles canadiennes percevaient leurs connaissances de la CUA, quelles étaient leurs opinions concernant leurs habiletés à appliquer la CUA ainsi que la facilité ou la difficulté avec laquelle ils ont été en mesure d'appliquer la CUA dans le cadre de leur poste.

Méthodologie : Quatre-vingt-onze orthophonistes travaillant en milieu scolaire ont répondu de façon anonyme à un sondage en ligne d'une durée de 25 minutes. Le sondage couvrait une variété de sujets en lien avec la pratique en milieu scolaire, incluant des questions portant spécifiquement sur la CUA.

Résultats : La majorité des orthophonistes connaissaient le terme et la définition de la CUA et ne percevaient pas qu'une connaissance générale de la CUA constituait un obstacle majeur à son application. Les répondants étaient moins certains de posséder les habiletés spécifiques nécessaires pour appliquer la CUA dans le contexte de classe. Les autres facteurs identifiés par la majorité des orthophonistes comme étant les principaux obstacles à l'application de la CUA étaient le temps, les occasions de collaborer avec le personnel de l'école et le soutien administratif. Les réponses aux questions ouvertes du sondage ont confirmé que ces facteurs étaient des obstacles et en ont fait ressortir d'autres.

Conclusion : Les orthophonistes ont rapporté de nombreux défis dans l'application de la CUA. Bien que les orthophonistes bénéficieraient d'activités de développement professionnel pour soutenir leurs habiletés spécifiques reliées à l'application de la CUA, un changement systémique est aussi nécessaire pour soutenir la participation des orthophonistes dans l'application collaborative de la CUA. De plus, une recherche de qualité est nécessaire pour étudier l'efficacité des services orthophoniques basés sur la CUA.

Inclusive education means that "all students attend and are welcomed by their neighbourhood schools in age-appropriate, regular classes and are supported to learn, contribute, and participate in all aspects of the life of the school" (Inclusive Education Canada, 2015). Philosophically, inclusion is founded on a core belief that "...every child, with or *without* disabilities, has the right to belong" (Causton & Tracy-Bronson, 2014, p. 32). Moreover, research shows that high quality inclusive education is associated with health, academic, and social benefits for students with disabilities (Katz, 2013; Morningstar, Shogren, Lee, & Born, 2015; Oh-Young & Filler, 2015; Timmons & Wagner, 2009), *without* impeding the academic progress of students who do not have disabilities (Green, Terry, & Gallagher, 2014; Specht, 2013). Indeed, the social benefits of inclusion extend to all children in the classroom – whether or not they have a disability (Katz, 2013). Yet, despite the philosophical and evidence-based reasons for embracing inclusive education, actual practices in Canada vary tremendously (Towle, 2015). For example, data from Statistics Canada's Children's Participation and Activity Limitation Survey revealed that most provinces educate only about one third of their students with disabilities in highly inclusive settings (Timmons & Wagner, 2009). A recent report on inclusive education in Canada indicates that the gap between policy and practice remains a high priority for this country (Towle, 2015).

Considering Towle's report, it seems both timely and worthwhile to consider what role speech-language pathologists (S-LPs) might play in closing Canada's policy-practice gap in inclusive education. A recent survey of the leadership of teacher's associations across Canada indicated that many teachers feel inadequately prepared to implement inclusive education and view increased collaboration with specialists as essential to building their capacity in this area (Thompson, Lyons, & Timmons, 2015). For example, although general educators are highly knowledgeable about curriculum and instructional design, many do not feel prepared to teach children with disabilities (Peebles & Mendaglio, 2014) and may not be aware of how best to support students with speech, language, and communication needs in the general education classroom (Ralabate, Currie-Rubin, Boucher, & Bartecchi, 2014). As a complement to educators, S-LPs have a wealth of knowledge about the learning challenges that children with communication difficulties are likely to encounter in the classroom, and moreover, the kinds of supports that are needed to support successful learning (Causton & Tracy-Bronson, 2014; Staskowski, Hardin, Klein, & Wozniak, 2012; Zurawski, 2014). The challenge remains: how can educators and S-LPs collaborate to integrate complementary sets of expertise and invite the practice of inclusive education?

Universal Design for Learning (UDL) is one approach to inclusive education that has been proposed to address this challenge; it provides a common foundation for educators and S-LPs to build an accessible curriculum that can support the speech, language, and communication needs of all students (Waller, 2012). UDL emerged from the 'universal design' movement in architecture that saw upfront planning of physical environments to include features such as ramps and curb cuts that benefit all individuals who may require their use (Ralabate, 2011). Redesigning such elements retroactively to meet specific needs was deemed costly and inefficient compared to proactive designs that were accessible to many. UDL was a parallel movement in the field of education that emphasized 'front-loading' curriculum planning to proactively address the learning needs of all students simultaneously (Staskowski et al., 2012); it sought to reduce the need for one-off accommodations that addressed the needs of single students or small, specialized groups (Ralabate, 2011). UDL is distinct from differentiated instruction or DI – an approach that also is relevant to S-LPs working in the schools. Specifically, whereas UDL emphasizes planning for diversity across *all* learners *from the outset*, DI focuses on making adjustments to curricular content or process *in response* to the learning needs of *individual* students (Center for Applied Special Technology, 2013). While some students will need both UDL and DI to fully access the academic curriculum (and potentially other supports as well), many other students' needs will be met by the curricular and instructional supports offered by UDL (Missiuna, Pollock, Levac, et al., 2012). In this way, UDL and DI can be thought of as complementary approaches to supporting inclusive education (Ontario Ministry of Education, 2013).

The primary purpose for implementing a UDL framework is to help all students become self-directed "expert" learners who are highly engaged, goal-directed, and knowledgeable about how they learn (Meyer, Rose, & Gordon, 2014); this is achieved by promoting choice and flexibility within curriculum via varied displays of information, assessment strategies, and methods of student engagement (Staskowski et al., 2012). Waller (2012) has highlighted that the "S-LP plays an integral role in UDL by working collaboratively with classroom teams to ensure that content is presented in a variety of forms, that teaching strategies promote active attention and engagement, and that students have various opportunities and modalities to communicate and to share information" (p.131). UDL

often incorporates benefits of technology within curriculum development and implementation, which can be a strength for S-LPs who have an expertise in assistive technology (Staskowski et al., 2012). Indeed, the American Speech-Language Hearing Association (ASHA) has endorsed UDL as a core component of school-based practice, stating that "knowledge of UDL principles and application should be foundational to how S-LPs conduct evaluations and assessments as well as interventions" (ASHA, 2016, http://www.asha.org/S-LP/schools/Universal-Design-for-Learning). However, despite this endorsement, results from the most recent ASHA Schools Survey indicated that only 23% of S-LPs are implementing UDL in the United States (ASHA, 2014). To our knowledge, no studies have examined the use of UDL by S-LPs in Canada. Given the potential role of UDL in supporting inclusive education more broadly, we believe that this is an important issue for the school-based clinical community to explore. Therefore, the purpose of this paper is to report findings from a recent survey of Canadian school-based S-LPs in which we sought to answer the following questions:

1. Are school-based S-LPs familiar with the term UDL and its definition?
2. What do S-LPs perceive as barriers to implementing UDL in their schools?
3. How confident are S-LPs that they have the knowledge and skills needed to implement UDL as part of their clinical practice in schools?

Method

Participants

Ethical approval for the study was received from the Hamilton Integrated Research Ethics Board (HIREB) at McMaster University (HIREB Approval #13-764). Participants were recruited from the membership of Speech-Language Audiology Canada (SAC), which is the national professional association for speech-language pathologists and audiologists in Canada. A total of 91 S-LPs working in the schools responded to our request for participants and completed our online anonymous survey.

Of the 91 members who completed our survey, 75 (82%) reported working full-time and 74 (81%) were employed by a school board. Participants included S-LPs from 9 provinces and 1 territory; however, a majority of participants were from British Columbia (n = 17; 19%), Alberta (n = 14; 15%), and Ontario (n = 33; 36%). A predominance of S-LPs from these three provinces is consistent with previous surveys of SAC school-based members (CASLPA, 2011). A majority of S-LPs considered their primary role to be a direct service provider (n = 72; 79%). On average, S-LPs had worked for 14.56 years (SD = 9.82; Mdn = 13.00; range = 1-35) with an average of 11.47 years in the school setting (SD = 8.32; Mdn = 10.00; range = 1-33). Twenty-five percent worked in rural communities with fewer than 1000 people; 34% in small communities with fewer than 30,000 people; 22% in medium communities of up to 100,000 people; and 48% in urban communities with greater than 100,000 people[1].

As might be expected given variations in community size, caseload size also varied widely. Specifically, the median caseload was reported to be 85 students and ranged from 0 for a S-LP manager to 900 for an S-LP working in rural and small communities. Approximately 80% of S-LPs reported providing services to students in Kindergarten through to Grade 5. The percentage of S-LPs providing services to students beyond Grade 5 decreased progressively with approximately 50% providing services to high school students. Close to half of the students receiving S-LP services presented with either phonological/articulation disorders (M = 43.89; SD = 20.67; Mdn = 50.00) or spoken language disorders (M = 45.03; SD = 25.87; Mdn = 45.00). Students with autism spectrum disorders (M = 12.76; SD = 13.19; Mdn = 10.00) and developmental disability (M = 13.30; SD = 13.26; Mdn = 10.00) each accounted for approximately 10% of students receiving school-based S-LP services. All other speech, language, and communication disorders accounted for 5% or less of S-LP caseloads.

Materials

The survey utilized in this study was developed for a project funded by a Clinical Research Grant from Speech-Language and Audiology Canada to examine caseload characteristics and practice patterns among school-based S-LPs with a particular focus on how S-LPs might support inclusive education (Gaines, Campbell, & Missiuna, 2013-2015). To facilitate comparison between our data and the extant literature, questions were adapted from existing surveys about school-based practice patterns where possible (ASHA, 2012; CASLPA, 2011; Dohan & Schulz, 1998; 1999; Missiuna, Pollock, Campbell, et al., 2012). Overall, our survey consisted of questions grouped into three broad sections: (1) background information about participants, their respective caseloads, and current models of service delivery [10 single and 5 multi-part questions; 1 open-ended question]; (2) knowledge and perceptions of initiatives in general and special education related to inclusion, including UDL and response to intervention (RtI) [8 single and 2 multi-part questions; 2 open-ended questions]; and (3) knowledge, skills, and experiences regarding collaborative

consultation and classroom-based approaches to service delivery that would support implementation of UDL or RtI [3 multi-part questions; 1 open-ended question]. The data reported in this paper are from 28 of these questions: 11 questions about the background of the S-LPs (Section 1); 9 questions focused on participants' knowledge of UDL and perceived barriers to its use (Section 2); and 8 questions from a multi-part question about skills relevant to implementing UDL collaboratively with educators (Section 3). A copy of the survey may be requested from the first author.

Prior to data collection, all survey questions and response options were reviewed by several practicing school-based S-LPs for clarity and completeness. Based upon their feedback, we elected to add definitions for three key terms in our survey (UDL, RtI, and collaborative consultation) to ensure that all respondents were provided with a consistent definition and were using the same terminology when responding to survey items. We selected the UDL definition proposed by the National Center on Universal Design for Learning and elaborated by Ralabate (2011):

> "Universal Design for Learning (UDL) is a set of principles for curriculum development that gives all individuals equal opportunities to learn. UDL provides a blueprint for creating instructional goals, methods, materials, and assessments that work for everyone – not a single, one-size-fits-all solution but rather flexible approaches that can be customized and adjusted for individual needs" (National Center on Universal Design for Learning, n.d.).
>
> "By facilitating the design and implementation of a flexible, responsive curriculum, UDL offers options for how information is presented, how students respond or demonstrate their knowledge and skills, and how students are engaged in learning. UDL implementation provides the opportunity for all students to...progress in the general education curriculum by reducing barriers to instruction" (Ralabate, 2011, p.14).

Once the survey questions were finalized, they were entered into Research Electronic Data Capture (REDcap), a web-based application to support online data collection through survey development and data management (Harris et al., 2009). Further pilot testing indicated that the survey could be completed in approximately 25 minutes.

Procedure

Participants were recruited from the general membership of SAC using three strategies: (1) a general email sent by SAC to all members of the Association in April 2014; (2) posters distributed to members attending the SAC biannual national convention in May 2014; and (3) a newsletter-style article about the study posted to the members-only section of the SAC website in December 2014. In each of these communications, we provided potential participants with a link to our survey in RedCap, which they could access in order to complete the survey anonymously. Participants were provided with a letter of information in the first page of the survey; consent was assumed by participants' choice to complete all sections of the survey and click on the "submit" button prior to exiting the survey. Participants could exit the survey at any time without saving their responses.

Analysis

For the purposes of this paper, only participants' responses to survey questions about their knowledge of and involvement in activities related to UDL were analyzed. Statistical analyses were completed using SPSS 22 (2013).

Results

According to survey results, 64% of the 91 participants recognized the term UDL and 65% were familiar with the concepts described in the definition of UDL, prior to completing the survey. The respondents who answered 'yes' to either survey item (n=64) continued to answer additional survey questions related to UDL. The remaining 27 respondents were automatically redirected to the next section of the survey. Of the 64 respondents who completed the survey items related to UDL, a total of 55% indicated that their school board used the term UDL; 20% of respondents stated that they were unsure whether or not the term UDL was used; and 25% of respondents indicated that their school board did not use the term UDL.

Next, this same subsample of respondents (n=64) were asked to rate the extent to which they had encountered five specific challenges to implementing UDL during the last year using a 7-point scale where 1 represented *not at all a challenge*, 4 represented a *moderate challenge*, and 7 represented a *substantial challenge*. A 'not applicable' option also was provided based upon feedback received during pilot testing that some challenges were not relevant to S-LPs if their current position did not include a role in UDL implementation. Approximately 25-30% of the participants in the subsample chose the 'not applicable' option for each of the 5 items. Figure 1 shows the distribution of

participants' responses across the 7-point scale for each potential challenge as well as the frequency with which the 'not applicable' category was selected. Overall, most participants reported that knowledge of UDL presented a low to moderate challenge with access to opportunities for professional development in UDL considered to be a moderate to substantial challenge. Having opportunities to collaborate with educators to implement UDL was considered by more than 50% of respondents to be a moderate to substantial challenge with 28% of this subsample reporting this to be a substantial challenge. Time to implement UDL activities was considered to be the greatest challenge in implementing UDL with approximately 57% of participants rating this item as a moderate to substantial challenge. Indeed, a total of 28% of respondents rated this item as a substantial challenge. Receiving administrative support for implementing UDL activities was also highly rated as a challenging aspect of implementing UDL.

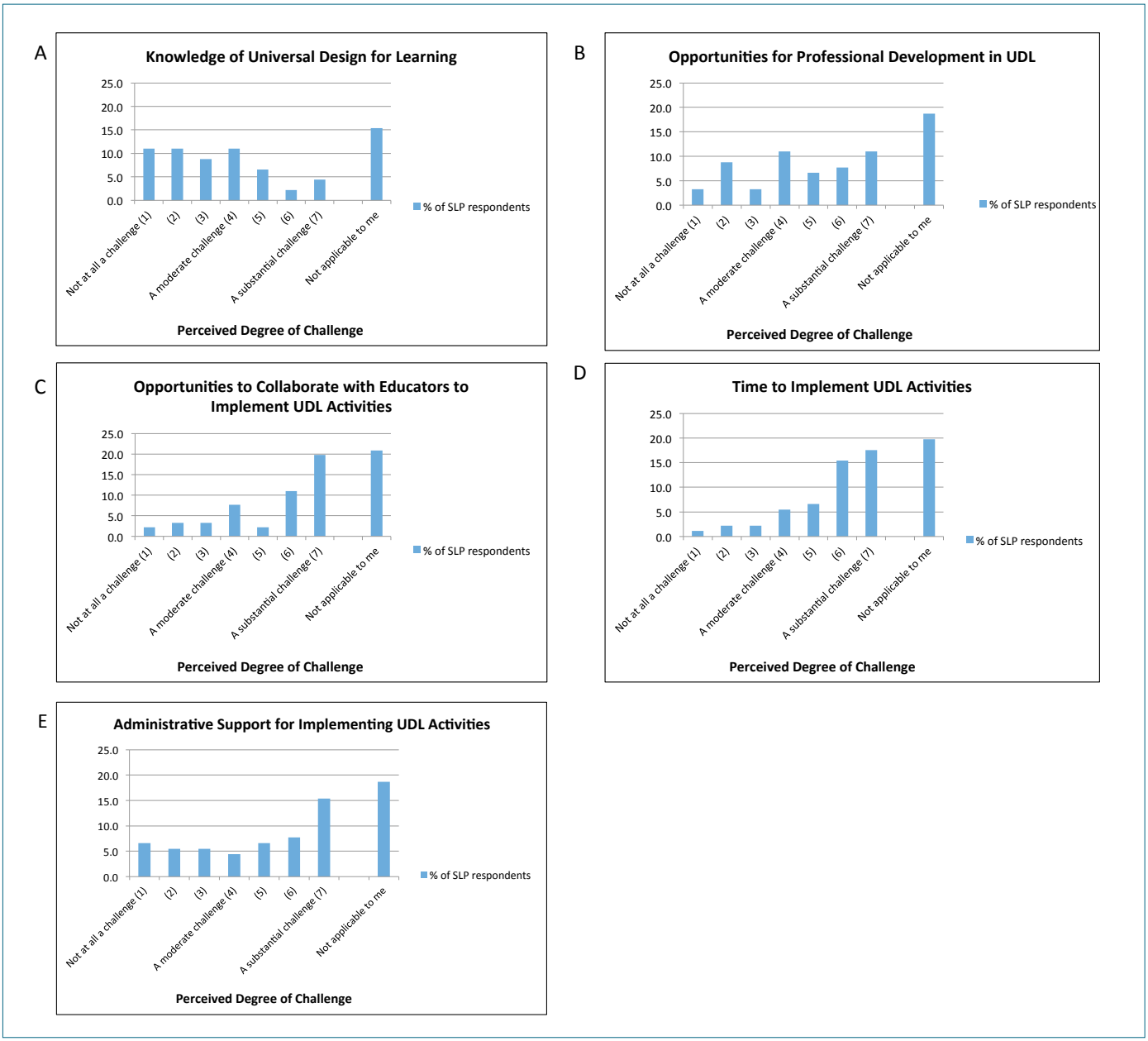

Figure 1. S-LPs' perceived barriers to implementing UDL in current position.

Open-ended feedback from respondents also indicated that a variety of challenges and barriers were experienced when considering implementation of UDL within the classroom. Other than those that had been had rated previously, participants also reported the following barriers: educators may not be invested in UDL themselves or may not be adequately trained in UDL; when school boards do offer training in UDL, S-LPs and other health professionals are often not included; UDL implementation requires building relationships with teachers and creating "buy-in" first, which requires time; schools may lack technological infrastructure to support UDL; there may be a lack of S-LP staff or other financial resources to include UDL-based services; school administrators and staff view the role of the S-LP as mainly a direct service provider rather than a collaborator; and families may prefer that their child receive individual support. Even though most respondents who provided open-ended feedback reported additional barriers, a small number did indicate that they worked in school boards that supported their involvement in UDL and indicated a positive perception of this aspect of their role.

In the final portion of the survey, participants rated their perceived level of competence for several skills, eight of which were particularly relevant to implementing UDL; items were rated on a 7-point scale with 1 representing a skill that was an *area for growth* and 7 representing a skill that was an *area of competence*. As shown in Figure 2, approximately half of respondents rated themselves between 5 and 7 on the following skills, suggesting these were areas of relative competence: a) helping teachers to use curriculum-based activities in the classroom to support receptive language (44%); b) helping teachers to use curriculum-based activities in the classroom to support speech/articulation (47%); and, c) helping teachers to use curriculum-based activities in the classroom to support expressive language (55%). The remaining five skills were viewed as relative areas for growth having been rated between a 1 and 4 by over two-thirds of respondents. Also shown in Figure 2, these included: a) creating curriculum-based resource/activity centres for targeting speech, language, or communication skills that could be used by all students within a classroom (65% rated between 1 and 4); b) helping teachers to use curriculum-based activities in the classroom to support written language (66%); c) designing and delivering a curriculum-based lesson related to speech, language, or communication for a large group of students (68%); d) explaining the principles of UDL as they relate to speech-language pathology (73%); and e) implementing classroom-based activities that reflect the principles of UDL (78%).

Discussion

Although several recent provincial initiatives (e.g., Ontario's Learning for All, Alberta's Action on Inclusion, and New Brunswick's Strengthening Inclusion, Strengthening Schools) have prioritized educational approaches that focus on inclusivity and the provision of high quality instruction to all students in the classroom, a significant gap remains between policy and practice in Canada's schools (Towle, 2015). Thus, in many schools across Canada, students with disabilities do not have access to the same academic and social opportunities as their peers (Timmons & Wagner, 2009). Research indicates that greater collaboration with experts is needed to build educator capacity for inclusive education (Thompson et al., 2015). To this end, S-LPs can make a valuable contribution by considering how they can work with educators to support students with communication-related disabilities in the general education classroom (Ehren, Montgomery, Rudebusch, & Whitmire, 2009). Universal design for learning is a framework that supports inclusion and offers a common foundation on which to build collaboration in the classroom (ASHA, 2015; Ralabate, 2011; Ralabate et al., 2014; Staskowski et al., 2012; Waller, 2012). In this study, we sought to determine the extent to which S-LPs working in Canadian schools perceived that they were knowledgeable about UDL, their belief that they had the skills needed to implement UDL, and the ease or difficulty with which they were able to implement UDL as part of their current role.

While a majority of the S-LPs who completed our survey recognized the term UDL and were familiar with its definition, it was notable that nearly 30% of respondents had never encountered this term or its concepts prior to completing our survey. This suggests that building basic awareness of UDL is a need for at least some school-based practitioners. Of those S-LPs who were already familiar with the term UDL, most did not identify a lack of knowledge about UDL to be a major barrier to implementation. Yet, most S-LPs also were not confident that they could explain how the principles of UDL related specifically to the field of speech-language pathology. Thus, even when S-LPs are familiar with the term and concepts of UDL more generally, they may still need support to apply those principles to their actual clinical practice. This may be why S-LPs identified insufficient opportunities for professional development in UDL as a significant barrier to implementation even though lack of knowledge was not viewed similarly. Furthermore, open-ended comments suggested that it was a lack of opportunities for *shared* professional development with their educator colleagues in particular that impeded implementation of UDL in the classroom. This observation

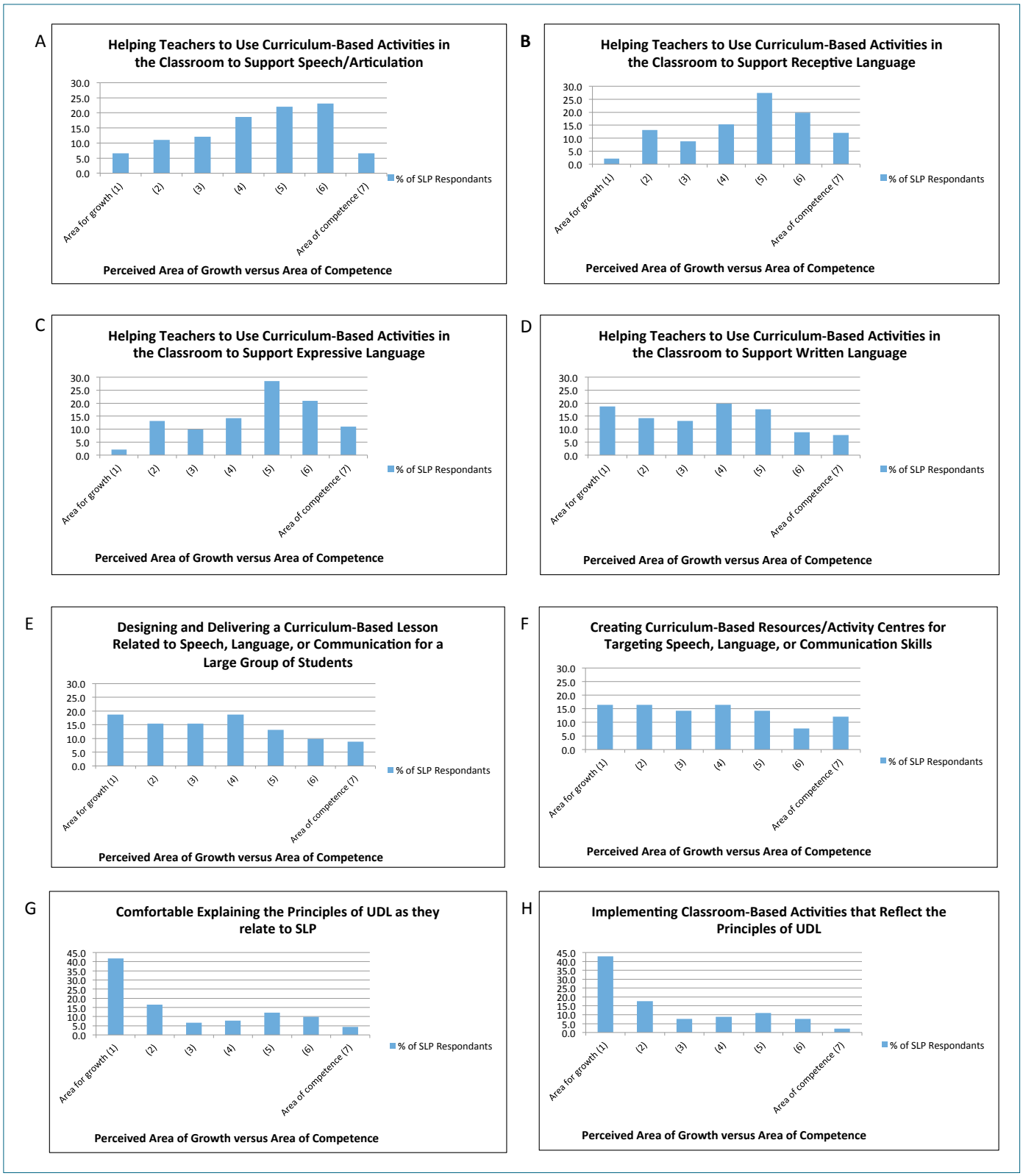

Figure 2. S-LPs' perceived level of competence for skills relevant to implementing UDL.

is worth noting given prior research suggesting that interprofessional training opportunities between S-LPs and educators may be essential to supporting successful collaboration in schools (Hartas, 2004; Hillier, Civetta, & Pridham, 2010; Suleman et al., 2013; Waller, 2012; Wilson, McNeill, & Gillon, 2015).

When asked about several specific skills that would be needed to actually implement UDL in a classroom setting, there was considerable variability in S-LPs' responses. In general, S-LPs felt confident that they could support teachers' use of curriculum-based activities to support speech and language skills in the classroom; however, they were less confident about their own ability to design and implement activities or strategies for use by all of the students in a classroom (e.g., designing a classroom activity center or delivering a whole-class lesson focused on communication skills). These findings dovetail quite well with the results of two recent Canadian studies showing that school-based occupational therapists needed formal training and mentoring to be able to collaboratively implement UDL-based activities in a whole-class setting (Missiuna, Pollock, Whalen, Dix, & Stewart, 2015; Missiuna, Pollock, Campbell, et al., 2012). In addition, Waller (2012) reported the results of a pilot study demonstrating the benefits of pre-professional clinical practica in preparing S-LPs to work in universally designed classrooms; specifically, "...graduate students learned to identify components of UDL in the classroom, incorporate components of UDL in targeted small group interventions, and incorporate components of UDL in whole-class lessons. This information had a positive impact on the overall role of the graduate clinicians in the classroom and on the clinicians' knowledge of school-based issues in speech-language pathology" (p. 134). These findings reinforce the importance of considering both pre- and post-professional training with respect to preparing S-LPs for classroom-based collaboration using UDL. As a first step, we recommend that S-LPs look for opportunities to build their foundational knowledge of UDL. Several free online resources to support professional development in UDL are described in Table 1. In addition, examples of professional practice articles that explicitly describe how S-LPs can be involved in UDL implementation are listed in Table 2. Finally, S-LPs may wish to join a virtual professional learning community to connect with colleagues and build a network in UDL implementation. The National Center on Universal for Learning's UDL Connect website is one such example that is free and open access (see http://community.udlcenter.org/ for more information).

Table 1. Online resources for developing foundational knowledge and skills in UDL

Online Resource	Description
www.cast.org	Website for the Centre for Applied Special Technology (CAST). Researchers from CAST are the original developers of UDL. Their website includes a wealth of resources about UDL, including free and fee-based online professional learning opportunities as well as several free e-learning tools to assist with UDL implementation.
www.udlcenter.org	Website for the National Center on Universal Design for Learning. The goal of the Center is to serve as a hub for UDL implementation by connecting stakeholders interested in UDL to information, research, resources, and professional learning communities.
www.udlresource.ca	Website focused on UDL developed by SET-BC (Special Education Technology – British Columbia) with support from the BC Ministry of Education (Department of Diversity and Equity). Includes a free self-paced course in UDL; online resources; extensive video gallery; and practical strategies for implementing UDL in K-12 classrooms.
http://udltheorypractice.cast.org	Free e-book, "Universal Design for Learning: Theory & Practice." Published in 2014 and written by CAST researchers, this is the most up-to-date resource on UDL research and implementation. It incorporates many illustrations, videos, and case examples of how UDL is implemented in classrooms and schools.

Table 2. Examples of professional practice articles describing S-LP role in UDL implementation

Citation
Horn, E., & Banerjee, R. (2009). Understanding curriculum modifications and embedded learning opportunities in the context of supporting all children's success. *Language, Speech, and Hearing Services in Schools, 40*, 406-415.
Ralabate, P. K. (2011). Universal design for learning: Meeting the needs of all students. *The ASHA Leader, 16* (10), 14-17.
Ralabate, P. K., Currie-Rubin, R., Boucher, A., & Bartecchi, J. (2014). Collaborative planning using universal design for learning. *ASHA SIG 16 Perspectives on School-Based Issues, 15*, 26-31. doi:10.1044/sbi15.1.26.
Staskowski, M., Hardin, S., Klein, M., & Wozniak, C. (2012). Universal design for learning: Speech-language pathologists and their teams making the common core curriculum accessible. *Seminars in Speech and Language, 33*, 111-129.

In addition to issues related to knowledge and knowledge application, S-LPs also identified factors such as lack of time, lack of opportunities to meet with teachers, and lack of administrative support as barriers in their participation in collaborative implementation of UDL. These kinds of barriers are not new to school-based practice and previously have been identified as interfering with collaboration in the school setting (Glover, McCormack, & Smith-Tamaray, 2015; Hartas, 2004). The fact that these barriers appear to impede S-LP involvement in implementation of UDL is underscored by our finding that up to 25% of the S-LPs completing this section chose to not even rate these barriers presumably because implementation of UDL was not relevant in their current position. In retrospect, we would have liked to have probed these respondents further to ascertain why they viewed that series of questions as not applicable. For example, perhaps the school board for which they work doesn't use UDL. In any case, even without that additional information, these responses suggest that UDL may be an underutilized option for collaboration in the classroom.

To address these types of systemic barriers, it will likely be necessary to advocate for change in how school-based S-LP services are viewed as a whole. As just one example of how this has unfolded in the United States, the American Speech-Language-Hearing Association, the American Occupational Therapy Association, and the American Physical Therapy Association issued a joint statement in 2014 outlining the rationale for shifting from a traditional caseload approach to a workload approach for therapists working in schools (ASHA, n.d.). In a caseload approach, consideration is given only to the number of students receiving services without taking into account other activities performed by S-LPs that support students, such as consultation and collaboration with school staff, participating in school-wide initiatives, working with parents, attending team meetings, planning, documentation, or travel time (ASHA, n.d.). In a workload approach, consideration is given to *all* of the activities performed by the S-LP as part of their role in the schools and caseload size is adjusted accordingly (ASHA, n.d.). As part of this initiative, ASHA has developed a number of resources that school-based S-LPs may use to help their states and local boards of education transition from a caseload to a workload approach (see ASHA's Practice Portal on Professional Issues).

In Canada, a parallel initiative was undertaken by the Canadian Association of Speech-Language Pathologists and Audiologists (CASLPA; recently renamed Speech-Language and Audiology Canada or SAC), the Canadian Association of Occupational Therapists (CAOT), and the Canadian Physiotherapy Association (CPA) to develop an evidence-based Caseload Management Planning Tool in which client needs, intervention complexity, and service intensity are considered in conjunction with non-client care activities to estimate the number of clients who can be managed successfully over a given period of time for a given number of therapists (CAOT, CPA, & CASLPA, 2011). These kinds of tools and resources can serve as a starting point for school-based S-LPs looking to advocate for a workload approach in their current school position.

Limitations

The sample size in this study is small relative to the total number of S-LPs working in Canadian schools and was not recruited proportionately from all provinces and territories in Canada. Thus, it cannot be assumed that the results reported in this study are representative of the

larger population of school-based S-LPs in this country. Moreover, as in most survey research, the S-LPs who chose to complete our survey were volunteers and may have been highly motivated to express their views on the topic of collaborative service delivery in schools – whether positive or negative. For that reason, we cannot be certain that had our survey reached a greater percentage of S-LPs practicing in the schools that our results would be replicated. That being said, the fact that our findings are consistent with the existing literature (e.g., Glover et al., 2015; Hartas, 2004) provides support for the validity of our findings.

Conclusions and Future Directions

The growing demand in Canada for schools to be fully inclusive (Towle, 2015) challenges educators and S-LPs alike to reconsider how they may best work together to support students with disabilities in the general education classroom. In this paper, we have suggested that collaborative implementation of UDL offers one means by which school-based S-LPs could help educators create inclusive classrooms. Yet our survey results indicated that S-LPs did not feel that they had sufficient training or supports to implement UDL in their current roles within the schools. Accordingly, professional development opportunities will likely be needed to build S-LPs' knowledge, skills, and capacity to engage in collaborative practice using UDL. In addition, there is a need for ongoing advocacy at a systems level to remove existing barriers to collaboration in the schools. Finally, high quality research is required to build an evidence base for UDL-based S-LP services as well as to determine best practices for professional development. Only when all of these elements are addressed is it likely to be possible to explore the potential role of school-based S-LPs within the broader context of inclusive education.

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End Notes

[1] Percentage does not equal 100% as categories were not mutually exclusive (i.e., a single S-LP might work in several communities of varying size).

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Language Matters: Measuring Reading Comprehension in Children with Oral Language Impairment

L'importance du langage : mesurer la compréhension de lecture chez les enfants ayant un trouble du langage oral

KEY WORDS

LANGUAGE DISORDERS

LITERACY

ASSESSMENT

CHILDREN

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Abstract

Purpose: This article presents a literature review focused on the association between oral language skills and performance on standardized reading comprehension. The investigators were particularly interested in the impact of atypical language skills among children with oral language impairment (LI) on test results and interpretation.

Method: A scoping review was undertaken to identify research focused on performance of school-aged children who have LI on standardized reading comprehension tests. Following initial searches, no literature was found to directly address the research question. The question was revised to include research comparing standardized reading comprehension measures, which included measurement of oral language skills. A search of 5 online databases was conducted, identifying 7 studies that compared reading comprehension tests based on participants' language and reading skills.

Conclusions: A gap in knowledge was identified regarding the use of standardized reading comprehension tests with children with LI. Three main conclusions were reached: (1) Further research is required documenting the relationship between the reading comprehension test scores and oral language skills in children with LI; (2) Selection of reading comprehension tests and oral language measures in research should be based on evaluation of participant characteristics and the purposes of assessment. The selection rationale should be stated in reports; (3) Reading comprehension is best represented by a profile of component skills, including various language skills, rather than by a single test score.

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Objectif : Cet article présente une revue de la littérature portant sur l'association entre les habiletés de langage oral et la performance à des tests standardisés de compréhension de lecture. Les chercheurs se sont particulièrement intéressés à l'impact des habiletés langagières atypiques présentes chez les enfants avec un trouble du langage oral (TL) sur les résultats et l'interprétation des tests.

Méthodologie : Une revue exploratoire de la littérature a été effectuée afin d'identifier les articles portant sur la performance des enfants d'âge scolaire avec un TL à des tests standardisés de compréhension de lecture. À la suite d'une première recherche, aucune littérature répondant directement à la question de recherche n'a été trouvée. La question a donc été révisée pour inclure des études qui comparent des mesures standardisées de compréhension de lecture et qui incluent une mesure des habiletés langagières orales. La recherche a été effectuée dans 5 bases de données en ligne. Sept études comparant des tests de compréhension de lecture et s'appuyant sur les habiletés langagières orales et de lecture des participants ont été identifiées.

Conclusion : Un manque de connaissances a été identifié en ce qui concerne l'utilisation des tests standardisés de compréhension de lecture auprès des enfants avec un TL. Trois conclusions ont été formulées : (1) Des recherches supplémentaires sont nécessaires pour documenter la relation entre les résultats aux tests de compréhension de lecture et les habiletés langagières orales des enfants avec un TL; (2) Le choix des tests de compréhension de lecture et des mesures de langage oral utilisés en recherche devrait être basé sur l'évaluation des caractéristiques des participants ainsi que sur les buts de l'évaluation. La justification des choix devrait être énoncée dans les articles; (3) La meilleure manière de décrire la compréhension de lecture est de fournir un profil de plusieurs habiletés, ce qui inclut les diverses habiletés langagières, au lieu de présenter le résultat d'un seul test.

The development of strong literacy skills among all students is a key goal in our school systems today. Consequently, the ability to accurately identify and plan intervention for children at risk of academic difficulties is of interest to educators and speech-language pathologists working in the schools. Children with developmental oral language impairment (LI) frequently experience difficulties with literacy skills; early and ongoing language difficulties place children at risk for long-term reading difficulties (Nation & Norbury, 2005). Both decoding and comprehension issues appear to be common, though not universal, with LI. Given that children with LI are at increased risk of reading difficulties, it is important to have reading tests that accurately characterize the skills of such children. The measurement of reading comprehension is part of a complete reading assessment. It may be that commonly used standardized reading comprehension tests are less appropriate for children with developmental oral language impairment, due to the impact of the child's oral language skills on the tasks being measured. It may also be the case that differences in how they respond affect how their test results should be interpreted.

In this paper, the results of a scoping review regarding the impact of oral language skills on scores from standardized reading comprehension tests are presented. The review summarizes studies that compared results from various reading comprehension tests and that linked the test results to measures of oral language skills. Implications and recommendations for measuring reading comprehension for children with LI are discussed.

Exploring the Relationship between Language Impairment and Reading Comprehension

Characteristics of Language Impairment

Developmental oral language impairment can come in a variety of forms, including when the language difficulties are concomitant with conditions such as ADHD. The term "specific language impairment" (SLI) refers to developmental oral language difficulties with no known etiology (Leonard, 2000). A diagnosis of SLI frequently requires nonverbal IQ scores within the expected range for the child's age. In this paper, the term "language impairment" will be used to include children with SLI, as well as those with lower nonverbal IQ scores, and who are not identified as globally delayed. This latter group is sometimes described as "nonspecific language impairment". Cognitive referencing in labelling developmental language difficulties is currently thought to have limited usefulness, as IQ measures are inconsistently correlated with language skills (Dethorne & Watkins, 2006). Therefore the terms "specific" and "nonspecific" are avoided here. The label "language impairment" is selected to describe children with language difficulties of unknown cause (see Bishop, 2014 for a full discussion of these issues).

Children with LI are a heterogeneous group. Difficulties may affect receptive language, expressive language, or both. Typically, the more language functions are affected, the higher the likelihood of the child experiencing reading difficulties (Simkin & Conti-Ramsden, 2006). Within receptive and expressive language, these children may have difficulty with phonology, semantics (including vocabulary), grammar, and/or usage (pragmatics) (Paul & Norbury, 2012). The language skills of individual children can be expected to impact the development of their reading skills, including reading comprehension.

Theories of Reading and Implications for Reading Comprehension Assessment

Theories of reading have varied in their consideration of language skills. A number of theories and models exist to describe the reading process, generally characterizing reading as the recognition of printed words and creation of a mental representation of what is read. A selection of models is briefly presented here to highlight how language abilities have been treated among reading models. The Spear-Sternberg Model of Reading Disability (Spear-Swerling & Sternberg, 1994) focuses largely on the development of automatic decoding; language skills beyond phonology are not specifically invoked until later stages. The model posits the normal path of reading acquisition as a single stepwise developmental sequence, working towards swift word recognition and eventually to the use of reading strategies. The model allows for categorization of reading disabilities based upon the stage at which a child has stalled in acquiring reading skills. In the Construction-Integration Model of Reading (Kintsch, 1998), basic language skills are primarily involved in deriving propositions from the text. Fluent adult reading is viewed as a set of processes that result in a mental representation of the text. This model recognizes the role of the reader's background knowledge and experience in comprehension, the ability to make inferences, and decoding abilities. The Lexical Quality Hypothesis (Perfetti, 2007) emphasizes the role of lexical knowledge, suggesting that the primary determinant of reading skill is the rapid and correct recognition of words, including "well-specified orthographic, phonological, and semantic-syntactic information" (p.211). Individual differences in reading skill, including comprehension, are attributed to differences in the quality of stored mental representations of words and the ability to activate them

quickly while reading. Based on this premise, reading difficulties would be expected in children with LI because the phonological and semantic-syntactic representations relate closely to the types of language skills typically affected in this population. The Integrated Model of Reading Comprehension (IMREC) (van den Broek and Espin, 2012) is presented as an effort to amalgamate current models of reading comprehension, with an eye toward developing more effective assessment tools. The work highlights the need to consider both automatic and strategic processing tasks and cognitive resources in the individual including such factors as language, working memory, ability to make inferences, background knowledge, and so on.

In general then, it appears to be accepted that language skills are involved in reading; however, not all models or theories clearly articulate how oral language skills are involved. When language is included in studies of reading, it is sometimes treated as only receptive language or comprehension. For example, much current research is founded in the Simple View of Reading (Gough & Tunmer, 1986), which has been validated by numerous studies. In short, this theory proposes that "reading equals the product of decoding and comprehension" (p. 7). Reading comprehension is essentially equated with listening comprehension when decoding is well-developed. This statement has important implications for research; the measurement tools typically used in oral language testing can then be used to evaluate comprehension. It also implies that expressive language need not be sampled in a reading assessment. It is possible that such measurement approaches may inadequately represent the skills of children with language impairment, particularly if expressive language is relatively more affected than receptive language.

No model currently considers all the subcomponents of language and their potential independent contribution to reading comprehension (but recall that IMREC does amalgamate current models of reading comprehension (van den Broek & Espin, 2012)). The specific model selected by a test developer or researcher typically determines whether or not oral language skills are examined and how they are measured.

The Role of Oral Language in Reading Comprehension

As noted in the previous section, oral language skills are typically assumed to function as part of reading comprehension processes. Current evidence suggests that both receptive and expressive language skills appear to be involved.

Receptive language. The role of receptive language in reading comprehension is not fully defined in the literature. The Simple View of Reading specifies "listening comprehension" as a key component of reading skills, yet this could be defined very differently depending on the researcher and/or test developer. Not only are various terms used to refer to receptive language skills (e.g. oral comprehension, listening comprehension), but how these constructs are operationalized can be quite variable (Keenan, Betjemann, & Olson, 2008; Ricketts, 2011). The term "receptive language" may construe a broader approach to the construct, whereas "listening comprehension" is often roughly equivalent to the understanding of spoken sentences and texts. It would be useful to know how these constructs are defined in research and whether there is disparity between studies.

A variety of schemes have been suggested to capture receptive language in the context of reading assessment. Carlisle (1991) laid out a method of assessing listening and reading comprehension and recommended screening measures such as "oral receptive … vocabulary, syntax, and verbal memory for sentences and stories" (p. 36). However, Ekins and Schneider (2006) found that comprehension measures were understudied in the context of predicting reading skills. Among six studies reporting on reading comprehension measures, they found some evidence that receptive measures of semantics and syntax are predictive of reading comprehension scores. Ricketts (2011) reviewed the reading comprehension literature for children with LI using the Simple View as a framework. Ricketts recommended that the definition of "language comprehension" should be expanded to include specific sub-skills such as vocabulary.

Expressive language. Expressive language skills are typically not specifically invoked in reading theories. An interesting situation arises regarding children with LI when the Simple View of Reading is applied: since only receptive skills are considered in the model, there is no logical reason to measure expressive skills. If one applies this reasoning to children with receptive skills within the expected range but with expressive language difficulties, such children would not be considered to be at risk for reading disability (assuming adequate decoding skills). In contrast, a number of sources suggest the relevance of expressive language to reading. A study reported by Catts, Fey, Zhang, and Tomblin (1999) found that a broad range of oral language skills, including expressive language, was needed to account for variance in reading comprehension scores. Snyder, Caccamise, and Wise (2005) detailed the key points to evaluate when selecting a reading comprehension

instrument. They noted that expressive vocabulary and syntax are useful measures to include in reading comprehension screenings for older children. As with receptive language however, Ekins and Schneider (2006) found expressive language measures were understudied in the prediction of reading comprehension: only 5 of 13 studies examined such measures. From these studies, they found that the ability to provide definitions, narrative skills, and "standardized measures" of expressive language (p. 32) predicted reading comprehension.

The Impact of Language Impairment on Reading Comprehension Assessment

There are many psychometrically sound standardized tests of reading comprehension available, with various methods of measuring reading comprehension. It is possible that presenting the same material with different response tasks could result in different performances for children with LI. In other words, not only are language skills at play during reading comprehension processes, but atypical language skills may impact how children can respond to reading comprehension tests themselves. Researchers and educators need to know how test results may differ for children with LI relative to children with well-developed oral language abilities in order to best select and interpret reading comprehension tests.

Carlisle (1991) provided an overview of reading comprehension assessment tasks, comparing them for validity. Among five response tasks (multiple-choice, free recall, cloze, sentence verification, and picture identification), Carlisle noted various difficulties in task design including points relevant to the student with oral language weakness. She asserted that expressive language skills should be considered and noted the impact of the test questions on measurement results. For example, free recall requires a child to remember and repeat detailed information; as such it is likely to underestimate comprehension for children with expressive language deficits. Carlisle recommends the sentence verification task as a fair measurement for children with varying language skills, and one that can be used for listening or reading. She concludes her review by recommending that the task be carefully matched to the student. Similar conclusions were reported by Cain and Oakhill (2006) in a review focused on the *Neale Analysis of Reading Ability (NARA)* (Neale, 1989). These authors evaluated five response tasks (cloze, true/false sentence recognition, sentence verification, multiple choice, and open-ended questions) based on the literature. They commented on potential concerns with each, particularly noting the need to avoid ceiling effects. The authors pointed out that these tasks may alter comprehension as they necessarily provide some information in the question. As an example, to measure *ability to make inferences* with true/false sentence recognition, the correct answer must be presented. The authors point out that the task is now to recognize an inference, not to make an inference. Similar concerns were presented for the sentence verification and multiple choice tasks. In this review, cloze tasks were noted to rely heavily on decoding skills. They noted that cloze tasks may also be more related to sentence- rather than text-level skills, unless properly designed. Other concerns with response tasks included high processing demands (e.g. multiple choice) and expressive language demands (open-ended questions). The authors concluded that these concerns could result in the misrepresentation of actual reading comprehension skills.

The impact of expressive deficits on the *NARA* was investigated by Spooner, Baddeley, and Gathercole (2004). The researchers compared a group of children who had age-appropriate decoding skills and weak reading comprehension on the *NARA* to a group who had both decoding and reading comprehension within the expected range. When the response task was switched from question response to forced choice, they found that the apparent reading comprehension differences between the groups disappeared. They suggested that the differences were reflective of tasks demands; children with reduced expressive ability were underestimated in terms of the amount they had actually comprehended, the effect predicted by Carlisle (1991) as noted above.

It seems likely that other test characteristics, such as text type and length, may affect the performance of children with LI differently than children with typically-developing language skills. Knowledge of such effects would be important in matching test to student in practice and research.

Research Questions

In the preceding discussion of the literature, a number of research questions were identified that we will attempt to answer in the following review of the literature:

1. Results for children with developmental oral language impairment: What is known regarding the appropriateness of standardized reading comprehension tests for children with developmental oral language impairment?

2. Comparability among reading comprehension tests: Do different tests yield comparable results?

3. Impact of response task on performance: What is

the impact of assessment task on the student with oral language impairment?

4. Definition and measurement of oral language skills:
    a. How is "listening comprehension" defined and operationalized in studies of reading comprehension measures?
    b. What is known about the role of expressive language skills in the measurement of reading comprehension?
    c. Do researchers provide clear selection rationale for oral language tasks?
5. Aspects of tests to consider: What are the characteristics of reading comprehension tests that may affect the performance of children with LI?

Methods

The scoping review methodology employed was described by Arksey and O'Malley (2005). The scoping format suited the purpose of the review: to identify existing literature on this topic. Five phases were followed: "identifying the research question"; "identifying relevant studies"; "study selection"; "charting the data"; "collating, summarizing", and "reporting the results" (Arksey & O'Malley, 2005, pp. 8-9). The review proceeded in an iterative process. Initially, the broad research question was: What is known regarding the appropriateness of standardized reading comprehension tests for children with developmental oral language impairment? This was refined into the current set of questions as relevant papers were identified. At each step, the accumulated literature was reviewed to search for answers to the questions that arose. The review was complete when no further questions arose and all existing questions were answered based on the literature that met the inclusion criteria. A researcher who was not involved in the initial review was recruited to review the inclusions list (Levac, Colquhoun, & O'Brien, 2010). Full agreement on inclusions was reached with discussion. A third researcher performed a reliability check on the results for two of the articles. This researcher answered the stated research questions relative to those two articles and the results were compared with the original findings; full agreement on the answers was achieved.

Since the purpose of the review was to inform future research, grey literature (i.e., material not published in journals or other commercial sources (Dijkers, Murphy & Krellman, 2012)) was not included in the search as would be typical for a scoping review. In addition, although scoping reviews do not typically include critical evaluation of articles, this process was employed in the interests of planning future studies.

A university librarian was consulted to determine the best databases and search terms to identify the literature of interest. Five databases were searched: Scopus, Web of Science, ComDisDome, ERIC, and ProQuest Dissertations and Theses. The search terms used were: "reading comprehension"; measur* OR assess* OR diagnos* OR identif*; "language impair*" OR "impairments in language" OR "language disorder*" OR "language delay*" OR "language deficit*"; child* OR school-age* OR school age* OR elementary NOT deaf* OR aphasia. The search of the 5 databases returned a combined list of 113 papers once duplicates were removed. At this time, no papers were found that directly addressed the primary research question. Inclusion criteria were amended to include literature that could shed light on the impact of oral language skills on reading comprehension test scores. Criteria were revised as follows: papers included measures of oral language and either directly compared measures of reading comprehension or evaluated the use of reading comprehension tests relative to oral language performance. Other inclusion criteria were unchanged: only papers including school-age participants were considered; if papers specified a disorder type, only those evaluating developmental oral language impairment were considered. Only English language papers were considered. The review continued with these criteria in place. An additional 17 papers for consideration were found by hand searching the references of relevant papers from the database search. This total list of 130 resulted in 6 inclusions. A Web of Science citation search of the list of 6 papers provided an additional 12 papers for consideration; this resulted in 1 additional inclusion for a total of 7 studies that met criteria. The literature search was completed by October, 2013. A total of six papers and one book chapter were identified as meeting the criteria of this review; each compared reading comprehension measures and included measures of oral language.

Results

The following table summarizes the seven studies that met inclusion criteria for this review. Next, the studies will be discussed in five sections that follow the research questions: results for children with LI; comparability among reading comprehension measures; impact of task on performance; definition and measurement of oral language skills; and aspects of tests to consider. Key details pertaining to each research question are elaborated in the section specific to that question.

Table 1. Summary of studies meeting inclusion criteria

Authors	Year and Location	Age Range	Number of participants	Number of children with LI included	Reading comprehension tests studied
Nation & Snowling	1997 UK	7-10 years	184	Not reported	*Neale Analysis of Reading Ability (NARA); Suffolk Reading Scale*
	Main results	Using hierarchical regression, more score variance in the NARA results was accounted for by listening comprehension scores than by decoding; the *Suffolk* results were better predicted by decoding skills than by listening comprehension.			
Nation & Snowling	1997 UK	7-10 years	Good comprehenders (N=17); poor comprehenders (N=17)	Not reported; expected overlap with "poor comprehenders"	*Neale Analysis of Reading Ability; Suffolk Reading Scale*
	Main results	As task complexity increased from single word to text reading, poor comprehenders did increasingly poorly compared to the good comprehenders. This effect was eliminated on the *Suffolk* results when single-word reading was used as a control, but not for the *NARA*.			
Spear-Swerling	2004 USA	Mean age 9 years 8 months (4th graders)	95	Not reported	*Connecticut Mastery Test -Degrees of Reading Power (DRP); Connecticut Mastery Test Reading Comprehension (RC)*
	Main results	In a hierarchical regression analysis, decoding skill explained more variance for cloze (DRP) than for question response (RC). Listening comprehension (measured as oral cloze) was nearly equally predictive for both tests.			
Francis, Fletcher, Catts & Tomblin (analysis 1)	2005 USA	Grade 1 and 2	945	Not reported	*Woodcock-Johnson Revised (WJRPC), Formal Reading Inventory*
	Main results	Results of these tests correlated differently to measures of oral and written vocabulary and to decoding measures. Although all correlations were significant, correlations with all measures were higher overall with the *WJRPC*.			
Francis, Fletcher, Catts & Tomblin (analysis 2)	2005 USA	Grade 2 and 4	570	Not reported	*Woodcock Reading Mastery Test Passage Comprehension (WRMTPC); Diagnostic Assessment Battery, Gray Oral Reading Test*
	Main results	Correlations between receptive language and reading comprehension scores were similar for the 3 measures but correlations with decoding varied significantly. For all 3 measures, correlations with decoding were stronger in Grade 2 than in Grade 4; in both grades, correlations were highest to the *WRMTPC*.			

Cutting & Scarborough	2006 USA	7 to 15 years	97	Not reported	*Gates–MacGinitie Reading Test—Revised (G-M); Gray Oral Reading Test—Third Edition (GORT-3); Wechsler Individual Achievement Test*
	Main results	In a hierarchical multiple regression analysis, the maximum variance accounted for by oral language skill and decoding together was for the *G-M*. The *GORT-3* had the lowest amount of variance accounted for. The instruments differentially tapped decoding skills and oral language skills, with both being useful predictors in regression models. The model for the *G-M* included both lexical and sentence processing composites; the *WIAT* was only predicted by the sentence composite.			
Keenan, Betjemann & Olson	2008 USA	8 to 18 years	510	Not reported; requirement for full scale IQ >85 suggests some children with LI could be excluded	*Woodcock-Johnson Passage Comprehension (WJ-PC); Qualitative Reading Inventory (QRI); Gray Oral Reading Test (GORT); Peabody Individual Achievement Test (PIAT-RC)*
	Main results	Via hierarchical regression, decoding skill explained more variance for the *PIAT-RC* and *WJ-PC* than the other two reading comprehension measures in the study. Conversely, listening comprehension was more strongly related to the scores from the *GORT* and the *QRI*.			
Kendeou, Papadopoulos & Spanoudis	2012 Cyprus	Mean age 6 years, 6 months; 7 years, 7 months	286	Children with history of speech, language or hearing problems were excluded	*Woodcock-Johnson Passage Comprehension (WJIII-PC),* Recall task, CBM-Maze
	Main results	The *WJIII-PC* was most linked to "orthographic processing and working memory skills" (p. 363) as was the recall task with the addition of phonological skills. The CBM maze task depended most upon vocabulary and fluency.			
Eason, Goldberg, Young, Geist & Cutting	2012 USA	10 to 14 years	126	Not reported; included children with reading disabilities	Stanford Diagnostic Reading Test —4th Ed.
	Main results	Repeated measures analysis of variance revealed an interaction between question type and text type. Functional text yielded similar results for the 3 questions types. Narrative and expository texts were similar in percent correct answers across question types; however they differed when specific question types were considered. The critical analysis and process strategies questions were most difficult. Regression analyses revealed that word recognition and receptive vocabulary significantly predicted reading comprehension for all 3 text types. Comprehension of expository texts was also predicted by inferencing.			

Results for Children with Oral Language Impairment: What is known regarding the appropriateness of standardized reading comprehension tests for children with developmental oral language impairment?

As can be seen from the preceding table, none of the included studies specifically evaluated results for children with identified LI. Note that in some cases, children with LI were included in the study samples. Implications for this population that may be extended from the included studies are explored in the discussion.

Comparability among Reading Comprehension Tests: Do different tests yield comparable results?

This relatively small body of literature is strikingly consistent in the primary findings of the studies: reading comprehension measures are not interchangeable. As will be further explored in the following sections, each research team took a different approach in comparing reading comprehension measures. Yet in each case, they found significant differences among the instruments. For both research and academic use, instrument selection must be an intentional process; for purposes of comparing between studies, researchers should clearly articulate the reasons for the instrument selections made.

Impact of Response Task on Performance: What is the impact of assessment task on the student with oral language impairment?

Response task was noted as one significant source of variation between instruments. The tests examined in the studies reviewed here are summarized in Table 2 in terms of the tests' characteristics and the type of response task for each; in some cases categories were unclear due to limited information in the reports.

Table 2. Summary of Reading Comprehension Tests Used in Comparison Studies

Test	Passage Length	Oral/Silent Reading	Genre of Passage	Response Task
Suffolk Reading Scale	Sentences	Not reported	Not reported	Cloze
Woodcock Johnson Passage Comprehension	Sentences, 2-3 lines	Silent	Not reported	
Woodcock Reading Mastery Test Passage Comprehension	Not reported	Not reported	Not reported	
Connecticut Mastery Test --cloze	Not reported	Not reported	Not reported	
Connecticut Mastery Test –question response	Not reported	Not reported	Not reported	Question response
Formal Reading Inventory: Silent Reading Score	"graded passages"	Silent	Not reported	
Diagnostic Assessment Battery--2	Not reported	Silent	Not reported	
Neale Analysis of Reading Ability	"short"	Aloud	Narrative	
Wechsler Individual Achievement Test	2-3 sentences	Silent	Narrative and expository	
Qualitative Reading Inventory	250-785 words	Aloud	Narrative and expository	*QRI also has recall*

Researcher-created recall task (Kendeou et al., 2012)	177 words	Not reported	Narrative	Recall
Gates-McGinitie Reading Test	3-15 sentences	Silent	Narrative and expository	Written multiple choice
Gray Oral Reading Test	6-7 sentences	Not reported	Narrative and expository	Spoken multiple choice
Stanford Diagnostic Reading Test—4th Edition	Not reported (timed)	Not reported	Narrative, expository and functional	Multiple choice (not reported as written/ spoken)
Peabody Individual Achievement Test— Reading comprehension	Not reported	Silent	Not reported	Picture pointing
CBM Maze (Kendeou et al., 2012)	155-183 words (time limited)	Not reported	Narrative	Maze

Cloze and question-response were the most common response formats evaluated. In general, cloze formats were found to be more related to decoding-level skills than were open-ended questions (Keenan et al., 2008; Kendeou, Papadopoulos, & Spanoudis, 2012; Nation & Snowling, 1997; Spear-Swerling, 2004). The interpretation of task results is complicated by the lack of a consistent passage length (Keenan et al., 2008). For example, Spear-Swerling (2004) reported results that were slightly at odds with Nation and Snowling (1997) regarding the relevance of listening comprehension to cloze tasks. The cloze task in Spear-Swerling's study involved passages, whereas the *Suffolk* cloze task in Nation and Snowling (1997) used single sentences. It is possible that the additional information in the passages allowed for higher-level processes to come into play, whereas the sentences comprehension was more constrained to information gained from lower-level processing, including decoding (Spear-Swerling, 2004). Similarly, a picture-pointing task found on the *PIAT*, on which correct answers depend upon recognition of key vocabulary words in short texts, was found to be linked to decoding ability (Keenan et al., 2008).

Cutting and Scarborough (2006) evaluated three tests with various question–response formats (*GORT-3, WIAT,* and *G-M*). They found that the three tests they evaluated were differentially related to the language composites they created, measuring "lexical" and "sentence processing" skills, as well as to decoding skills. The results from the *WIAT* were the most closely related to decoding skills; the *G-M* was most related to the oral language composites used. The *WIAT* is a question-response task, whereas the *G-M* uses a written multiple choice format. The authors note that even when the measures compared are constrained to those using question-response tasks as opposed to including measures using cloze procedures, significant differences between measures were found, implicating other test characteristics in affecting results.

The study by Eason, Goldberg, Young, Geist, and Cutting (2012) directly examined the impact of task and text on reading comprehension accuracy. This team used a single reading comprehension instrument with one response type (multiple choice) but with 3 levels of complexity in the questions and three different text types. The specific results of their analyses are summarized in Table 1; in short, both question type and text type had significant impact on reading comprehension accuracy for the participants.

Definition and Measurement of Oral Language Skills

How is "listening comprehension" defined and operationalized in studies of reading comprehension measures? There was significant variability between studies in the definition and measurement of oral language skills. Oral language comprehension or "listening comprehension" was the construct of interest in four studies (Francis, Fletcher, Catts, & Tomblin, 2005; Keenan et al., 2008; Nation & Snowling, 1997; Spear-Swerling, 2004). Measures of oral language comprehension ranged from vocabulary measures to inferential questions based on passages. Cutting and Scarborough (2006) took a different approach; rather than focus on listening comprehension, they used a

variety of measures to develop two language composites. This was interesting given their reference to the Simple View of Reading, since their composites included a number of expressive tasks. As discussed earlier, the Simple View refers directly to comprehension tasks only. The language tasks employed by Eason et al. (2012) were receptive in nature, tapping vocabulary, morpho-syntactic awareness, and ability to make inferences. The cognitive processing measures used by Kendeou and colleagues (2012) included several language-loaded tasks that tapped receptive vocabulary and sentence comprehension including syntax. The definition and measurement of oral language in the studies are summarized in Table 3.

What is known about the role of expressive language skills in the measurement of reading comprehension? Expressive language was not focused upon in any of the studies. As noted, the measures employed by Cutting and Scarborough (2006) did include expressive scores, but since composites were reported, no specific conclusions regarding expressive skills could be made.

Do researchers provide clear selection rationale for oral language tasks? Again there was variability among the studies. Francis et al. (2005), Keenan et al. (2008), and Nation and Snowling (1997) stated the need to measure oral language comprehension without further elaboration. Spear-Swerling (2004) provided discussion regarding the necessity of sampling vocabulary as well as language comprehension. Nation and Snowling (1997) provided a brief description of their listening task without information on the development of the stories or questions. Cutting and Scarborough (2006) presented research evidence for the importance of vocabulary and syntax in reading comprehension as rationale for their variable selection. Eason et al. (2012) explained their study motivation in terms of fusing the developmental perspective of the Simple View of reading and the Construction-Integration Model of Reading to lead to the inclusion of basic oral language and inferencing variables. Kendeou et al. (2012) laid out in detail the theoretical bases and research evidence underlying their test and variable selections.

Aspects of Tests to Consider

The impact of response task on reading comprehension test results has been considered, but other test characteristics may impact results. Eason et al., (2012) directly investigated the impact of text genre. This group found an interaction between text type and question type, with expository text, not narrative, tapping inferencing ability. Numerous researchers commented on other aspects of tests that could impact results such as reading tasks. Keenan and colleagues (2008) purposely selected their assessments to vary in terms of reading task, including oral/silent reading, and passage length. They concluded that passage length was significant in explaining their results; shorter passages appeared to measure decoding more than comprehension.

Discussion

This review has identified a gap in the literature on the use of standardized reading comprehension tests with children with LI. Although a number of studies were found examining the link between oral language skills and scores on reading comprehension tests, no studies specifically examined the interaction of reading comprehension tests with atypical language skills among students with LI. It is important to note that the samples of at least some of the studies reviewed included such children; however, results for these children were not separately explored in these studies to see whether the patterns of results were similar to those of children without LI. Post hoc categories based on discrepancy between reading comprehension and decoding as identified by Nation and Snowling (1997) can give some information regarding the population of children with LI. However, more focused results based upon the performance of children with identified oral language difficulties may result in different conclusions.

Implications for Children with Language Impairment

Based on the results of the included studies, some implications for children with LI and questions for future study are suggested by the authors of this review. In every study, the oral language measures selected accounted for different patterns of variance in reading comprehension scores. Overall, results suggest that tests that are more closely linked to listening comprehension deficits may reveal different weaknesses in students with LI than those that primarily depend upon decoding.

The work of Eason and colleagues (2012) highlights the importance of vocabulary across text genres and question complexity. Given that children with LI frequently have impoverished vocabularies (Paul & Norbury, 2012), their results suggest that it may be clinically useful to augment reading comprehension tests with vocabulary assessment in order to tease out a possible source of reading comprehension weakness. They also found inferencing to predict scores for expository text, but not narrative text. Since children with LI may be limited in inferencing skill (Barnes, Johnston, & Dennis, 2007), a child's reading comprehension might be overestimated by assessment tools that include only narrative text.

Table 3. Definition and Measurement of Oral Language Skills

Authors and year	Theoretical basis	Language construct	Operational measures
Nation & Snowling, 1997	Simple View of Reading	Listening comprehension	Orally presented stories with direct and inferential questions
Spear-Swerling, 2004	Spear-Sternberg Model of RD	Listening comprehension	LC subtest of the *Woodcock-Johnson Psychoeducational Battery*: an oral cloze task; *PPVT III*
Keenan et al., 2008	Not directly stated; consistent with Simple View of Reading	Listening comprehension	LC subtest of the *Woodcock-Johnson Psychoeducational Battery*: an oral cloze task; passage task from *Qualitative Reading Inventory* with retell and questions; *KNOW-IT Test*: a passage task with the teaching of background knowledge
Francis et al., 2005	Not directly stated	Receptive language	*WISC-R* Vocabulary score in one analysis, and a "receptive language" composite in the other (receptive language tests used were not specified)
Cutting & Scarborough, 2004	Simple View of Reading	Oral language (divided into lexical skills and sentence processing)	**Lexical Composite:** *PPVT-III* and the *Boston Naming Test* [expressive vocabulary]; Word Classes subtest *CELF-3*; [semantic relations] **Sentence processing composite:** *CELF-3* subtests: Concepts and Directions, Formulated Sentences, Recalling Sentences; also a complex sentence comprehension task **Verbal memory:** Immediate Recall subtest of the *Wide Range Assessment of Memory and Learning* [story recall]; and a "nonstandardized sentence span measure"
Eason et al., 2012	Simple View and Construction-Integration Model of reading	Oral language (only receptive skills sampled) and inferencing	*PPVT-III* ["semantic awareness"]; Grammatic Comprehension subtest of the *Test of Language Development—Intermediate (3rd Ed.)*: sentence-level grammaticality judgement task [morpho-syntactic awareness]; Making Inferences subtest of the *Test of Language Competence—Expanded Edition*: ability to make inferences based on a passage
Kendeou et al., 2012	Verbal Efficiency Theory	Cognitive processing (rather than language per se)	*Dyslexia Early Screening Test* [receptive vocabulary]; verbal spatial relations task: sentence-level comprehension task with picture-pointing response [working memory; also preposition comprehension]; sentence repetition: repeat nonsense sentences and answer questions about them [working memory, syntax]

PPVT III: Peabody Picture Vocabulary Test III; a word-level picture pointing task of receptive vocabulary

CELF 3: Clinical Evaluation of Language Fundamentals, Third Edition

LC: listening comprehension

Keenan et al. (2008) found that a given test may measure different skills depending upon the age or decoding skill of the participant. This suggests that further work comparing reading comprehension measures for children with LI may reveal additional variability in test score interpretation, as this group can be expected to include a relatively higher proportion of children with reading problems than the general population and are by definition less skilled in language. Conversely, Cutting and Scarborough (2006) did not find such effects, although they acknowledged that this was not consistent with previous findings.

Kendeou et al. (2012) excluded students with a history of speech or language impairments. It would be interesting to find out whether results regarding cognitive processing demands would be similar with this population. For example, since many children with LI have working memory limitations (Archibald, 2006), these children might be expected to perform more poorly on instruments that tax this resource, such as recall tasks. Note that this would not invalidate the test results, as working memory is generally considered to be a true sub-skill required for reading comprehension. The point is that it would be important to know how children with LI would score across tests for optimal test selection and interpretation. The results obtained by Kendeou et al. (2012) were not consistent with Cutting and Scarborough (2006) who reported that "the prediction of comprehension scores was not enhanced by taking into account any measure of verbal memory, rapid serial naming, IQ, or (with one minor exception) attention" (p. 294). Note that the studies differed in terms of study population, working memory measures, and reading comprehension tests evaluated.

Definition and Measurement of Oral Language Skills

Language measures employed in the studies described here were primarily receptive measures, attributable to the use of the Simple View of Reading framework (Gough & Tunmer, 1986). It may be that the Simple View applies well to children with language systems developing within the expected range, but less well to children with LI who may have inconsistent abilities across language domains. If children with typically developing language skills have relatively more consistent language skills, any one language measure will be more representative of their overall language profiles. For children with LI and potentially with more inconsistent language profiles, a broader selection of language measures may be necessary to appropriately characterize their skills. It has been suggested that the Simple View could be enhanced by more clearly specifying the language comprehension and cognitive skills that it encompasses (Ricketts, 2011). In addition, the preponderance of receptive measures may limit studies from revealing the impact of expressive language problems on reading comprehension. The study by Spooner et al. (2004) suggested that poor expressive language skills can limit children's ability to demonstrate their understanding of a text. Simkin and Conti-Ramsden (2006) reported that children's reading skills varied with their language skills: children with combined receptive and expressive deficits had the most difficulty, but a majority of children with expressive-only deficits also had reading problems. The question remains whether poor expressive language skills are a primary factor in children's responses in assessment tasks, or whether expressive language represents an underlying skill of reading comprehension itself. Studies comparing results for various reading comprehension tests for children with identified oral language impairments in both receptive and expressive domains will enhance our ability to select appropriate measures for our purposes. This in turn should lead to more effectively targeted intervention programs based upon accurate assessments.

It was interesting to note that the rationale for selection of oral language measures was not consistently reported in these studies. Recall that Kendeou et al. (2012) laid out the research evidence and rationale for their variable selections in detail. This would seem to be sound practice which facilitates the interpretation of results across studies and for practical application.

Aspects of Tests to Consider

As discussed above, reading comprehension tests cannot be considered equivalent. This could be a benefit, given that there are a variety of purposes served by these tests. Selecting the best instrument for one's purpose then will require careful evaluation of relevant factors. All of the studies in this review included some discussion of test characteristics as potential sources of variation, although they were not necessarily studied as separate variables. In some cases it may be challenging to separate the effects of different test characteristics. For example, it is difficult to disambiguate reading task from response task for cloze presentations as the response item is embedded in the stimulus text. A clear understanding of test characteristics and the resulting ability to select measures for a given purpose has direct relevance to student outcomes. Cutting and Scarborough (2006) discussed the importance of test selection in the identification of reading comprehension problems. They reported the results of a study with a portion of their sample demonstrating that application

of the tests they studied would yield different diagnostic results (Rimrodt, Lightman, Roberts, Denckla, & Cutting, 2005). The tables provided in Appendix A summarize variables that may impact test results, as identified in the literature presented above and by task analysis performed by the first author.

Measuring Reading Comprehension in Practice

Based upon the articles reviewed here, it appears that compiling a profile of language and reading skills is an appropriate method to document reading comprehension. Variety in both test formats and tasks sampling component skills must be employed (Spear-Swerling, 2004). Particularly for a child with LI, intervention planning requires a thorough understanding of the learning profile, including receptive and expressive language skills in semantics, syntax, vocabulary and discourse level skills, as well as working memory, reading comprehension with authentic texts, and decoding skills. The most parsimonious method to compile a learning profile for the child might be to coordinate among teacher, speech-language pathologist, and school psychologist. Among them, it is likely that many, if not all, of the measures needed may be readily available. Pooling this knowledge will permit the development of a language and literacy profile that could provide a rich basis for intervention planning.

Conclusions

1) Further research needs to be done to document the relationship of oral language skills in children with oral language impairment, particularly expressive skills, to reading comprehension. In particular, comparison of results among standardized reading comprehension tests for children with oral language impairment will facilitate interpretation of the results from these measures.

2) Selection of reading comprehension measures in studies of language and reading should be based upon criteria such as those detailed in Snyder and colleagues (2005). This selection rationale should be explicitly stated to facilitate interpretation of results and cross-study comparisons. Oral language measures should be similarly selected and specified for the same reasons.

3) Reading comprehension is best represented as a profile of component skills including a variety of oral language skills. No single available instrument appears to document all the applicable skills; measurement selection will vary by the purpose of the assessment. The necessary comprehensive assessment will be facilitated by inter-professional collaboration among teachers, speech-language pathologists, and psychologists to provide the broadest overview of skills with the least duplication of assessment.

The studies reviewed here comprise a small but remarkably consistent body of literature demonstrating that reading comprehension tests sample different underlying skills. This presents a challenge: test users will need familiarity with the specific skills tapped by the measure in use to best match test to the student and the purpose of assessment. Given that not all reading comprehension tests have been studied, further research in this area should be fruitful in clarifying the skills tapped by these tests.

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Appendix A
Aspects of Tests to Consider

Stimulus Text

-text genre: expository, narrative, poetry, mixed (Eason et al., 2012)

-length of text (Cutting & Scarborough, 2006; Keenan et al., 2008; Kendeou et al., 2012)

- syntactic complexity and language forms (Cutting & Scarborough 2006)

-vocabulary level and familiarity of topic (Francis et al., 2005, Keenan et al., 2008)

-interest level of text (Francis et al., 2005)

-macrostructure (including propositional and intersentential complexity) (Francis et al., 2005)

Reading Task

-oral or silent reading (Keenan et al., 2008)

-level of support: errors corrected in oral reading or not

-time limited or not

Response Task (recognized by numerous authors as sources of inter-test variation)

-cloze (sentence or passage), maze, oral reading fluency, question response (closed or open-ended; direct or inferential; provided orally or written), multiple choice, sentence verification, picture selection, retell, and recall (this characteristic is noted by most authors)

-response mode: oral, written; short or long response; selection/forced choice or open-ended (Francis et al., 2005)

-question complexity relative to text

-level of question (recall, inferencing, etc) (Eason et al., 2012)

-availability of text for answering questions (Cutting & Scarborough, 2006; Kendeou et al., 2012)

-time limited or not (Kendeou et al., 2012)

Additional considerations

-Group or individual administration

-Success criterion: norm-referenced (consider norming sample), criterion-referenced (Snyder et al., 2005)

-Scoring: interpretation required or not (consider reliability) (Francis et al., 2005)

-Norming sample: truncated sample or not; comparability to population of interest (Snyder et al., 2005)

-Administration time: consider effects of attention and fatigue

-Theoretical basis for test construction (Cutting & Scarborough, 2006, van den Broek & Espin, 2012)

-internal factors of the examinee (e.g. motivation) (Francis et al., 2005)

Conception et qualités psychométriques d'un outil d'évaluation de la compréhension d'inférences en contexte de récit chez des enfants âgés de 3 à 6 ans

Design and psychometric qualities of an assessment tool used for understanding inferences in a narrative context with children 3 to 6 years of age

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Abrégé

L'habileté à comprendre des inférences joue un rôle crucial dans la réussite éducative du jeune enfant. Or, il s'agit d'un construit complexe et il n'existe pas d'outil standardisé pour le mesurer. De manière à contribuer à ce domaine de connaissances, un outil d'évaluation intitulé *Évaluation de la Compréhension Inférentielle en Récit* (ÉCIR) a été élaboré sur *iPad* afin d'évaluer la compréhension d'inférences ciblant les éléments de la grammaire de récit chez des enfants âgés de 3 à 6 ans. Suite à cette conception, la présente étude vise à examiner la validité de contenu, évaluée auprès d'orthophonistes experts, afin d'optimiser l'outil avant son utilisation auprès d'enfants. Puis, la recherche en détermine les qualités psychométriques à partir d'un échantillon de 121 enfants, âgés de 3 à 6 ans. La validité de construit, la validité concurrente, la fidélité inter-juge et test-retest sont ainsi mesurées. Les résultats démontrent que l'ÉCIR s'avère valide sur le plan du contenu et démontre de bonnes qualités psychométriques. Ce nouvel outil d'évaluation contribuera à préciser le développement de la compréhension inférentielle chez les jeunes enfants en contexte de récit et pourra être utilisé en clinique comme en recherche.

Abstract

The ability to understand inferences plays a crucial role in the educational success of a young child. Yet, this is a complex construct, and there is no standardised tool to measure it. In order to contribute to this area of knowledge, an assessment tool called *Évaluation de la Compréhension Inférentielle en Récit* (ÉCIR) has been developed for the iPad to evaluate the comprehension of inferences focussing on elements of narrative grammar in children from 3 to 6 years of age. This study aims to examine the validity of the contents of the ÉCIR, evaluated with the help of expert speech language therapists, in order to optimise the tool before using it with children. This research also examines the psychometric qualities of this assessment tool using a sample of 121 children from 3 to 6 years of age. Therefore, the validity of the construct, the concurrent validity, the inter-judge reliability, and the test-retest reliability were measured. The results showed that the ÉCIR seems to be valid with respect to its contents, and that it demonstrates good psychometric qualities. This new assessment tool will help to clarify the development of inferential comprehension in young children in a narrative context, and can be used in clinics as well as in research.

Introduction

La compréhension inférentielle constitue un élément important de la compréhension en lecture à l'âge scolaire (Bianco et al., 2010; Cain & Oakhill, 2007; Joffe, Cain, & Maric, 2007; van den Broek et al., 2005; van Kleeck, 2008). En effet, pour comprendre un texte, un enfant doit non seulement décoder et comprendre les informations explicites qu'il lit, comme les mots et les phrases, mais il doit également interpréter les informations implicites, ce qui l'oblige à réaliser des inférences afin de bien saisir le sens du texte (Bishop, 1997). Cette habileté permet ainsi à l'enfant de se créer une représentation mentale cohérente et complète d'un message (Ford & Milosky, 2003; Joffe et al., 2007). Il n'est donc pas surprenant que plusieurs études aient démontré des liens positifs significatifs entre la compréhension inférentielle pendant la petite enfance et le succès ultérieur en compréhension en lecture (Ferreiro & Taberoski, 1982; Kontos & Wells, 1986), lui-même relié à la réussite scolaire ultérieure de l'enfant. En effet, des récentes études longitudinales ont soulevé la contribution relativement indépendante du développement des habiletés inférentielles et de la compréhension orale précoce sur la réussite ultérieure en compréhension de lecture (Bianco et al., 2010; Kendeou, van den Broek, White, & Lynch, 2009; NICHD, Early Child Care research Network, 2005).

Des écrits scientifiques ont démontré que les habiletés de compréhension inférentielle s'inscrivent tôt dans le développement de l'enfant (Bianco et al., 2010; Das Gupta & Bryant, 1989; Desmarais, Nadeau, Trudeau, Filiatrault-Veilleux, & Maxes-Fournier, 2013b; van Kleeck, 2008). Effectivement, les informations dont on dispose jusqu'à maintenant, quoique parcellaires, indiquent que les habiletés inférentielles sont présentes dès le jeune âge de l'enfant. Ainsi, dès l'âge de 3 ou 4 ans, les enfants seraient capables de répondre à des questions inférentielles en lien avec une histoire qui leur est lue (Deconti & Dickerson, 1994; Makdissi & Boisclair, 2006, van den broek et al., 2005). Par ailleurs, dès l'âge de 4 à 6 ans, il est possible de distinguer, à des tâches de compréhension inférentielle, la performance d'enfants au développement typique lorsqu'elle est comparée à celle d'enfants qui présentent un trouble de langage (Adams, Clarke, & Haynes, 2009; Desmarais et al., 2013b; Filiatrault-Veilleux, Tarte, & Desmarais, 2015; Ford & Milosky, 2003, 2008; Spackman, Fujiki, & Brinton, 2006; Trabasso & Nickels, 1992). Ces derniers présenteraient des difficultés à comprendre des inférences et obtiendraient des résultats comparables à ceux d'enfants plus jeunes (Bishop, 1997; Botting & Adams, 2005; Bowyer-Crane & Snowling, 2005; Ryder, Leinonen, & Schulz, 2008; Skarakis-Doyle & Dempsey, 2008). Étant donné que cette habileté apparaît tôt, et aussi compte tenu de son implication en compréhension de lecture et dans la réussite scolaire notamment, il est pertinent pour les orthophonistes de s'intéresser précocement à son développement.

Dans une perspective de dépistage précoce des difficultés langagières chez les petits, il importe de pouvoir évaluer l'habileté à comprendre des inférences en bas âge. Or, l'état actuel des connaissances ne permet pas de le faire. D'une part, peu d'études ont été menées pour évaluer cette habileté pendant la période de la petite enfance (Ford & Milosky, 2003, 2008; Trabasso & Nickels, 1992; van Kleeck, Vander Woude, & Hammett, 2006; Wenner, 2004). D'autre part, les méthodes utilisées pour mesurer cette habileté sont variées et, à l'heure actuelle, aucun outil n'est adapté aux enfants qui ne lisent pas encore.

Partageant la préoccupation actuelle concernant la rareté des outils d'évaluation en orthophonie en contexte franco-québécois (Bouchard, Fitzpatrick, & Olds, 2009), et parce qu'il n'existe pas encore d'outil clinique évaluant spécifiquement la compréhension des inférences chez les jeunes enfants, nous avons entrepris le développement de cet outil chez les enfants non-lecteurs de 3 à 6 ans. Sa conception, de même que sa validation, ont suivi les quatre étapes proposées par la concertation de l'American Educational Research Association, l'American Psychological Association et le National Council of Measurement in Education (AERA, APA, & NCME, 1999) ainsi que par Laveault et Grégoire (2014). La première étape consiste à expliciter le construit théorique, qui permet de faire le point sur les perspectives pertinentes dans l'évaluation de la compréhension des inférences chez les enfants d'âge préscolaire. La deuxième étape repose sur la création d'un outil d'évaluation à partir des éléments conceptuels et méthodologiques importants mis en évidence par une recension des écrits (Filiatrault-Veilleux, Bouchard, Trudeau, & Desmarais, 2015). La troisième étape vise à valider le contenu des variables sélectionnées à l'aide d'experts dans le domaine. Finalement, la quatrième étape comprend la réalisation d'analyses statistiques pour déterminer les qualités psychométriques de l'outil.

Dans une perspective développementale, les écrits scientifiques proposent des pistes intéressantes pour conceptualiser la compréhension des inférences chez les enfants qui n'ont pas encore appris à lire. La méthode actuellement privilégiée pour évaluer cette habileté en contexte de langage oral chez les jeunes enfants est

la lecture partagée (Desmarais et al., 2013b; Makdissi & Boisclair, 2006; van Kleeck et al., 2006). La lecture partagée consiste en la lecture d'une histoire où l'adulte interagit avec l'enfant, en lui offrant des modèles et en lui posant des questions afin, entre autres, de l'aider à aller plus loin dans sa compréhension du récit (Whitehurst & Lonigan, 1998). Ce type de lecture offre donc de nombreuses occasions pour amener l'enfant à faire des inférences, ce qui tend à augmenter son intérêt envers l'histoire (Desmarais et al., 2013b; Justice & Kaderavek, 2004; Whitehurst & Lonigan, 1998).

Le livre utilisé doit être composé d'une structure narrative classique, qui devient prévisible pour l'enfant. Les éléments de la grammaire de récit qui constituent cette structure classique sont une situation initiale, un événement déclencheur, un problème qui génère une réponse interne, un but qui motive les actions du personnage au cours du récit, des tentatives de résolution du problème et une solution (Mandler & Johnson, 1977; Stein & Glenn, 1979). Dans ce contexte facilitant et signifiant, où les jeunes enfants peuvent inférer grâce au soutien de l'adulte qui les guide dans leur compréhension de l'histoire, ils sont capables de répondre à des questions inférentielles de différents types (Bianco & Coda, 2002; Desmarais et al., 2013b; Ford & Milosky, 2003, 2008; Makdissi & Boisclair, 2006; Trabasso & Nickels, 1992; van den Broek et al., 2005; van Kleeck et al., 2006).

Comme il s'agit d'une habileté en développement, il importe de s'intéresser aux types de questions inférentielles qui seraient comprises précocement par les jeunes enfants. Les questions ciblant les éléments de la grammaire de récit (c'est à dire le problème, les réponses internes, le but du personnage, les tentatives pour le résoudre, la prédiction de la prochaine étape et la solution de l'histoire) sont reconnues pour être comprises tôt par les enfants d'âge préscolaire (Filiatrault-Veilleux et al., 2015; Makdissi & Boisclair, 2006). Ces types d'inférences sont appelées « inférences causales », c'est-à-dire qu'elles requièrent la compréhension d'un lien de causalité entre des événements (Bianco & Coda, 2002; Dupin de Saint-André, 2008; Graesser, Singer, & Trabasso, 1994; Johnson & von Hoff Johnson, 1986; Lefebvre, Bruneau, & Desmarais, 2012; Richards & Anderson, 2003). En plus d'émerger précocement, les inférences causales sont considérées « nécessaires » à la compréhension d'une histoire, s'avérant essentielles pour bien saisir le sens d'un récit (Bianco & Coda, 2002). Finalement, selon d'autres auteurs, ces inférences permettent également d'assurer la « cohérence globale » d'un récit, en reliant ensemble les idées quant aux buts/motivations des personnages qui ne sont pas explicitement mentionnées dans l'histoire (Currie & Cain, 2015). La classification des inférences causales basées sur les éléments de la grammaire de récit utilisée dans cette étude est présentée dans le Tableau 1 (Bianco & Coda, 2002; Bowyer-Crane & Snowling, 2005; Makdissi & Boisclair, 2006; van Kleeck, 2008).

En contexte de lecture partagée, il apparaît également primordial de concevoir une tâche qui peut soutenir et optimiser cette habileté en développement chez l'enfant. Les éléments se dégageant d'une récente recension des écrits (Filiatrault-Veilleux et al., 2015) ont guidé l'élaboration de l'outil. Premièrement, la modalité employée pour présenter l'histoire à l'enfant peut jouer un rôle dans sa performance. Comme l'enfant n'est pas encore apte à lire une histoire, l'information doit être présentée à l'oral et, idéalement, accompagnée d'illustrations, voire de courtes vidéos servant de support visuel au récit (Gibbons, Anderson, Smith, Field, & Fisher, 1986; Kendeou, Bohn-Gettler, White, & van den Broek, 2008; Wenner, 2004). En effet, l'utilisation d'une combinaison de ces modalités de présentation optimise l'attention de l'enfant (Verhallen, Bus, & de Jong, 2006), tout en soutenant ses habiletés inférentielles (Ford & Milosky, 2003).

Deuxièmement, les enfants peuvent générer plus facilement des inférences au cours de la lecture du récit, plutôt qu'à la toute fin (Makdissi & Boisclair, 2006). En effet, lors de l'administration d'une tâche, poser des questions après la présentation de l'histoire semble surcharger davantage les habiletés mnésiques du jeune enfant plutôt que d'évaluer ses habiletés de compréhension (Blanc, 2010; van den Broek, Tzeng, Risden, Trabasso, & Basche, 2001). Ainsi, une piste prometteuse consiste à explorer l'habileté à faire des inférences pendant la présentation de l'histoire. Cette méthode favoriserait une augmentation de la complexité des expressions causales produites pendant le récit (Desmarais et al., 2013b; Makdissi & Boisclair, 2006; van Kleeck et al., 2006).

Troisièmement, la méthode sélectionnée pour évaluer le niveau de performance de l'enfant doit également tenir compte d'un continuum de degré de compréhension inférentielle, plutôt que d'utiliser un système dichotomique de réponse correcte vs incorrecte. Un enfant peut effectivement déduire une partie de la réponse qui n'est pas entièrement vraie ou fausse, mais qui se situe entre les deux, sur un continuum de qualité. La classification des types de réponses données par les enfants en fonction de leur niveau de qualité utilisée dans

certaines études permet une meilleure discrimination des performances des enfants (Adams et al., 2009; Desmarais et al., 2013b; Gnepp & Gould, 1985; Spackman et al., 2006). Par exemple, à la question « Que va faire le garçon ? » après avoir cassé son jouet préféré, un enfant qui répond « il va demander à son père pour de l'aide » plutôt que « le garçon va pleurer » pourrait démontrer un niveau de compréhension plus élevé.

En s'appuyant sur les recommandations de création d'outils d'évaluation robustes (AERA et al., 1999; Laveault & Grégoire, 2014), la présente étude vise à concevoir un nouvel outil d'évaluation de la compréhension des inférences en contexte de récit et à en déterminer la validité de contenu, de même qu'à en mesurer les qualités psychométriques. Sur le plan de la validité de contenu, elle vise à évaluer, via une consultation d'experts cliniques (a) le matériel de l'outil que constitue la structure narrative du récit, les questions posées et la qualité des illustrations qui accompagnent le récit, (b) la fonctionnalité via le médium utilisé, soit un iPad et (c) les scores obtenus par des enfants à la tâche sur un continuum de qualité afin de concevoir une échelle de codification. En ce qui concerne les qualités psychométriques, l'étude vise à déterminer la validité de construit et la validité concurrente de l'outil de même que sa fidélité inter-juge et test-retest.

Méthode

L'étude a reçu l'approbation éthique de l'Institut de Réadaptation en Déficience Physique de Québec (IRDPQ). Considérant sa nature, elle s'est déroulée en deux phases distinctes et les éléments de cette section sont donc présentés de la façon suivante : 1) conception de l'outil Évaluation de la Compréhension Inférentielle en Récit (ÉCIR) et validité de contenu auprès d'experts (participants, matériel et procédure) et 2) qualités psychométriques de l'outil (participants, matériel, procédure et analyse des données).

1) Conception de l'outil : *Évaluation de la Compréhension Inférentielle en Récit* (ÉCIR) et validité de contenu

Comme les nouvelles technologies prennent un essor considérable en évaluation auprès des jeunes enfants (Brandone, Michnick Golinkoff, & Hirsh-Pasek, 2008), l'outil d'évaluation a été conçu sur *iPad* dans le but d'uniformiser la procédure de passation. Ce médium permet de combiner des illustrations attrayantes à une présentation audio de la narration, des questions et des effets sonores, ce qui permet une standardisation essentielle dans un contexte d'outil de mesure. Six types d'inférences causales ciblant les éléments de la grammaire de récit d'une histoire sont mesurés par l'outil : le problème, les réponses internes, le but du personnage, les tentatives de résolution du problème, les prédictions et la solution. Le nombre, le contexte de l'histoire et les exemples de questions posées sont présentés dans le Tableau 1.

L'application *iPad* ÉCIR apparaît sous la forme d'un livre d'histoire pour enfant comprenant vingt illustrations réalisées par une graphiste. Le résumé de l'histoire est présenté en Annexe. Les deux premières pages du livre préparent l'enfant au fonctionnement de l'outil en l'exposant à cinq questions littérales. La tâche consiste ensuite à répondre à dix-neuf questions inférentielles, soit une par page (pages 3 à 20), à l'exception d'une page où deux questions sont posées (page 19). Lors de l'administration, à chacune des pages l'enfant est invité à regarder l'illustration tout en écoutant la narration, puis à répondre à la question inférentielle posée. Les questions sont posées pendant la présentation de l'histoire.

Les réponses produites par les enfants sont codifiées selon un continuum de qualité en quatre niveaux afin de pouvoir obtenir une gradation de la performance de cette habileté en développement. En s'inspirant du *Preschool Language Assessment Instrument–Second Edition* (PLAI-2) (Blank, Rose, & Berlin, 2003) et d'un précédent projet de recherche (Desmarais, Archambault, Filiatrault-Veilleux, & Tarte, 2012; Desmarais et al., 2013b), les réponses produites par les enfants sont classées en quatre catégories de réponses {A, B, C, D} sur un continuum de qualité. Le Tableau 2 présente le nom et la définition des catégories de réponses ainsi que des exemples de réponses et le nombre de points accordés (de 0 à 3 points).

Participants. Pour évaluer la validité de contenu de l'outil, six orthophonistes œuvrant dans des contextes différents (centre de réadaptation, CSSS, cabinet privé) ont été invités à participer. Les orthophonistes devaient : (1) être membres de l'Ordre des Orthophonistes et Audiologistes du Québec (OOAQ) et (2) présenter un minimum de cinq ans d'expérience auprès d'enfants d'âge préscolaire avec des difficultés langagières. De plus, un chercheur expert dans le domaine de la compréhension inférentielle chez les jeunes enfants a été sollicité pour participer à l'étape de la validation des scores obtenus.

Matériel et procédure. La validité de contenu a été effectuée en deux temps au moyen de deux rencontres de type focus groupe (Tableau 3). (1) Une version papier de l'outil comprenant les vingt illustrations, la narration associée et les questions à poser aux enfants a été

Tableau 1. Classification des six inférences ciblant les éléments de la grammaire de récit ainsi que le nombre, le contexte de l'histoire et les exemples de questions inférentielles élaborées pour l'*ÉCIR*

Types d'inférence	N	Contexte de l'histoire	Questions inférentielles
Événement déclencheur/ problème du personnage	2	L'orage brise le nid de Pinson.	Oh oh! Qu'est-ce qui arrive ? Pourquoi Pinson se cherche un abri ?
Réponse interne	4	• Il a peur, car ses parents quittent le nid et l'orage arrive. • Il est triste, car son nid se brise. • Il est découragé, car il ne trouve pas d'abri. • Il est content, car il retrouve ses parents et il a une nouvelle maison.	Comment il se sent Pinson ? Pourquoi ? (justification de la réponse interne) (*question posée à quatre moments différents*)
But du personnage	2	Il se cherche un abri.	Il veut quoi Pinson?
Tentatives de résolution du problème	7	Il rencontre trois animaux qui tentent de l'aider, mais qui n'y arrivent pas (une moufette, un porc-épic et un castor).	Est-ce que Pinson va être bien dans cette maison ? Pourquoi ? (*prédiction du succès de la tentative de résolution, 4 questions*) Est-ce un bon abri pour Pinson ? Pourquoi ? (*évaluation du résultat de la tentative de résolution, 3 questions*)
Prédiction de la prochaine étape	2	• La branche d'arbre va casser en raison de l'orage. • Tom va lui construire une cabane en bois.	La branche d'arbre va casser en raison de l'orage. Tom va lui construire une cabane en bois.
Conséquences ou solution	2	Tom lui a construit une cabane en bois bien solide.	Est-ce un bon abri pour Pinson ? Pourquoi ? (*évaluation de la solution*) Qui a le plus aidé Pinson selon toi ? Pourquoi ?

ÉCIR : Évaluation de la Compréhension Inférentielle en Récit

Tableau 2. Définition des quatre catégories de réponses sur un continuum de qualité, exemples de réponses obtenues à la question « *Il veut quoi Pinson, tu penses ?* » et points accordés

	Continuum de qualité des réponses			
	Faible →			Élevée
Catégorie	D - Inadéquate	C - Peu contingente	B - Incomplète	A - Attendue
Définition	Absence de réponse ou réponse erronée.	Trop vague ou n'est pas directement en lien avec ce qui est attendu	Logique, mais incomplète ou imprécise	Correspond entièrement à la réponse cible
Exemples de réponses	Il veut aller dans l'eau.	Il veut manger.	Il veut retrouver ses parents.	Il veut se trouver un abri.
Points accordés	0	1	2	3

remise aux six orthophonistes. Pour chaque élément de cotation envisagé, les orthophonistes ont évalué la pertinence selon une échelle de Likert {très pertinent, assez, peu, pas pertinent}. Une première rencontre (focus groupe #1) d'une durée de deux heures a ensuite permis d'échanger sur le contenu et a conduit à des ajustements. (2) Après cette rencontre, le contenu de l'outil a été transféré sur l'application *iPad*. La même procédure de validation a été reprise pour cette autre version de l'outil. Avant la deuxième rencontre (focus groupe #2), les orthophonistes devaient utiliser la version *iPad* avec trois enfants âgés de 3 à 6 ans. Les deux focus groupes ont été réalisés dans le but d'obtenir un consensus pour chacun des éléments discutés. Le but et les éléments discutés lors des deux focus groupes sont présentés dans le Tableau 3. Cette étape de validation du contenu visait à optimiser l'outil, avant son utilisation auprès d'enfants.

2) **Qualités psychométriques de l'outil**

Participants. Cent vingt et un enfants au développement typique (59 filles et 62 garçons) ont été recrutés, en collaboration avec des centres de la petite enfance (CPE) et des écoles primaires de la région de Québec, de même que par le biais d'une invitation par courriel aux étudiants et employés de l'Université Laval. Les parents des enfants devaient au préalable avoir signé le formulaire de consentement lié à l'approbation par le comité d'éthique de la recherche de l'Institut de Réadaptation en Déficience Physique de Québec (IRDPQ) (#2013-309). Les enfants devaient respecter les critères d'inclusion suivants : (1) avoir entre 3;0 et 6;11 ans et (2) détenir le français comme langue maternelle. De plus, ceux présentant un retard de langage ou tout autre problème cognitif ou développemental, rapporté via un questionnaire complété par les parents, étaient exclus de la recherche. Les 121 enfants ont été divisés en trois groupes en fonction de leur âge et du milieu fréquenté (milieu de garde ou maternelle). La description de l'échantillon est présentée dans le Tableau 4.

Matériel. Trois tâches ont été administrées aux enfants. La première tâche est l'ÉCIR, le nouvel outil de la compréhension des inférences. La seconde tâche est un outil expérimental de la compréhension des inférences, élaboré à partir du livre *Petit cochon s'est perdu* (Desmarais, Nadeau, Trudeau, Filiatrault-Veilleux, & Maxes-Fournier, 2013a)[1]. Comme il n'existe pas de test de référence absolu permettant de mesurer la compréhension inférentielle en contexte de lecture partagée chez les enfants, cette tâche expérimentale a été sélectionnée puisqu'elle s'est avérée sensible au développement langagier dans un précédent projet (Desmarais et al., 2013a). Dans *Petit cochon s'est perdu*, dix questions inférentielles ciblant les éléments du récit et les connaissances du monde sont posées aux enfants pendant la lecture. Finalement, une mesure de la taille du vocabulaire réceptif, un construit démontré comme étant relié à la compréhension inférentielle (Currie & Cain, 2015; Florit, Roch, Altoè, & Levorato, 2009; Kendeou et al., 2008), a été réalisée grâce à l'*Échelle de vocabulaire en images Peabody* (EVIP) (Dunn, Thériault-Whalen, & Dunn, 1993).

Procédure. La collecte de données était d'une durée d'une heure au CPE ou à l'école fréquenté par chaque participant à la recherche. Les tâches ont été administrées par deux assistantes de recherche ayant reçu une formation au préalable afin qu'elles soient familières

Tableau 3. But et résumé des éléments évalués par les experts cliniciens lors des deux focus groupes

	But de la rencontre	Éléments évalués et discutés
Focus groupe #1	Valider le contenu du matériel employé de l'outil en version papier.	• Pertinence et clarté de l'histoire ; adaptée aux enfants de 3 à 6 ans ; respect de la structure du récit. • Formulation des questions posées ; qualité et quantité quant aux six types d'inférences à évaluer. • Clarté et caractère non équivoque des illustrations ; visuellement attrayantes pour les jeunes enfants.
Focus groupe #2	Valider la fonctionnalité de l'outil sur *iPad* suivant la passation à trois enfants.	• Facilité d'utilisation de l'outil sur *iPad*. • Attrait et attention des enfants lors de la passation. • Fonctionnement des paramètres de l'application. • Temps de passation.

Tableau 4. Caractéristiques des trois groupes de participants : moyenne (et écart-type) pour l'âge, pourcentage de mères ayant terminé leurs études secondaires et pourcentage de familles ayant un revenu supérieur au seuil de faible revenu

Groupe	N (Filles-Garçons)	Âge moyen en mois (E-T)	Scolarité mère > DES (%)	Revenu > SFR (%)
3 ans fréquentant un milieu de garde	30 (14-16)	42,16 (3,44)	100	100
4 et 5 ans fréquentant un milieu de garde	37 (18-19)	56,18 (6,17)	100	91,9
5 et 6 ans fréquentant la maternelle	54 (27-27)	73,27 (3,67)	100	94,4

DES : Diplôme d'études secondaires; SFR : seuil de faible revenu

avec les procédures de passation. Les rencontres étaient filmées afin de faciliter la codification des résultats. Des 121 enfants recrutés, 34 ont été revus deux semaines suivant la première administration afin de déterminer la fidélité test-retest de l'outil.

Analyse des données

L'analyse des données a été réalisée avec le logiciel SPSS version 22. Pour évaluer la validité de construit, une analyse en composantes principales a été réalisée avec une rotation varimax (Kim & Mueller, 1978; Tabachnick & Fidell, 2001). Cette analyse factorielle a permis d'examiner les patrons de corrélations entre les six types d'inférences mesurées par l'outil de mesure ÉCIR. À cette occasion, l'indice Kaiser-Meyer-Olkin (KMO) a permis d'évaluer la qualité représentationnelle de l'échantillon, c'est-à-dire à quel point la matrice de corrélation est cohérente. Idéalement, l'indice KMO doit se situer entre 0,6 et 0,9 (Kaiser, 1974). Pour déterminer la validité concurrente, des mesures de coefficients de corrélation de Pearson ont été réalisées entre le nouvel outil et les deux autres tâches (*Petit cochon s'est perdu*, Desmarais et al., (2013a) et l'ÉVIP, Dunn et al., (1993)). La fidélité inter-juge a été mesurée avec la statistique pondérée AC1 de Gwet (Wongpakaran, Wongpakaran, Wedding, & Gwet, 2013), un estimateur développé pour corriger les paradoxes de la statistique Kappa de Cohen. La pondération permet aussi de prendre en compte la taille de l'écart entre les cotes attribuées par les juges. En effet, une différence de 1 entre deux catégories (p.ex. A et B), équivalait à un coefficient de 0,89, une différence de 2 (p.ex. A et C) à un coefficient de 0,56, alors qu'une différence de 3 (p.ex. entre A et D) à un coefficient de 0. Finalement, une analyse de coefficient intra-classe (ICC) de type 2,1 a été employée afin de mesurer la fidélité test-retest à deux semaines d'intervalle (modèle mixte, ICC relatif). En effet, cette analyse s'avère préférable au coefficient de corrélation de Pearson (*r*), car elle permet de comparer la variabilité des cotations d'un même sujet à la variation totale du test et de tous les sujets (Steffen & Seney, 2008).

Résultats

Comme pour la section Méthode, les résultats sont présentés en deux sections distinctes : 1) validité de contenu (matériel employé et fonctionnalité sur *iPad*) et 2) qualités psychométriques (validité de construit, validité concurrente, fidélité inter-juge et test-retest).

1) Validité de contenu

Le matériel employé dans l'ÉCIR. Les experts ont jugé très pertinentes la structure narrative du récit (pour 73% des éléments à juger), les questions posées (72%) et dans une moindre mesure, les illustrations (57%). Tous les éléments jugés « assez pertinents » (structure narrative du récit = 27%, questions posées = 27% et illustrations = 36%) et « peu pertinents » (questions posées = 1% et illustrations = 7%) ont été discutés lors du premier focus groupe afin de dégager un consensus quant aux modifications à apporter à l'outil. À titre d'exemple, la formulation de certaines questions a été simplifiée et adaptée pour se rapprocher davantage du langage utilisé avec de jeunes enfants en contexte franco-québécois. Également, certains éléments des illustrations jugés non pertinents et pouvant nuire à l'interprétation visuelle ont été retirés.

La fonctionnalité de l'outil sur iPad. Le deuxième focus groupe a permis d'obtenir un consensus quant aux modifications à effectuer à l'application informatique. Il est à noter que puisque les modifications suggérées ont été abordées dans le contexte d'une discussion qui a menée à un consensus, aucune analyse quantitative n'a été effectuée quant à l'échelle de pertinence. Suite au focus groupe, certains paramètres et fonctionnalités ont été modifiés pour en simplifier l'utilisation. Par ailleurs, le temps de passation, d'environ 15 minutes, était jugé adéquat. Les résultats obtenus lors des deux focus groupes ont donc permis de modifier l'outil d'évaluation afin de vérifier que le contenu de l'outil était adéquat et que son administration sur *iPad* convenait à des enfants âgés de 3 à 6 ans.

2) Qualités psychométriques

Validité de construit. La matrice de corrélations soumise à l'analyse en composantes principales affiche une excellente structure représentationnelle (indice KMO=0,865; p<,001; Kaiser, 1974). Quatre facteurs ont été retenus parce que leur valeur propre (eigenvalue) était supérieure à un. Le Tableau 5 présente les résultats de l'analyse en composantes principales à quatre facteurs après rotation varimax (Tabachnick & Fidell, 2001), et ce, pour les six types d'inférences. Seules les saturations supérieures ou égales à .4 en valeur absolue sont soulignées. Les types d'inférence « Résolution de problème » (facteur 1) (eigenvalue = 1,5, saturation=0,855), But (facteur 2, eigenvalue = 1,4, saturation=0,930), Événement déclencheur (facteur 3, eigenvalue = 1,3, saturation=0,917) et Solution (facteur 4, eigenvalue=1,2, saturation=0,867) sont des sources de variance presque indépendantes. Elles apportent donc des informations différentes. Les types d'inférence « Réponse interne » et « Prédiction » sont associés à plusieurs facteurs dont l'information est déjà contenue dans les quatre types d'inférence précédents. Selon l'analyse en composantes principales, ces deux types sont plus hétérogènes et conséquemment plus difficiles à préciser conceptuellement. Ces deux types d'inférences pourraient également partager des sources de variance avec les autres types de questions posées. En effet, la « Réponse Interne » partage vraisemblablement des sources de variance avec « Résolution de problème », « But » et « Solution » alors que la « Prédiction » pourrait partager des sources de variance avec « Événement déclencheur » et « Résolution de problème ».

Validité concurrente. Les résultats obtenus par les enfants aux trois tâches sont présentés dans le Tableau 6. Les résultats montrent une forte corrélation de Pearson ($r(119) = 0,77$; $p<.001$) entre le nouvel outil ÉCIR et la tâche expérimentale *Petit cochon s'est perdu*. Également, ils partagent 58% de variance commune. Il existe une corrélation moindre, quoique modérée, entre l'ÉCIR et l'ÉVIP-A, soit de $r(119) = 0,43$, $p<.001$ et où la part de variance commune est de 18%.

Fidélité inter-juge de la grille de codification. La fidélité inter-juge de l'utilisation de la grille de codification a été mesurée à deux reprises. La première mesure a porté sur la classification des scores obtenus par les enfants à la tâche. Un document compilant toutes les possibilités de réponses aux questions fournies par les 121 enfants a été

Tableau 5. Résultats de l'analyse factorielle après rotation varimax de l'ÉCIR

	Facteurs			
	1	2	3	4
Événement déclencheur	0,149	0,125	<u>0,917</u>	0,248
Réponse interne	<u>0,487</u>	<u>0,554</u>	0,144	<u>0,450</u>
But	0,162	<u>0,930</u>	0,161	0,148
Résolution du problème	<u>0,855</u>	0,160	0,155	0,325
Prédiction	<u>0,607</u>	0,348	<u>0,571</u>	0,087
Solution	0,291	0,201	0,273	<u>0,867</u>

ÉCIR : Évaluation de la Compréhension Inférentielle en Récit

Tableau 6. Résultats des trois groupes de participants à l'ÉCIR, à la tâche *Petit cochon s'est perdu* et à l'ÉVIP

Groupe	ÉCIR M (É-T)	Petit cochon s'est perdu M (É-T)	EVIP score brut M (É-T)
3 ans fréquentant un milieu de garde (N=30)	46,1% (18,4)	44,6% (15,8)	41,0 (13,0)
4 et 5 ans fréquentant un milieu de garde (N=37)	68,9% (11,1)	69,4% (15,0)	69,5 (16,7)
5 et 6 ans fréquentant la maternelle (N=54)	78,6% (7,1)	78,9% (8,9)	89,8 (13,8)

ÉCIR : Évaluation de la Compréhension Inférentielle en Récit

soumis à trois juges experts, soit deux orthophonistes ayant participé aux focus groupes et un chercheur expert dans le domaine. Les trois juges ont été invités à compléter une grille de codification des réponses en accordant la catégorie de qualité de réponses (A, B, C ou D) qu'ils jugeaient la plus appropriée pour chaque réponse obtenue, et ce, pour chaque question. Les décisions quant aux catégories de réponse à sélectionner ont été prises selon le nombre de juges en accord pour chaque question de l'histoire. Pour cette analyse, les statistiques AC1 de Gwet (pondération quadratique) pour chaque question de l'outil se situent entre 0,53, p<.001 (question 3) et 0,96 p<.001 (question 19), pour une moyenne de 0,83. Cette première analyse de fidélité inter-juge a permis de concevoir la version finale de la grille de codification.

Une seconde analyse inter-juge visait la vérification de cette version finale de la grille. Pour ce faire, deux examinateurs à l'aveugle ont codifié les réponses des enfants à l'aide de la version finale de la grille de codification, et ce, sur 20% des données (n = 25 enfants sélectionnés au hasard). Les valeurs des statistiques AC1 de Gwet avec la version finale de la grille de codification de la qualité des réponses des enfants sont plus élevées et se situent entre 0,92 p<.001 et 1,00, pour une moyenne de 0,99. Les statistiques AC1 de Gwet et les intervalles de confiance à 95% pour chacune des 19 questions de l'outil lors des deux analyses inter-juge sont présentées dans le Tableau 7.

Fidélité test-retest. La stabilité temporelle de l'outil à deux semaines d'intervalle a été réalisée sur 34 enfants sélectionnés au hasard, soit 28% de l'échantillon, basée sur les procédures employées par le *Wechsler Preschool and Primary Scale of Intelligence – Third Edition* (WPPSI-III) (Wechsler, 2002). Les résultats obtenus par les enfants lors des deux temps de mesure sont présentés dans le Tableau 8. Le coefficient de corrélation intra-classe (ICC) de type 2,1 entre les deux temps de mesure est très élevé, valeur relative de l'ICC (33) = 0,948, p<.001 (Shrout, 1998). Également, les résultats au deuxième temps de mesure sont plus élevés qu'au premier temps de mesure. Le test T pairé révèle effectivement que les scores au temps 2 (deux semaines post) s'avèrent significativement plus élevée (M =76,47) que ceux au temps 1 (M = 67,08), t(33) = -6,461, p< .001. Les enfants ont obtenu en moyenne 9,4% de plus au temps 2 que lors de la première administration.

Discussion

L'*Évaluation de la Compréhension Inférentielle en Récit* (ÉCIR) constitue un outil d'évaluation sur *iPad* de la compréhension de six types d'inférences causales ciblant les éléments de la grammaire de récit. Il a été conçu de manière à tenir compte d'éléments méthodologiques précédemment mis en lumière dans les écrits scientifiques (Bianco & Coda, 2002; Filiatrault-Veilleux et al., 2015; Gibbons et al., 1986; Kendeou et al., 2008; van den Broek et al., 2005; van Kleeck, 2008; Wenner, 2004). Cette étude visait à en déterminer la validité de contenu, de même que les qualités psychométriques. Elle a ainsi permis de démontrer que l'outil est valide et fidèle pour mesurer cette habileté chez les enfants âgés de 3 à 6 ans.

Validité de contenu l'outil. L'outil a été validé à l'aide d'orthophonistes et d'un chercheur expert dans le domaine. Cette étape de validation de contenu a permis d'optimiser l'outil en cours de création, tant sur le plan du matériel employé (structure narrative du récit, questions posées et illustrations qui accompagnent l'histoire) que de sa fonctionnalité et son applicabilité sur *iPad*. Compte tenu des résultats obtenus lors des focus groupes, des modifications importantes (ex. : contenu de l'histoire et des illustrations, formulation des questions et paramètres de l'application informatique) ont été réalisées afin de le rendre le plus adéquat et fonctionnel possible pour une utilisation auprès de jeunes enfants.

Tableau 7. Statistiques AC1 de Gwet et intervalle de confiance à 95% pour chaque question lors des deux analyses inter-juges

No. questions	Trois experts lors de la conception de la grille de codification		Deux examinateurs à l'aveugle qui utilisent la version finale de la grille	
	AC1 de Gwet	IC à 95%	AC1 de Gwet	IC à 95%
1	0,84*	0,78 – 0,91	0,99*	0,98 – 1,00
2	0,82*	0,59 – 1,00	0,98*	0,93 – 1,00
3	0,53*	0,21 – 1,00	1,00*	1,00 – 1,00
4	0,82*	0,67 – 0,98	0,99*	0,94 – 1,00
5	0,86*	0,67 – 1,00	1,00*	1,00 – 1,00
6	0,91*	0,82 – 1,00	0,96*	0,91 – 1,00
7	0,95*	0,90 – 1,00	0,94*	0,76 – 1,00
8	0,81*	0,50- 1,00	1,00*	1,00 – 1,00
9	0,80*	0,45 – 1,00	0,99*	0,96 – 1,00
10	0,93*	0,84 – 1,00	1,00*	1,00 – 1,00
11	0,88*	0,72 – 1,00	0,98*	0,94 – 1,00
12	0,86*	0,75 – 0,98	0,99*	0,97 – 1,00
13	0,87*	0,64 – 1,00	1,00*	1,00 – 1,00
14	0,85*	0,58 – 1,00	0,99*	0,97 – 1,00
15	0,70*	0,11 – 1,00	0,98*	0,95 – 1,00
16	0,84*	0,67 – 1,00	0,96*	0,88 – 1,00
17	0,86*	0,65 – 1,00	0,98*	0,94 – 1,00
18	0,86*	0,74 – 0,97	0,97*	0,91 – 1,00
19	0,96*	0,86 – 1,00	0,95*	0,87 – 1,00

**p<,001*

Tableau 8. Résultats obtenus par les 34 enfants sélectionnés au hasard au test-retest à deux semaines d'intervalle

Groupe	ÉCIR M (E-T)		
	Temps 1	Temps 2	Différence de moyenne (E-T)
3 ans fréquentant un milieu de garde (n=8)	41,5% (22,8)	53,2% (21,6)	+11,7% (11,8)
4 et 5 ans fréquentant un milieu de garde (n=10)	73,2% (14,1)	80,6% (11,1)	+7,4% (7,5)
5 et 6 ans fréquentant la maternelle (n=16)	76,0% (7,6)	85,5% (6,4)	+9,5% (7,3)
T (n=34)	67,1% (20,0)	76,47% (18,08)	+9,4% (8,5)

Qualités psychométriques. En ce qui concerne la validité de construit, nos résultats indiquent que l'ensemble des variables mesurées, soit les différents types d'inférences, forme un ensemble cohérent permettant de mesurer adéquatement la compréhension inférentielle chez les enfants de 3 à 6 ans dans un contexte de récit (Tabachnick & Fidell, 2001). Bien que l'analyse factorielle ait permis de distinguer conceptuellement plus facilement quatre types d'inférences, soit les tentatives de résolution de problème, le but, l'événement déclencheur et la solution, elle met en évidence que la réponse interne et la prédiction partagent des sources de variance avec d'autres types d'inférences. Comme les six inférences mesurées sont de type « causales », elles requièrent par conséquent la compréhension d'un lien de causalité entre des événements (Bianco & Coda, 2002; Dupin de Saint-André, 2008; Graesser et al., 1994; Johnson & von Hoff Johnson, 1986; Lefebvre et al., 2012; Richards & Anderson, 2003). Ceci s'avère particulièrement vrai pour ces deux types d'inférences plus difficiles à distinguer conceptuellement. À titre d'exemple, dans la réponse interne, afin de bien saisir l'émotion ressentie par le personnage, la compréhension du but de l'histoire, soit la cause de l'émotion, est essentielle. La compréhension des tentatives de résolution du problème et de la solution de l'histoire sont également liées à l'émotion du personnage (par ex. : Pinson est content, parce qu'il a une nouvelle maison et que ses parents sont revenus). De même, l'inférence de type « prédiction » est une inférence causale liée à l'événement déclencheur et aux tentatives de résolution du problème. L'enfant ayant besoin de capacité prédictive pour y arriver. Ainsi, dans l'ÉCIR, ces deux types d'inférences apparaissent davantage dépendants et impliquent des processus déjà contenus dans les inférences précédentes.

La validité concurrente démontre quant à elle que l'outil permet d'obtenir des scores fortement corrélés à ceux d'une tâche expérimentale, *Petit cochon s'est perdu* (Desmarais et al., 2013a), mesurant un construit similaire. Il est à noter que puisque *Petit cochon s'est perdu* ne comprenait que 10 questions inférentielles, était administré en format papier et qu'il mesurait des inférences portant à la fois sur le récit et les connaissances du monde, la corrélation entre les deux ne pouvait être parfaite. D'autre part, la valeur de la corrélation obtenue entre le nouvel outil et le vocabulaire réceptif était plus faible, s'expliquant entre autres par le fait que d'autres habiletés langagières et cognitives sont impliquées dans la compréhension d'inférences, en plus du niveau de vocabulaire réceptif (Florit, Roch, & Levorato, 2011; Kendeou et al., 2008).

À partir d'une démarche réalisée en collaboration avec des experts dans le domaine, il a été possible de concevoir un outil qui permet de capter la performance des enfants au construit complexe qu'est la compréhension inférentielle en contexte de récit. En effet, tout en tenant compte du fait que les réponses s'appuient sur un processus de réflexion et non pas sur une décision oui/non, l'outil propose une échelle de codification valide s'appuyant sur un continuum de qualité des réponses en fonction d'une cible. L'ÉCIR démontre aussi de bonnes qualités psychométriques quant à la fidélité. Grâce à une démarche minutieuse, la fidélité inter-juge de la grille de codification créée a atteint un niveau très élevé. Il faut toutefois rappeler que cette dernière a été évaluée dans un deuxième temps auprès de deux juges seulement, plutôt que trois, ce qui augmente nécessairement la valeur obtenue. Cependant, de façon générale, les mesures obtenues tendent à démontrer que la compréhension inférentielle chez les jeunes enfants peut être

documentée de façon valide et fidèle, quand la démarche employée tient compte des caractéristiques du construit.

Finalement, l'outil a démontré une bonne stabilité temporelle à deux semaines d'intervalle. Étant donné qu'il s'agissait de la même histoire, les enfants ont obtenu un résultat significativement plus élevé au deuxième temps de mesure. Ceci n'est pas surprenant compte tenu de l'effet connu et documenté dans les écrits scientifiques de la lecture répétée d'une même histoire (Morrow, 1988; Verhallen et al., 2006).

Forces et limites de la présente étude. Bien que la compréhension inférentielle soit un construit complexe à définir et, par le fait même, difficile à mesurer, l'ÉCIR permet de répondre à ce besoin. En effet, il a permis de dégager des résultats valides et fidèles avec des enfants de 3 à 6 ans dans un contexte narratif. Qui plus est, cette étude mènera sous peu à la diffusion de cet outil d'évaluation, un apport considérable à la pratique clinique franco-québécoise auprès de la jeune clientèle pédiatrique (Bouchard et al., 2009). L'ÉCIR permettra aux orthophonistes et autres professionnels ayant une expertise en développement langagier de l'enfant de mesurer une habileté langagière démontrée essentielle à la compréhension en lecture (Cain & Oakhill, 2007; Ferreiro & Taberoski, 1982; Joffe et al., 2007; Kontos & Wells, 1986; van Kleeck, 2008) et par le fait même, à la réussite éducative du jeune enfant. Effectivement, il faut souligner l'unique et relativement indépendante contribution de la compréhension inférentielle sur le développement de la compréhension en lecture (Bianco et al., 2010; Kendeou et al., 2009; NICHD, Early Child Care research Network, 2005). Les habiletés en compréhension orale chez les jeunes enfants, dont la compréhension inférentielle, jouent un rôle de premier plan dans l'apprentissage et la réussite en compréhension en lecture à l'âge scolaire (Cain, Oakhill, & Elbro, 2003; Kintsch & Kintsch, 2005; Trabasso & Wiley, 2005; van den Broek et al., 2005; Zwaan & Singer, 2003). Il importe donc d'outiller les orthophonistes dans l'évaluation et la prévention des enfants, et ce, dès leur plus jeune âge.

Cependant, une limite importante de ce projet de recherche concerne la représentativité de l'échantillon. En effet, comme l'échantillonnage n'est pas représentatif de l'ensemble des enfants québécois de 3 à 6 ans, les données développementales obtenues ne permettent de proposer des normes développementales. Une utilisation de type critérié visant à décrire le développement des enfants est donc conseillée.

Perspectives futures : l'outil d'évaluation, utile en clinique comme en recherche. L' ÉCIR a été conçu afin d'être utile non seulement en recherche, mais également dans les milieux cliniques. En recherche, ce nouvel outil pourrait contribuer à uniformiser les méthodes employées pour pallier la grande diversité des outils actuellement utilisés (Filiatrault-Veilleux et al., 2015; Florit et al., 2011; Hudson & Slackman, 1990). En contexte clinique, plus précisément auprès des petits, les orthophonistes pourront désormais avoir accès à un outil valide et fidèle permettant d'évaluer et de documenter le niveau de développement des enfants. Également, il pourrait être pertinent de poursuivre la validation de cet outil auprès d'un plus grand échantillon et d'autres populations, tels qu'auprès d'enfants de familles à plus faible revenu ainsi qu'auprès d'autres types de clientèles d'enfants (ex. : déficience langagière ou trouble du spectre de l'autisme).

Conclusion

L'ÉCIR a été conçu selon une procédure rigoureuse et structurée et ses qualités psychométriques confirment qu'il est fidèle et valide. Malgré le fait que l'évaluation de la compréhension inférentielle demeurera un défi pour les orthophonistes, ce nouvel contribue à la pratique clinique en proposant une démarche standardisée permettant de décrire la compréhension inférentielle du jeune enfant. Cet outil pourra aussi être utilisé en recherche dans le but de poursuivre le développement des connaissances sur la compréhension inférentielle pendant la petite enfance.

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Notes marginales

[1] Conçu à partir du livre pour enfant *Petit cochon s'est perdu* (Amery & Cartwright, 2001) en s'inspirant des travaux réalisés par van Kleeck et al. (2006).

Note des auteurs

Les demandes au sujet de cet article devraient être adressées à Chantal Desmarais, Ph. D., orthophoniste et professeure titulaire à l'Université Laval, 1050, avenue de la Médecine, Québec, Qc, G1V 0A6. Courriel : chantal.desmarais@rea.ulaval.ca.

Annexe

Résumé de l'histoire de l'ÉCIR

Le personnage principal de l'histoire est un oiseau qui se nomme Pinson. Au début de l'histoire, ses parents quittent le nid à la recherche de nourriture et Pinson reste seul. Soudain, un orage arrive et son nid tombe et se brise. Pinson est mouillé et a peur. Il part donc à la recherche d'un abri pour se protéger. Il rencontre alors trois animaux (une moufette, un porc-épic et un castor) qui tentent de l'aider, mais qui n'y arrivent pas. À la fin, un petit garçon construit une nouvelle maison pour Pinson et ses parents.

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MOTS CLÉS

OUTILS D'ÉVALUATION

ORTHOPHONIE

VALIDATION

NORMALISATION

FRANCO-QUÉBÉCOIS

Recension des outils franco-québécois pour l'évaluation des troubles du langage et de la parole

Inventory of Quebec French Tools for Assessing Speech and Language Disorders

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Membres de l'axe 4 du REPAR

Abrégé

La démarche d'évaluation des troubles de la communication est un élément clé de la pratique des orthophonistes. Lors de la collecte d'informations, les orthophonistes doivent utiliser des outils d'évaluation qui leur permettent de porter un jugement clinique objectif à propos des capacités de communication de leur client. La sélection de ces outils est donc une étape déterminante dans la démarche d'évaluation. Cependant, les outils disponibles en français sont nettement moins nombreux par rapport à ceux disponibles en anglais, sans parler du nombre encore plus restreint de ceux spécialement adaptés à la population franco-québécoise. Le but général de la présente étude est d'effectuer une recension la plus rigoureuse possible des tests existants en orthophonie afin d'identifier ceux qui ont été soumis à un processus de vérification des propriétés de mesure et de normalisation dans les domaines de la parole, du langage oral et du langage écrit tant chez l'enfant que chez l'adulte franco-québécois. Bien que les résultats de l'étude, présentés pour chacune des clientèles et des domaines, fassent part du peu de tests existants selon ces critères, cette recension permet de dresser un tableau représentatif et précis des outils disponibles pouvant être utilisés par les orthophonistes selon les différentes clientèles.

Abstract

The evaluation process of communication disorders is a key element of the speech-language pathologists' practice. When gathering information, speech-language pathologists must use assessment tools that allow them to make an objective clinical opinion about the communication abilities of their client. The selection of such tools is, therefore, a critical step in the evaluation process. However, the tools available in French are clearly fewer than to those in English, not to mention the even more limited number of those tailored to the needs of Quebec's French-speaking population. The overall goal of this research is to build the most thorough inventory of existing speech and language tests in order to identify those that have already been put through a process for testing the measurement and standardisation properties of speech, and oral and written language in both French-Quebecer children and adults. Even though the results of the study, separated by client-groups and subject area, are made up of only a limited number of tests that meet this criteria, this inventory makes it possible to build a representative and precise picture of the tools available for speech-language pathologists to use for client with differing abilities.

Introduction

La démarche d'évaluation des troubles de la communication est un élément clé de la pratique des orthophonistes (American Speech-Language-Hearing Association [ASHA], 2014). Dans le cadre de leur travail, ces professionnels consacrent une importante partie de leur temps à collecter, analyser et interpréter une grande quantité d'informations provenant de diverses sources. Cette démarche permet de caractériser l'état de la communication du client, ainsi que de mesurer et comparer les capacités langagières et de parole à celles d'individus du même groupe. Bien que les actions cliniques associées à la démarche d'évaluation varient selon les domaines (langage, parole), les clientèles (enfants, adultes) et les milieux de pratique (ex. centres hospitaliers, centres de réadaptation, commissions scolaires), elles poursuivent des buts communs, soit établir le profil communicatif du client ainsi que ses forces, déterminer les composantes atteintes et le niveau de sévérité, établir des recommandations et/ou objectifs cohérents et poser une conclusion (Owen, Metz & Farinella, 2011). S'inscrivant dans une pratique clinique orthophonique appuyée sur les preuves scientifiques, le clinicien utilise activement et consciencieusement les connaissances issues de la recherche en conjonction avec son expertise clinique et les aspects liés à la personne qui le consulte (préférences, culture, valeurs, besoins, etc.) (Sackett, Rosenberg, Gray, Haynes & Richardson, 1996). Il garantit ainsi la validité de son évaluation et la pertinence de ses interventions (ASHA, 2014). Lors de la collecte d'informations, les cliniciens doivent utiliser des outils d'évaluation leur permettant de dresser un portrait le plus juste et complet possible des habiletés communicatives du client. La sélection de ce matériel, qui doit être adapté au langage, à la culture et à la condition du client (New York State Department of Health, 2002), est donc une étape déterminante dans la démarche d'évaluation. Plusieurs activités peuvent être utilisées lors de la démarche d'évaluation : activités informelles, analyse de situation famille-client, observations de comportements, instruments critériés, tests normés, etc. (Sackett et al., 1996) Or, les outils disponibles en français sont peu nombreux et plusieurs ne sont pas adaptés à la population franco-québécoise, ou encore, ne démontrent pas de propriétés de mesures adéquates (Gaul Bouchard, Fitzpatrick & Olds, 2009). Afin de pallier le manque d'outils d'évaluation disponibles, certains cliniciens empruntent des tests européens, adaptent ou traduisent des tests déjà existants en anglais, ou élaborent des outils qualifiés « d'outils maison » (Garcia & Desrochers, 1997). Bien que ce matériel permette de recueillir certaines informations pertinentes sur les capacités du client, les propriétés de mesure de ces outils sont souvent insuffisantes ou inexistantes et aucune donnée normative n'est disponible spécifiquement pour la population franco-québécoise. Cette situation peut ainsi engendrer une plus grande marge d'erreur dans l'interprétation des données et l'établissement de la conclusion orthophonique (Garcia & Desrochers, 1997). Les biais associés aux traductions ou aux adaptations de tests ne suivant pas un processus rigoureux peuvent mener à trois principaux écueils (Gaul Bouchard et al., 2009). D'abord, les différences linguistico-culturelles peuvent créer des divergences de vocabulaire (ex. régionalismes), pouvant mener à une mauvaise interprétation des résultats du client. À cet effet, les réponses acceptées dans chacun des tests doivent tenir compte des réalités linguistiques et culturelles de la population à laquelle il est destiné. Ensuite, l'équivalence linguistique avec la version originale doit être assurée dans le cas d'une adaptation ou d'une traduction directe d'un outil. En effet, le processus d'élaboration d'un test est effectué de façon précise et réfléchie, notamment en ce qui a trait aux paramètres psycholinguistiques sélectionnés (ex. fréquence, longueur des mots), à la longueur du texte ou encore au degré de difficulté des structures grammaticales. L'outil traduit se doit donc d'être comparable à la version originale. Enfin, un outil doit être normé auprès de la population auprès de laquelle il sera utilisé. Si ces principes d'utilisation des tests normés ne peuvent pas être respectés, l'interprétation des résultats doit demeurer qualitative, car les scores bruts obtenus ne sont comparables à ceux d'aucun échantillon de référence (Lefebvre & Trudeau, 2005). En résumé, les processus de traduction ou d'adaptation d'outils d'une langue ou d'une culture à une autre doivent être effectués avec rigueur sur le plan scientifique, selon des règles strictes, afin d'assurer l'équivalence des deux versions (Geisinger, 2003). Sur le plan clinique, le code déontologique de l'Ordre des orthophonistes et audiologistes du Québec (OOAQ, 2013) soutient également que les membres doivent faire une interprétation prudente des résultats et éviter toute éventualité de fausse interprétation lors de la transmission d'informations. À cette fin, il est recommandé d'utiliser des outils d'évaluation possédant des qualités de mesures satisfaisantes et étant normés auprès de la population sélectionnée.

Propriétés de mesures et interprétation clinique

Plusieurs caractéristiques devraient être vérifiées pour confirmer la valeur d'un test, soit (1) la fidélité

(niveau de constance de la performance d'un usager au test), (2) la validité (capacité de l'outil à évaluer l'aspect/objet ciblé) et (3) la normalisation (résultats obtenus au test par un groupe de référence spécifique) (Lefebvre & Trudeau, 2005). Bien que le type et la sous-division des propriétés de mesure utilisées lors de l'élaboration des outils diffèrent selon les sources et/ou les domaines d'études, le présent article retient et rapporte les types de fidélité et validité jugés comme étant les plus utilisés dans les domaines de l'orthophonie.

D'abord, en ce qui a trait à la **fidélité** des tests dans le domaine de la communication, les outils font principalement l'objet des trois mesures suivantes : a) fidélité par consistance interne (indique si l'ensemble des items sélectionnés dans l'outil d'évaluation permet effectivement de mesurer une même dimension), b) fidélité par accord inter-juges (niveau de stabilité de différents évaluateurs dans leur attribution de résultats à un même client pour un même test) et c) fidélité par test-retest (niveau de constance des résultats obtenus par une même personne lors de deux administrations d'un même outil dans un intervalle de temps donné) (Anastasi & Urbina, 1997). De plus, les outils d'évaluation font généralement l'objet de mesures quant à leur **validité** : a) validité de surface (domaine d'évaluation identifiable par une personne qui ne connaît pas le test), b) validité de contenu (contenu de l'outil approprié et représentatif du construit devant être évalué), c) validité concordante (capacité du test à évaluer adéquatement le construit mesuré, comparé à un critère de référence externe reconnu), d) validité prédictive (capacité du test à prédire un score futur d'une autre mesure d'un domaine relié) et e) validité de construit (concordance avec des fondements théoriques guidant l'élaboration du test) (Lefebvre & Trudeau, 2005). Enfin, les normes qui accompagnent un test sont essentielles lorsque l'objectif poursuivi est de comparer les résultats du client avec ceux obtenus par un groupe représentatif de ceux à qui l'utilisation du test est destinée, soit à l'échantillon de **normalisation** (Anastasi & Urbina, 1997; Lefebvre & Trudeau, 2005). Cet échantillon doit par ailleurs être suffisamment imposant pour permettre d'établir la courbe normale. Un test normé permet aux professionnels de déterminer si un client obtient des résultats significativement sous la norme ou non dans une évaluation, et donc, de statuer sur la présence ou l'absence d'un problème (Lefebvre & Trudeau, 2005). Sans normes, l'interprétation des résultats doit être effectuée de manière qualitative. En somme, les outils d'évaluation doivent être sélectionnés judicieusement en fonction du but de l'évaluation, des caractéristiques du client et des propriétés de mesures associées au test. Le protocole de passation doit par ailleurs être rigoureusement respecté afin que les résultats du client soient comparables à l'échantillon de normalisation (Lefebvre & Trudeau, 2005).

La présente étude

La réalité de la pratique orthophonique franco-canadienne en matière d'évaluation a été documentée jusqu'à maintenant par deux études, publiées respectivement en 2006 et 2009. La première, menée par le *Groupe de recherche sur l'évaluation des troubles de la communication* (GRETCOM), met en relief que peu d'outils français sont utilisés en ce qui concerne la clientèle pédiatrique, que les cliniciens utilisent fréquemment des adaptations françaises d'outils d'évaluation initialement conçus en anglais et qu'ils sont généralement insatisfaits en ce qui a trait à la disponibilité des outils d'évaluation en français (Garcia, Paradis, Sénécal & Laroche, 2006). La seconde étude, qui s'intéressait aux outils d'évaluation du langage et de la parole adaptés pour les enfants franco-canadiens, montre que peu d'entre eux possèdent des propriétés psychométriques satisfaisantes. À notre connaissance, aucune étude n'a évalué les caractéristiques métrologiques des tests utilisés chez l'adulte franco-québécois. La création d'un répertoire actualisé des outils d'évaluation, facilement accessible aux orthophonistes, s'insère et se justifie donc tout à fait dans le développement d'une pratique clinique appuyée sur les faits scientifiques, un incontournable promu tant par le milieu universitaire que par les organismes professionnels, afin d'assurer la qualité des services aux clients. Le but général de la présente étude est d'effectuer une recension des tests existants en orthophonie pour la clientèle franco-québécoise, plus spécifiquement dans les domaines du langage oral et écrit ainsi que de la parole chez l'enfant et l'adulte. Les objectifs spécifiques sont :

- Identifier et répertorier les tests valides, fidèles ou normés en franco-québécois dans le domaine du langage oral et écrit pour les clientèles pédiatrique et adulte.
- Identifier et répertorier les tests valides, fidèles ou normés en franco-québécois dans le domaine de la parole pour les clientèles pédiatrique et adulte.

MÉTHODOLOGIE

Seuls les tests datant de 1980 à 2014 ont été considérés dans la recension. Étant donné l'avancement rapide des connaissances scientifiques dans les domaines du langage et de la parole, les outils créés à une date antérieure ont été jugés désuets. La construction du

répertoire des tests existants s'est concrétisée en plusieurs étapes :

a) Sondage : Un sondage a d'abord été réalisé auprès des professeurs et chercheurs du domaine de l'orthophonie au Québec ainsi que des cliniciens œuvrant dans différents milieux, afin de recenser les outils d'évaluation couramment utilisés. Trente-cinq professionnels travaillant dans le domaine de la communication et étant membres de l'Ordre des Orthophonistes et Audiologistes du Québec (OOAQ) ont participé au sondage. Les répondants sont répartis selon les différents milieux de pratique : commissions scolaires, centres hospitaliers, centres de réadaptation, centres de santé et de services sociaux, secteurs privés et universités. Le sondage comprenait quatre catégories de questions afin d'identifier les outils utilisés pour évaluer (1) le langage oral auprès de la clientèle pédiatrique, (2) le langage écrit auprès de la clientèle pédiatrique, (3) le langage oral et écrit auprès de la clientèle adulte et (4) les aspects de la parole auprès des populations pédiatriques et adultes. Pour chacune de ces catégories, un choix fermé était d'abord donné (« *Veuillez cocher tous les outils d'évaluation que vous utilisez parmi les suivants…* »). Un espace était ensuite alloué afin que les répondants puissent préciser les autres outils ou autres versions des outils utilisés, dans le cas où ils n'avaient pas été listés dans la question précédente.

b) Recherche bibliographique : une recherche non-systématique a été effectuée à partir des banques de données CINAHL Plus, Medline et Pubmed en utilisant les mots clés suivants, en français et en anglais : évaluation, test, langage, orthophonie, normalisation, validation, français/Québec. Cette recherche a permis de recenser plusieurs outils et de vérifier différentes informations (c.-à-d. validation ou normalisation franco-québécoise) concernant les différents tests, en plus de préciser leur référence à l'intention des cliniciens.

c) Consultation de tests : Tous les tests ont été consultés pour relever davantage d'informations, notamment concernant la méthodologie de l'élaboration des outils et les procédures. Pour certains tests, le processus de validation était inclus dans l'outil directement et aucun article n'existait sur ce processus. L'information sur les qualités de mesure a donc parfois été dégagée uniquement à partir des manuels.

RÉSULTATS

Cent dix-sept tests du volet « orthophonie » ont d'abord été recensés à la suite du sondage (voir figure 1 pour un survol) : quarante-six outils pour l'évaluation du langage oral – clientèle pédiatrique –, 29 outils pour l'évaluation du langage écrit – clientèle pédiatrique –, 31 outils pour l'évaluation du langage oral et écrit – clientèle adulte –, et 13 outils pour l'évaluation des aspects de la parole – clientèle pédiatrique et adulte. À la suite de la recherche bibliographique et de la consultation de chacun des tests, seulement 23 de ces tests avaient suivi un processus de vérification de leurs propriétés de mesure et de normalisation en franco-québécois. La liste des tests est rapportée dans les tableaux 1 à 4, selon les domaines : (1) langage (a. langage oral chez la clientèle d'âge préscolaire – 0-5 ans–, b. langage oral et écrit chez la clientèle d'âge scolaire, c. langage oral et écrit chez la clientèle adulte), et (2) parole. Pour chacun des tests, différentes informations sont fournies : nom du test, référence, composantes évaluées, population cible, références concernant la validation et/ou la normalisation franco-québécoise.

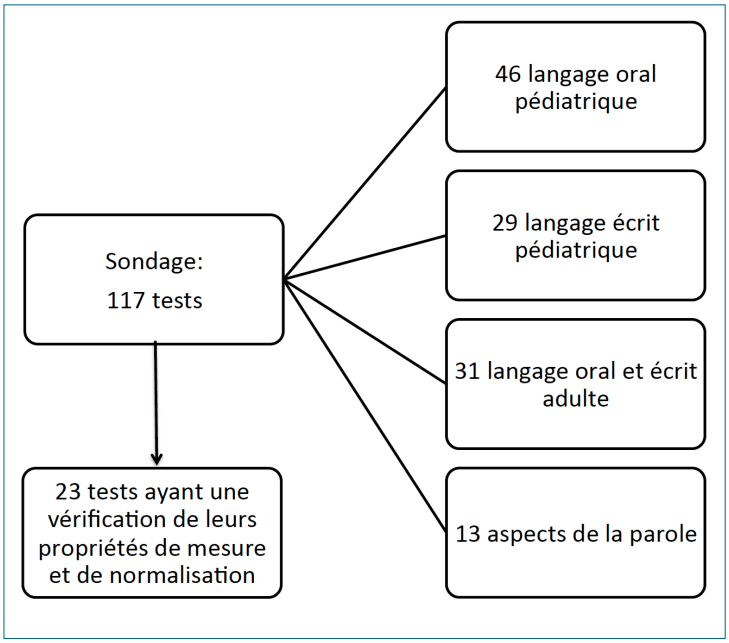

Figure 1. Résumé des résultats du sondage et des tests identifiés.

1. Langage

a) Langage oral chez la clientèle d'âge préscolaire

Le Tableau 1 présente les tests validés ou normés en franco-québécois qui sont disponibles pour évaluer les enfants de 0 à 5 ans, incluant les enfants qui fréquentent la maternelle, sur le plan du langage oral. Cette catégorie de tests inclut six outils (voir Tableau 1).

Tableau 1. LANGAGE ORAL - CLIENTÈLE PÉDIATRIQUE

Nom du test	Composante(s) évaluée(s)	Population cible	Normalisation franco-québécoise	Propriétés de mesure
Inventaires MacArthur-Bates du développement de la communication (IMBCD) (Fenson et al., 1993, Trudeau, Frank & Poulin-Dubois, 1999)	Compréhension, vocabulaire réceptif et expressif, comportements de communication non verbale, combinaison de mots, formes grammaticales.	8 à 30 mois	Boudreault, Cabirol, Trudeau, Poulin-Dubois et Sutton (2007)	Boudreault et al. (2007)
Échelle de vocabulaire en images Peabody (ÉVIP) (Bracken, McCallum & Prasse, 1984; Dunn, Thériault-Whalen, & Dunn, 1993)	Vocabulaire réceptif.	2 ½ à 18 ans	Franco-canadiennes : 2 ½ à 18 ans (Dunn et al., 1993)[a] Franco-québécoises : données normatives préliminaires auprès d'enfants de 4; 6, 5; 0 et 5; 6 ans (Thordardottir, Keheyia, Lessard, Sutton & Trudeau, 2010)	Dunn et al. (1993)
Test de dénomination Expressive One Word Picture Vocabulary Test – Revised (EOWPVT-R) (Gardner, 1990; Groupe coopératif en orthophonie, 1995)	Vocabulaire expressif.	2 à 18 ans	Maternelle à la 2e année du primaire (Groupe coopératif en orthophonie, 1995)	n/d
Épreuve de compréhension du langage Carrow – Woolfolk (Groupe coopératif en orthophonie, 1999; Thordardottir et al., 2010)	Compréhension de : - classes de mots et relations - morphèmes grammaticaux - phrases complexes.	3 à 9 ans (version originale)	Maternelle à la 2e année du primaire (Groupe coopératif en orthophonie, 1999); Données normatives préliminaires auprès d'enfants de 4; 6, 5; 0 et 5; 6 ans (Thordardottir et al., 2010)	n/d
Évaluation clinique des notions langagières fondamentales® – version pour francophones du Canada (CELF-CND-F) (Wiig, Secord, Semel, Boulianne & Labelle, 2009)	Langage expressif et réceptif (structure et contenu du langage), mémoire.	4 à 16 ans	« Exécutions de directives, répétition de nombres » Données normatives préliminaires auprès d'enfants de 4; 6, 5; 0 et 5; 6 ans (Thordardottir et al., 2010)	Wiig, et al. (2009)
Children's Communication Checklist-2 (CCC-2) (Bishop, 2006; Vézina, Samson-Morasse, Gauthier-Desgagné, Fossard & Sylvestre, 2011)	Habiletés langagières, comportements pragmatiques.	4 à 16 ans	n/d	Vézina et al. (2011)

[a]Normalisation franco-canadienne contredite par Godard et Labelle (1995).

b) Langage oral et écrit chez la clientèle d'âge scolaire

Le Tableau 2 présente les tests validés ou normés en franco-québécois qui sont disponibles pour évaluer les enfants d'âge scolaire sur le plan du langage oral et écrit. Cette catégorie de tests inclut huit outils, dont cinq chevauchent également la clientèle d'âge préscolaire (voir Tableau 2).

c) Langage oral et écrit chez la clientèle adulte

Le Tableau 3 présente les tests validés ou normés en franco-québécois qui sont disponibles pour évaluer les adultes ou personnes âgées présentant un trouble acquis (incluant accidents vasculaires cérébraux, traumatismes crâniens, lésions cérébrales droites et maladies neurodégénératives) sur le plan du langage oral et écrit. Cette catégorie de tests inclut douze outils (voir Tableau 3).

Tableau 2. LANGAGE ORAL et ÉCRIT- CLIENTÈLE SCOLAIRE

Nom du test	Composante(s) évaluée(s)	Population cible	Normalisation franco-québécoise	Propriétés de mesure
Échelle de vocabulaire en images Peabody (ÉVIP) (Bracken et al., 1984; Dunn et al., 1993)	Vocabulaire réceptif.	2 ½ à 18 ans	Franco-canadiennes : 2 ½ à 18 ans (Dunn et al., 1993); Franco-québécoises : données normatives préliminaires auprès d'enfants de 4; 6, 5; 0 et 5; 6 ans (Thordardottir et al., 2010)	Dunn et al. (1993)
Test de dénomination Expressive One Word Picture Vocabulary Test-Revised (EOWPVT-R) (Gardner, 1990; Groupe coopératif en orthophonie, 1995)	Vocabulaire expressif.	2 à 18 ans	Maternelle à la 2e année du primaire (Groupe coopératif en orthophonie, 1995)	n/d
Épreuve de compréhension du langage Carrow – Woolfolk (Carrow-Woolfock, 1985)	Compréhension de : - classes de mots et relations - morphèmes grammaticaux - phrases complexes.	3 à 9 ans (version originale)	Maternelle à la 2e année du primaire (Groupe coopératif en orthophonie, 1999); Données normatives préliminaires auprès d'enfants de 4; 6, 5; 0 et 5; 6 ans (Thordardottir et al., 2010)	n/d
Évaluation clinique des notions langagières fondamentales® – version pour francophones du Canada (CELF-CND-F) (Wiig et al., 2009)	Langage expressif et réceptif, (structure et contenu du langage), mémoire.	4 à 16 ans	Sous-tests « Exécutions de directives, répétition de nombres », données normatives préliminaires auprès d'enfants de 4; 6, 5; 0 et 5; 6 ans (Thordardottir et al., 2010)	
Children's Communication Checklist-2 (CCC-2) (Bishop, 2006; Vézina et al., 2011)	Habiletés langagières, comportements pragmatiques.	4 à 16 ans	n/d	Vézina et al. (2011)

Test de rendement individuel de Wechsler – deuxième édition-version pour les francophones du Canada (WIAT-II CND-F) (Wechsler, 2005, 2008)	Identification de mots/orthographe, compréhension de lecture/ expression écrite.	6 à 29 ans	Franco-ontarienne (Wechsler, 2005); Québécoise : 6 à 17 ans (Wechsler, 2008)	Wechsler (2008)
La Forme Noire (Maeder, 2010)	Rapidité de lecture, compréhension écrite.	9 à 12 ans	Maeder (2010)	Maeder (2010)
Test de rendement pour francophones - version canadienne (TRF) (Sarrazin, 1995)	Vocabulaire, compréhension de l'écrit, opérations arithmétiques, résolution de problèmes, orthographe.	Adolescents	Franco-canadienne (du Québec et hors Québec) (Sarrazin, 1995)	Sarrazin (1995)

Tableau 3. LANGAGE ORAL ET ÉCRIT – CLIENTÈLE ADULTE

Nom du test	Composante(s) évaluée(s)	Population cible	Normalisation franco-québécoise	Propriétés de mesure
Protocole Montréal-Toulouse d'examen linguistique de l'aphasie (MT86-1B) (Nespoulous et al., 1992)	Production et compréhension orales et écrites.	Adultes	19-49 ans, 50-69 ans, 70-87 ans (Béland & Lecours, 1990; Béland, Lecours, Giroux & Bois, 1993)	n/d
Échelle de communication Verbale de Bordeaux (ECVB) (Darrigrand & Mazaux, 2000; Darrigrand, Mazaux, Duteilh, Koleck & Pradat-Diehl, 2000)	Communication fonctionnelle.	Adultes	n/d	Faucher, Maxès-Fournier, Ouimet et Macoir (2009)
Fluence formelle et sémantique (Fontaine & Joubert, 2010a)	Fluence verbale.	Adultes et personnes âgées	60-69 ans, 70-79 ans, 80 ans et plus (Fontaine & Joubert, 2010a)	n/d
Test Français de Répétition de Phrases (TEFREP) (Bourgeois-Marcotte, Wilson, Forest & Monetta, 2015)	Capacité de répétition de phrases.	Adultes	40-64 ans, 65 ans et plus (Bourgeois-Marcotte, Wilson et al., 2015)	Bourgeois-Marcotte, Wilson et al. (2015)

Batterie d'Évaluation de la Compréhension Syntaxique (BCS) (Bourgeois, Bergeron, Fossard, Desmarais & Lepage, 2010-2012)	Compréhension de phrases.	Adultes	n/d	Bourgeois et al. (2010-2012)
Language Screening Test – version Québécoise (LAST-Q) (Bourgeois-Marcotte, Monetta, Flamand-Roze & Denier, 2015)	Compréhension et expression orales.	Soins aigus post-AVC	40-59 ans, 60-79 ans (Bourgeois-Marcotte, Monetta et al., 2015)	n/d
Protocole Montréal d'Évaluation de la Communication (Protocole MEC) (Joanette, Ska & Côté, 2004)	Prosodie, lexique-sémantique, discours, pragmatique.	Adultes	30-49 ans, 50-64 ans, 65-85 ans (Joanette et al., 2004)	Joanette et al.(2004)
Protocole Montréal d'Évaluation de la Communication de Poche (PROTOCOLE MEC-P) (Ferré, Lamelin, Côté, Ska & Joanette, 2011)	Prosodie, lexique-sémantique, discours, pragmatique.	Adultes Soins aigus	18-35 ans, 36-60 ans, 60 ans et plus (Ferré et al., 2011)	Ferré et al. (2011)
Pyramids and Palm Trees Test (PPTT) (Howard & Patterson, 1992)	Système sémantique.	18 à 80 ans	19-39 ans, 40-59 ans, 60-69 ans, 70 ans et plus pour la modalité non-verbale (Callahan et al., 2010)	n/d
Bilingual Aphasia Test (BAT) (Adapté dans 65 langues différentes et 140 paires de langues spécifiques) (Paradis & Libben, 1987)	Communication orale.	Adultes bilingues	n/d	Paradis et Libben (1987)
Épreuve de compréhension écrite (Fontaine & Joubert, 2010b)	Compréhension écrite.	Adultes et personnes âgées	60-69 ans, 70-79 ans, 80 ans et plus (Fontaine & Joubert, 2010b)	n/d
Test de Compréhension de Textes (TCT) (Chesneau, 2012)	Compréhension de textes.	Adultes et personnes âgées	France et Québec : 16 à 80 ans (Chesneau, 2012)	n/d

2. Parole

Le Tableau 4 présente les tests validés ou normés en franco-québécois qui sont disponibles pour évaluer la parole. Cette catégorie de tests inclut deux outils, destinés à l'évaluation de la clientèle pédiatrique (voir Tableau 4). Aucun outil pour évaluer la parole d'un adulte n'a été identifié par notre recension.

DISCUSSION

Le but général de la présente étude était d'effectuer une recension des tests existants en orthophonie ayant suivi un processus de vérification de leurs propriétés de mesure et/ou normés en franco-québécois, dans les domaines du langage oral et écrit ainsi que de la parole chez l'enfant et l'adulte. Les résultats montrent

Tableau 4. PAROLE - CLIENTÈLE PÉDIATRIQUE ET ADULTE

Nom du test	Composante(s) évaluée(s)	Population cible	Normalisation franco-québécoise	Propriétés de mesure
Évaluation Sommaire de la phonologie chez l'enfant d'âge préscolaire (ESPP) (MacLeod, Sutton, Sylvestre, Thordardottir & Trudeau, 2014)	Phonologie.	Enfants d'âge préscolaire	Enfants de 20 à 53 mois, (MacLeod et al., 2014)	MacLeod et al. (2014)
Test de Dépistage Francophone de la Phonologie (TDFP) (Rvachew, Brosseau-Lapré & Paul, 2012)	Phonologie.	Enfants	Enfants de maternelle et de première année (Rvachew et al., 2012)	Rvachew et al. (2012)

qu'il existe six tests en franco-québécois pouvant être utilisés auprès de la clientèle préscolaire (0-5 ans), huit pouvant être utilisés auprès de la clientèle scolaire, douze auprès des adultes et deux dans le domaine de la parole. Les résultats de cette étude montrent qu'il existe peu de tests dont les propriétés de mesures ont été vérifiées ou qui ont été normés en franco-québécois et sur lesquels les orthophonistes cliniciens peuvent appuyer leur interprétation, et ce, auprès des différentes populations étudiées. De plus, à l'heure actuelle, plusieurs composantes de la communication ne peuvent être évaluées par aucun outil existant normé ou possédant des propriétés psychométriques satisfaisantes. Un défi de taille attend donc les orthophonistes et les chercheurs dans le domaine de la communication, afin de contribuer au développement d'une pratique clinique basée sur les évidences scientifiques, en développant des outils d'évaluation pertinents, fiables, valides et avec des normes établies pour la population franco-québécoise, permettant d'évaluer de façon juste les différentes composantes de la communication. Bien que les résultats de l'étude fassent part du peu d'outils d'évaluation comportant ces caractéristiques en franco-québécois, plusieurs outils cliniques demeurent intéressants même s'ils n'ont pas été inclus dans la recension. Ces outils peuvent avoir été exclus, car (1) ils ne répondaient pas aux critères de recension initiaux ou (2) parce que leurs propriétés de mesures ou données normatives sont présentement en cours de développement ou de vérification. Par exemple, un test destiné à la clientèle scolaire représentait de nombreux avantages, car il permet d'évaluer plusieurs composantes. L'outil Exalang est une batterie informatisée d'évaluation du langage oral et écrit ainsi que de certaines compétences transversales, disponible en quatre versions : 3-6 ans; 5-8 ans, 8-11 ans et 11-15 ans. Certaines propriétés psychométriques ont aussi été montrées (Thibault, Lenfant & Croteau, 2003; Thibault, Lenfant & Helloin, 2007). Cependant, l'élaboration a été effectuée en France et aucune donnée normative n'existe pour la population franco-québécoise. En ce qui concerne la clientèle adulte, le *Protocole d'évaluation neuropsychologique optimal* (PENO) s'avérait aussi intéressant. Cet outil évalue les gnosies, la mémoire, les praxies et le langage (Joanette, Poissant, Ska & Fontaine, 1990). Néanmoins, le processus de validation de l'outil n'a pas fait l'objet d'étude et le processus de normalisation a été effectué auprès de quatre ou cinq individus seulement.

Conclusion

Cette recension rigoureuse, bien qu'elle ne soit pas systématique au sens strict du terme et ne garantisse pas l'exhaustivité des outils, permet de dresser un tableau représentatif et précis des différents tests disponibles pouvant être utilisés par les orthophonistes auprès des différentes clientèles. La retombée escomptée est de faciliter la pratique clinique orthophonique en ce qui concerne la sélection des divers outils d'évaluation, qui doit être effectuée judicieusement et consciencieusement. Cette recension de tests et batteries, pour lesquels un processus métrologique

de vérification et une normalisation ont été réalisés, permet aux orthophonistes d'analyser rapidement les outils disponibles pour évaluer diverses composantes langagières chez les patients franco-québécois. Néanmoins, de nombreux aspects du langage oral ou écrit et de la parole ne sont pas couverts par les outils identifiés dans cette étude. Parmi les aspects les plus ignorés, notons le manque d'outils pour l'évaluation de la morphosyntaxe, du discours et des aspects pragmatiques de la communication. Il n'existe qu'un seul outil pour les adultes bilingues et aucun pour la clientèle pédiatrique et peu de tests permettent d'évaluer le langage écrit chez l'adulte. Au niveau de la parole, aucun outil n'est disponible pour évaluer les praxies et la dysarthrie, autant chez l'enfant que chez l'adulte. Finalement, il y a un manque au niveau des questionnaires portant sur la qualité de vie, la qualité de la communication ou le niveau de satisfaction de la communication pour le client et ses proches. Le développement d'outils d'évaluation validés, fiables et normés demeure donc à poursuivre.

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