Application of childhood apraxia of speech clinical markers to French-speaking children: A preliminary study

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In addition to the challenges outlined above, distinguishing between CAS and PD in French-speaking children has additional challenges: a lack of research on SSD in French-speaking children, and limited normative data and assessment tools. Specifically, there are few studies with normative data that describe typical phonological development and limited standardized, norm-referenced assessment tools. To our knowledge, three studies have investigated phonological development in Québécois-French speaking children (Paul & Rvachew, 2008; MacLeod et al., 2011; Rvachew et al., 2013) and two studies on France-French-speaking children (Aircart-de Falco & Vion, 1987; Vinter, 2001). Although these studies are essential for SLPs, they present some limitations: they are mostly based on picture naming of short words, some consonants are not mastered within the age range targeted, and two of these five studies present a very low number of participants (Vinter, 2001, N=13; Paul & Rvachew, 2008, N=10). Concerning standardized assessment tools, four tasks are available for Québécois French (TFP from Paul & Rvachew, 2008; ESPP from MacLeod et al., 2014; TDFP from Rvachew et al., 2012; and Test de Phonologie du Français from Bérubé et al., 2015) and eleven tasks are available for France French (for a review see Meloni, 2015). However, these tasks focus on picture naming, have restricted age ranges, and limited psychometric properties.

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Taken together, the lack of data on SSD in French-speaking children and limited normative data and assessment tools may explain why only 5% of French SLPs are confident in their diagnostic of CAS, and 30% are moderately confident (Masson, 2017). Diagnostic criteria are highly variable across clinicians (Forrest, 2003; Masson, 2017) and may include, but are not limited to, very poor intelligibility, persistence of speech difficulties despite intervention, error patterns specific to motor speech difficulties such as slow articulation rate, groping, intrusive pauses, and clinical impression.

Current Study

The research reviewed above highlighted the difficulty in differentiating between children with CAS and PD, and the particular challenge faced when working with French-speaking children. We will focus on two questions. First, do the English markers of CAS correspond to the clinical impression of French SLPs? We hypothesize that a subset of clinical markers from English will be also found in French, such as vowel and consonant errors or slow diadochokinetic rate, but other markers will not. In particular, we expect the following three markers to be less relevant for French-speaking children: (1) word length would be less likely to impact phoneme accuracy as they are more used to producing bi- or polysyllabic words; (2) voiceless consonants would be less likely to be replaced with voiced cognates, as pre-voicing is more demanding in terms of timing and coordination between the glottis and articulators; and (3) intrusive schwas would not be a common error pattern of cluster simplification, since schwa elision is frequent in the dialects of French studied, and cluster reduction is typically produced by omission of one segment rather than schwa insertion.

Method

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(6) A picture-naming task (PN) comprising 68 items, with consonants of French occurring in word initial, word-medial and word-final position, and in syllable-initial, syllable-final, and consonant clusters. In particular, this task included 25 polysyllabic words with three or four syllables.

The TYP children were assessed in a quiet room in their school during school hours by a graduate SLP student and trained graduate or undergraduate students in linguistics. Children with SSD were assessed at home or in the SLPs' clinic where they received treatment. The children with SSD were assessed by one of four trained SLPs involved in this research. On average, the assessment procedure took 40 minutes to complete. For children with SSD, the procedure was divided into two periods of 20 minutes, each one week apart. The children sat in front of a laptop screen on which pictures were displayed. The audio stimuli were presented

Regarding vowel errors, results slightly differ from consonant errors. On the PN task, the best-fitting model only includes group, with no effect of age. Multiple comparisons indicate that TYP children produced fewer vowel errors than the CAS group ($p<.001$) and the PD group ($p<.001$), and the difference between CAS and PD children is close to significance ($p=.05$). In sum, vowel errors seem to be a clinical feature for SSD, but they fail to distinguish between the PD and CAS groups in the PN task. Interestingly, in the non-word repetition task, this clinical marker does seem to distinguish between diagnoses. For NWR, the best-fitting model includes group, age, and their interaction. Multiple comparisons indicate that the CAS group produced more errors than the PD ($p=.002$) and TYP ($p<.001$) groups, but that the PD and TYP groups do not differ from each other. In this case, vowel errors on NWR could be a marker to identify the CAS group.

Overall, the number of schwa epentheses is very low. It seems that all groups produced very few tokens of schwa epenthesis. (e.g. mean number of occurrences = 0.75 per child for the CAS group in the 68 items of the PN task, 0.5 in the 16 items of the NWR task). In order to complement this finding, we looked for vowel epentheses and found them to be similarly infrequent (e.g. mean number of occurrences = 2.4 per child for the CAS group in the 68 items of the PN task, 1.25 in the 16 items of the NWR task).

Contrary to what was found for devoicing errors, TYP children almost never produced a prevoicing error, but these were sometimes observed for both the CAS and the PD groups. The results show an effect of diagnosis group only for the PN task, and an effect of diagnosis group, age, and their interaction for the NWR task. For prevoicing errors in PN, multiple comparisons reveal a difference between the CAS and TYP groups ($p < .001$) and between the PD and TYP groups ($p < .001$) but no difference between the two groups of children with SSD. However, for the NWR task, there is a significant difference between the CAS and PD groups ($p = .005$), while the PD and TYP groups have similar error rates ($p > .05$). Even though we observed significant differences, the total number of prevoicing errors is very low (with a mean number of 1.6 occurrences per child for the CAS group in the 68 items of the PN task, as opposed to the 13.4 occurrences of devoicing errors for the same group in the same task).

For the diadochokinetic task (Figure 4A), the linear model indicates a diagnosis group effect, but no effect of age. Further statistical tests on the difference between groups show that there is no significant difference between children with PD and TYP children, but a significant difference between children with CAS and TYP children ($p=.04$). These results suggest that children with CAS can be distinguished from TYP children on the DDK task, whereas children with PD cannot.

For the inconsistency score (Figure 4B), the linear model analyses on the PN task reveal a main effect of diagnostic group and age. Children with CAS and PD have similar inconsistency scores, but the two groups

(8) Word Length effect

Discussion

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Markers that seem to be a gradient of severity

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Contrary to what is usually described in English-speaking children with CAS, we observed very few tokens of schwa intrusion, vowel epentheses, or prevoicing errors. One explanation for the scarcity of schwa or vowel epentheses or prevoicing errors might be the small number of participants. Due to the very low prevalence of CAS and lack of confidence in diagnosis, recruiting participants was challenging. Another explanation might be language differences as proposed by Wong et al. (2020). Intrusive schwa is a segmental feature in Strand's 10-point checklist (Shriberg et al., 2012) and it is defined by a mid-central vowel appearing inside clusters. In our sample, the number of intrusive schwas was close to zero for children with SSD but also for children with typical development. We further examined vowel epentheses to identify if French-speaking children would use other intrusive vowels. Again, children, with SSD or with TYP, produced very few vowel epentheses. From these results, it seems that French-speaking children do not use this strategy to facilitate cluster production or word onsets. Data available on French phonological development indicate that typically-developing children tend to simplify clusters by deleting one of the consonants in the cluster. This phonological pattern is highly frequent for children between 24 and 29 months (around 30% of the possible contexts, Brosseau-Lapr et al., 2018). Alternatively, the lack of intrusive schwas could be due to the high variability in schwa production across French dialects where schwa is an optional vowel (Rose & Wauquier, 2007). Schwa realization (or non-realization) depends on factors such as segmental and suprasegmental structure or dialectal variation. In standard (non-southern France) French, many schwa deletions are observed and cluster simplification is achieved by segment deletion rather than schwa or vowel intrusion. The SSD children in this study seem to behave similarly. For these reasons, the marker "intrusive schwas" might not be a good marker to identify difficulties in segment coarticulation. The third feature that did not seem to apply to French-speaking children was prevoicing errors, which were rare in SSD children. In French, voiced stops are produced with pre-voicing, which requires a dissociation between laryngeal and supralaryngeal control, whereas, in voiceless stops, voice onset can be launched together with closure

Conclusion

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Geneviève Meloni, Valérie Schott-Brua, Anne Vilain, Hélène Lœvenbruck, Eulalies Consortium*, et al.. Application of childhood apraxia of speech clinical markers to French-speaking children: A preliminary study. *International Journal of Speech-Language Pathology*, 2020, 22 (6), pp.683-695. [10.1080/17549507.2020.1844799](https://doi.org/10.1080/17549507.2020.1844799). [hal-03344800](https://hal.archives-ouvertes.fr/hal-03344800)

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French-speaking children. This study highlights the need for more cross-linguistic research to better understand the core deficits of CAS, and of subtypes of SSD more broadly.

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Declaration of interest

The authors report no conflicts of interest.

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Primary characteristics of Childhood Apraxia of Speech and Phonological Disorder

Cover terms	Childhood Apraxia of Speech	Phonological Disorder
Level of breakdown	Impaired ability to convert phonological codes to motor speech commands (speech motor planning and programming) ^a	Primary difficulties at representational level including auditory-perceptual encoding and/or phonological memory and/or in phonological encoding. ^e
Prevalence ¹	A very small minority of children with Speech Sound Disorders (5% or less) ^b	Around 20% of children with Speech Sound Disorders ^h
Speech errors types	<p>Inconsistency in speech errors^{a,c,d}</p> <p>Vowel and consonant distortions^e</p> <p>Syllable segregation^{a,e}</p> <p>Inappropriate prosody^{a,e}</p> <p>Inappropriate pauses^f</p> <p>Voicing errors^{d,e}</p> <p>Slow diadochokinetic rate^{e,g}</p> <p>Schwa epentheses^e</p> <p>Increased difficulty with longer words^e</p>	<p>Speech errors that are frequently observed in younger typically developing peersⁱ.</p> <p>High occurrence of omissions, substitutions, distortions, or cluster simplifications that eliminate meaningful contrasts between words.</p> <p>Children's representation of speech sounds may lack precision and robustness^j</p>

Note. ¹Estimate proportion of Childhood Apraxia of Speech and Phonological Disorder is highly variable (Law et al., 2000).

^aASHA, 2007, p.4. ^bBrosseau-Lapr & Rvachew, 2018, p. 348. ^cForrest, 2003, p.378. ^dIuzzini-Seigel et al., 2017. ^eShriberg et al., 2012, p. 453. ^fShriberg et al., 2017. ^gOzanne, 2005, p. 71-82., ^hDodd, 2014, p. 193. ⁱDodd & Bradford, 2000, p. 190. ^jMunson et al., 2005.

Differences in the phonological systems of France French and American English.

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Description of the participants

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Nonwords	Phonotactic frequency ^a	Syllable structure (C: consonant, V: vowel, G: glide)	Syllable length	Lexical component ^b
ʒɔ̃tjɔ̃	0.003	CV.CGV	2	—
guʃã	0.039	CV.CV	2	—
tʁɛsmœl	0.307	CCVC.CVC	2	—
vʁalɔ̃ʁ	0.096	CCV.CVC	2	—
ʃosyʁẽ	0.019	CV.CV.CV	3	chaussure, /ʃosyʁ/ (shoe)
dypɛkɛ	0.355	CV.CV.CV	3	—
zebɥifã	0.007	CV.CGV.CV	3	—
kanakɔ̃glɔ̃z	0.334	CV.CVC.CCVC	3	canard, /kanak/ (duck)
fœkpidɔ̃k	0.365	CVC.CV.CCVC	3	—
muʃisɔ̃ð	0.091	CV.CVC.CV	3	—
vwatyɔ̃tɔ̃	0.277	CGV.CV.CV.CV	4	voiture, / vwatyɔ̃/ (car)
pukosẽta	0.22	CV.CV.CV.CV	4	—
lazynigð	0.151	CV.CV.CV.CV	4	—
adbaldɔ̃ziɔ̃	0.246	CVC.CV.CV.CVC	4	ballon, /balɔ̃/ (ball)
œbkolistik	0.643	V.CCV.CVC.CVC	4	—
spelyzbavɛz	0.101	CCV.CVC.CV.CVC	4	—

- frequency of the onset-nucleus sequence in syllables 1 and 2 and, if applicable syllables 3 and 4,
- frequency of the coda consonant in each syllable, if applicable,
- frequency of the heterosyllabic cluster if applicable.

^bThese words intend to be easily accessible for children and have been selected from the words of the French MacArthur Bates Communicative Development Index (Kern, Zesiger & Bovet, 2009)

Segmental distribution for the nonword repetition task

	1st syllable	2nd syllable	3rd syllable	4th syllable	Total
p	pukosēta spelyzbavez	fœkpidʁak			3
t	tœsmœl	ʒõtjœ vwatyʁotã		vwatyʁotã œbʁolistik pukosēta	5
k	kanagloz	pukosēta	fœkpidʁak		3
b		zebɥifã adbaloziʁ œbʁolistik	spelyzbavez		4
d	dynœœ adbaloziʁ		fœkpidʁak		3
g	guʃã		kanagloz	lazynigõ	3
f	fœkpidʁak		zebɥifã		2
s	tœsmœl spelyzbavez	ʃosyʁẽ muʃiskõ	pukosēta	œbʁolistik	5
ʃ	ʃosyʁẽ	guʃã muʃiskõ			3
v	vʁaloŋ vwatyʁotã			spelyzbavez	3
z	zebɥifã	spelyzbavez	kanagloz	adbaloziʁ spelyzbavez	5
ʒ	ʒõtjœ	lazynigõ			2
ʁ	tœsmœl vʁaloŋ fœkpidʁak	kanagloz œbʁolistik	ʃosyʁẽ dynœœ fœkpidʁak muʃiskõ vwatyʁotã	adbaloziʁ œbʁolistik	13
m	muʃiskõ	tœsmœl			2
n		kanagloz	lazynigõ		3

Note. Segments appear at least two times in different word positions, except for glides which appear only once.

Items	API	Translation	Items	API	Translation
1 syllable					
fraise	fʁɛz	strawberry	hibou	i.bu	owl
gare	gaʁ	railway station	Indien	ẽ.djẽ	Indian (person from India)
griffe	gʁif	claw	menton	mã.tõ	chin
huile	ɥil	oil	poisson	pwa.sõ	fish
jambe	ʒãb	leg	tomate	to.mat	tomato
langue	lãg	tongue	voiture	vwa.tyʁ	car
livre	livʁ	book	yaourt	ja.uʁt	yoghurt
loup	lu	wolf	aquarium	a.kwa.ɕjom	aquarium
main	mẽ	hand	chocolat	ʃo.ko.la	chocolate
neige	nɛʒ	snow	cinéma	si.ne.ma	cinema
œuf	œf	egg	couverture	ku.ver.tyʁ	blanket
ongle	õgl	finger nail	crocodile	kʁo.ko.dil	crocodile
ours	uʁs	bear	déguisement	de.giz.mã	costume
peigne	pɛn	comb	éléphant	e.le.fã	elephant
pieuvre	pjœvʁ	octopus	escargot	es.kɑʁ.go	snail
robe	ʁɔb	dress	oreiller	oreje	pillow
stade	stad	stadium	parapluie	pa.ʁa.plɥi	umbrella
tigre	tigʁ	tiger	pyjama	pi.ʒa.ma	pyjamas
zèbre	zebʁ	zebra	téléphone	te.le.fɔn	telephone
2 syllables					
avion	avjõ	aeroplane	toboggan	to.bo.gã	playground slide
biberon	bi.bʁõ	baby's bottle	uniforme	y.ni.fɔʁm	uniform
bonhomme	bo.nɔm	person	aspirateur	as.pi.ʁa.tœʁ	vacuum cleaner
camion	ka.mjõ	truck	bibliothèque	bi.bli.o.tɛk	library
capuche	ka.pyʃ	hood	extraterrestre	ek.stʁa.te.ʁes tʁ	alien
chaussette	ʃo.set	sock	hélicoptère	e.li.kɔp.tɛʁ	helicopter
ciseaux	si.zo	scissors	hippopotame	i.po.po.tam	hippopotamu s
citron	si.tʁõ	lemon	locomotive	lo.ko.mo.tiv	locomotive
dentiste	dã.tist	dentist	machine à laver	ma.ʃi.na.la.ve	washing machine
docteur	dɔk.tœʁ	doctor	médicament	me.di.ka.mã	medicine (pill)

euro	ø.ko	euro	ordinateur	ɔk.di.na.tœk	computer
enveloppe	ã.vlɔp	envelope	rhinocéros	ʁi.no.se.ʁɔs	rhinoceros
farine	fa.kin	flour	supermarché	sy.pœʁ.maʁ.ʃe	supermarket
fourchette	fuk.ʃet	fork	ventilateur	vã.ti.la.tœk	fan
grenouille	gʁø.nuj	frog	vétérinaire	ve.te.ʁi.nœʁ	veterinarian

Description of items – *learned frequency of the picture naming task* (2-11)

1 syllable		2 syllables		3 syllables		4 syllables	
Items	Lexical frequency ^a	Items	Lexical frequency	Items	Lexical frequency	Items	Lexical frequency
fraise	60.54	avion	63.71	aquarium	53.47	aspirateur	53.26
gare	61.70	biberon	55.87	chocolat	66.50	bibliothèque	56.04
griffe	36.25	bonhomme	61.04	cinéma	62.01	extraterrestre ^a	—
huile	57.25	camion	62.07	couverture	53.85	hélicoptère	57.34
jambe	59.13	capuche	35.74	crocodile	61.74	hippopotame	55.97
langue	60.56	chaussette	45.86	déguisement	42.59	locomotive	56.85
livre	67.85	ciseaux	58.79	éléphant	64.20	machine à laver	60.72
loup	67.13	citron	61.01	escargot	56.74	médicament	51.29
main	66.05	dentiste	55.35	oreiller	57.88	ordinateur	51.35
neige	67.41	docteur	55.98	parapluie	60.36	rhinocéros	51.04
œuf	65.07	euro ^a	—	pyjama	58.64	supermarché	53.48
ongle	54.56	enveloppe	60.70	téléphone	63.31	ventilateur ^a	—
ours	68.08	farine	63.61	toboggan	52.65	vétérinaire	45.98
peigne	58.88	fourchette	55.13	uniforme	50.77		
pieuvre	31.86	grenouille	61.11				
robe	64.10	hibou	59.30				
stade	46.06	indien	56.33				

tigre	59.27	menton	57.19		
zèbre	60.80	poisson	68.65		
		tomate	56.75		
		voiture	68.79		
		yaourt	57.36		

^aThese frequencies are not provided by MANULEX.

	Word-initial	Onset	Coda	Cluster	Word-final	Total
p	par apl uie py jama pe igne	super marché hippo potame cap uche aspi rateur	hélico ptère	poiss on pieuv re para pluie	envelop pe	13
t	télé phone tobogg an tomat e tigr e	vété rinaire ventil ateur dent iste doct eur ment on voit ure extrater restre couvert ure ordinat eur locomot ive hippopot ame hélicopt ère		stad e extrater restre citron dentiste yaour t	chausset te fourchet te tomat e	28

Word-initial	Word-final	Total
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