

A review of reading prosody acquisition and development

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Résumé

1 Introduction

The interest in reading fluency, and how to improve it for beginning readers, is growing. Fluency has long been defined as reading accurately and automatically. However, for a few decades, a new term appears in the key features of fluency : *reading prosody*. Fluency is no longer a matter of accuracy and speed, but it takes into account the listener and the communicative aim of reading.

Indeed, prosody is known to be "the music of speech" (Wennerstrom, 2001). Pauses length and frequency, lengthening of phonemes give a rhythm to speech. Variations of the fundamental frequency (F0), phoneme duration and intensity together with other verbal and coverbal cues shape speech rhythm and intonation. The way these cues encode different phonological units and structures varies among languages (Hirst and Di Cristo, 1998), but also among people (Bolinger and Bolinger, 1989). Despite these inter-individual variations, we are able to decode these precious prosodic indications given by our interlocutors about the discourse structure as well as their emotional, mental and socio-psychological states. In fact, the functions of prosody in speech are essential from a communicative point of view (Bolinger and Bolinger, 1989; Wennerstrom, 2001). Firstly, prosody has an essential linguistic function : intonation and rythmical structure (e.g. pauses) supplement content-based lexical and morphosyntactic information with redundant and complementary cues that help the listener to parse, disambiguate, understand and remember what is said (Frazier et al., 2006). It also has a paralinguistic function – such as emphasizing a word to focus the listener attention to various linguistic units (words, phrases ...), or adding sarcasm to mean the opposite of what is said. Finally prosody also gives information about the speaker – e.g. his/her emotional and physiological state – and how the content affects him/her. These two last functions of prosody are clearly summarized by Bolinger (Bolinger and Bolinger, 1989) :

Intonation is "a symptom of how we feel about what we say, and how you feel when you say it".

As prosody is essential for communication, the sensitivity to prosody is crucial in speech development. Babies rely on prosody to understand speech and learn to speak (de Boysson-Bardies, 1996; Morgan and Demuth, 2014). The sensitivity to their native language and in particular to the mother's prosody begins very early in life. The motherese used with infants eases the acquisition process (Nelson et al., 1989; Harris, 2013). In turn, infants' babbling is also coloured by their native language prosody, even before they utter their first sentences (de Boysson-Bardies et al., 1984; Prieto and Esteve-Gibert, 2018). The development of prosody continues until early adolescence, e.g. see Filipe et al. (2017) in Portuguese or Wells et al. (2004) in English.

Prosody, especially speech rhythm, plays also a role in early reading development. It was first considered as a consequence of the development of vocabulary and phonological awareness (Wood et al., 2009). However, recently, it was shown to predict a part of variance on its own in word reading of first graders in both English (Holliman, 2014; Holliman et al., 2017) and Spanish (Calet et al., 2015a). Furthermore it was shown that dyslexic readers show, among other impairments, a lower

prosodic sensitivity than typical readers, both in English (Goswami et al., 2002, 2011) and in Spanish (Cuetos et al., 2018).

As prosody is necessary to understand a speaker, prosody in reading aloud seems helpful to understand what is read, both for the listener and the reader. Some young readers often read too fast, aiming at arriving at the end of the text as quickly as possible. That is not the image we have of a “good reader”. In early 90’s, this observation leads to add prosody to the definition of fluency in reading Dowhower (1991). An expert reader is supposed to read like he speaks, with appropriate rhythm and intonation, to allow the listener to easily process the speech and understand the content. He is also supposed to add expressivity to his reading : emphasize, add focus, convey emotions... That’s what recent models of fluency assessment now include (e.g. Kuhn et al., 2010; Rasinski, 2004), in particular phrasing and expressivity. These skills probably develop along with the other reading skills.

Given the importance of prosody in both speech and reading acquisition and comprehension, it seems important to precisely understand reading prosody development. Unfortunately, this particular reading skill has been little studied for itself, although prosody is often mentioned in reading fluency studies, under different terms. To our knowledge, no review on reading prosody development have been proposed yet. To fill this gap, we review here researches on reading prosody acquisition and on how prosody and comprehension develop in parallel for their mutual benefit throughout reading experience.

2 Prosody and reading

2.1 Spontaneous speech prosody versus reading prosody

The need to specifically define reading prosody comes first from the observation of prosody differences between a spontaneous speaking and a reading aloud performance. Indeed, while the goal of a fluent reader is to sound like someone talking spontaneously, a closer look to reading prosody reveals many differences between these two conditions of speech production (Guaïtella, 1999).

First of all, the distribution of pauses and their duration differ between spontaneous speech and reading. In read speech, pauses are more likely to occur at major boundaries, are shorter and less frequent than in spontaneous expression (Grosjean and Collins, 1979; Lalain et al., 2016; Goldman et al., 2009; Hirschberg, 2000). Pauses mark a lawful prosodic structure, strongly related to punctuation (Guaïtella, 1999) as well as to paragraph structure (Bailly and Gouvernayre, 2012), that are non existent in the planning of spontaneous speech. Articulation rate is also reported to be higher in reading, but different studies in different languages did not give similar results : Goldman et al. (2009) in French and Hirschberg (2000) in English reported higher reading rate, while Beinun (1991) found the opposite in Dutch. Finally, Goldman et al. (2009) reported a narrower melodic pattern in spontaneous compared to read speech in French and Howell and Kadi-Hanifi (1991) found a difference in stress pattern. In English, Cowie et al. (2002) reported that this contrast depends on context, emotional expression being more likely to raise mean pitch height and intensity when spontaneously performed.

There is also a large variability in reading style among readers and reading situations (Dellwo et al., 2015; Howell and Kadi-Hanifi, 1991; Cowie et al., 2002). For example, pause placement is particularly reader-dependent. Dellwo et al. (2015) looked at listeners’ ability to distinguish read and spontaneous German sentences. In spite of very few acoustic differences, their 26 listeners were able to accurately distinguish read vs. spontaneous sentences. This let the authors think that the cues are more subtle than just pauses, speaking rate and melodic differences. In Japanese, an acoustic comparison between spontaneous speech and read speech shows that spontaneous speech can be characterized by a reduced spectral space (Nakamura et al., 2008).

To conclude, reading prosody is different enough from spontaneous speech prosody to enable listeners to easily discriminate between them. This difference seems acoustic as well as linguistic. The acoustic markers of that difference are however not evident, in particular because of the large variability of speaking styles between readers.

2.2 Reading Fluency and Prosody

First let's put reading prosody in the context of the reading fluency curriculum. Even if the definitions, terms and features used in the literature to refer to reading prosody are diverse, all authors agree that reading prosody is a part of reading fluency. For [Kuhn and Schwanenflugel \(2008\)](#) "a second critical component of reading fluency is the ability to read with prosody ; that is, with appropriate expression or intonation coupled with phrasing that allows for the maintenance of meaning."

One of the earliest publication including reading prosody in the definition of reading fluency comes from [Dowhower \(1991\)](#). Reading fluency has been previously equated to the reading rate – i.e. the number of word correctly read in one minute – discarding the contribution of prosody, considered harder to assess, even though speed and fluency does not always correlate ([Grosjean and Collins, 1979](#); [Valencia et al., 2010](#)). According to [Dowhower \(1991\)](#), "prosodic reading is the ability to read in expressive rhythmic and melodic patterns". In that respect, she proposed six relevant acoustic features of mature reading prosody : appropriate pausal intrusion, phrase segmentation and length, phrase-final lengthening, terminal intonation contours and stress. Since then, several authors have stressed the importance of prosody in the reading fluency curriculum ([Rasinski, 2004](#); [Rasinski et al., 2009](#); [Kuhn et al., 2010](#); [Schwanenflugel et al., 2004](#); [Schwanenflugel and Benjamin, 2012](#)). Now, prosody is generally considered as one reading skill but its definition is still not completely clarified, especially regarding its relation with reading fluency. Some definitions, such as the one proposed by [Kuhn et al. \(2010\)](#) consider prosody as one essential component of fluency : "Fluency combines accuracy, automaticity, and reading prosody [...] It is demonstrated during oral reading through the ease of word recognition, appropriate pacing, phrasing and intonation." Contrastingly, [Cowie et al. \(2002\)](#) consider fluency and expressivity as different skills : "[...] fluency displays structured oriented skills, expressiveness displays sense-oriented skills." They proposed to integrate phrasing into fluency and put aside intonation and expressivity, i.e. separating syntactic from semantic maturing.

Whatever the authors, a distinction is always drawn between three contributions of prosody to reading fluency : phrasing, intonation and expressivity.

2.2.1 Phrasing

An essential function of prosody is to chunk the discourse into meaningful units in order to facilitate the listener's comprehension. The rhythm of speech, in particular the lengths of syllables, the positions and lengths of pauses, strongly contribute to this chunking. In fact boundary accents, pauses and pre-pausal lengthening cue syntactic grouping and structure. This chunking is variously termed as phrasing ([Kuhn et al., 2010](#); [Rasinski et al., 2009](#)), rhythmic organization ([Cowie et al., 2002](#)) or syntactic prosody ([Erekson, 2010](#)).

Three types of pauses should be differentiated : breath, syntactic and hesitation pauses ([Lalain et al., 2016](#)). Breath pauses are necessary for air intake. They could be accompanied by audible breath noises, often used as discourse markers ([Bailly and Gouvernayre, 2012](#)). Hesitation pauses are symptomatic of a cognitive activity – mostly due to decoding or planning problems when it comes to reading. They are often ungrammatical pauses. Syntactic pauses aim at highlighting syntactic units in order to ease sentence parsing and comprehension.

Pause position and duration as well as the distribution of pauses vary along reading acquisition ([Lalain et al., 2014](#)). Pause misplacement is often symptomatic of young readers. Hesitation and respiratory pauses are very frequent in early reading. Hesitations are mainly due to decoding issues, while acquiring accuracy and automaticity. Respiratory pauses are also frequently produced by early readers because of their slow speech rate and low lungs volume. Once children have acquired automaticity, they learn to coordinate their breathing and the syntactic parsing of the text. In expert readers, respiratory pauses are often placed at punctuation marks while syntactic pauses further highlight the grammatical structure. Respiratory pauses of skilled readers are generally longer than syntactic pauses and located at major syntactic boundaries. But when reading speed increases, the placement of respiratory pauses may become more anarchic : the need to breath takes over grammar. Training children to read fast may then contradict the acquisition of expert reading skills ([Grosjean and Collins, 1979](#)).

To summarize, phrasing is closely linked to the text structure. So it is quite explicit and may be the easiest part of reading prosody to be acquired by young readers.

2.2.2 Intonation and Expressivity

Intonation and expressivity are both employed in the literature to refer to the subjective impact of the melodic variation of the voice. Those terms are not always well defined and overlap easily. If we refer to speech prosody studies, intonation refers to the suprasegmental prosody : the variation of pitch linked to linguistic and paralinguistic functions. It is really specific to the language (Hirst and Di Cristo, 1998). For example, syllables within a word may be accented in various positions in languages with lexical stress such as English or Spanish. French is considered as a language with no stress (Rossi, 1980), since accents only occur at the end of the words. In tonal languages, lexical tones coexist with intonation, with the lexical changes of pitch like waves superimposed on larger swells.

These language particularities are likely to strongly impact reading acquisition and performance. Intonation is mostly linked to punctuation (e.g., it is used to mark declarative vs interrogative sentences). It can also mark asides – cued in the text by commas or brackets – as well as focus (Wennerstrom, 2001). Exclamation marks are also used by authors to induce a variation in the melodic pattern of the sentence. They often trigger expressive reading : the choice of attitude – incredulity, contempt, irony, evidence ... (see Golan et al., 2006, for an extensive taxonomy of complex emotional displays by face and voice) – depends on the context and the reader’s understanding of the situation (see below). In prosodic phonology, intonation and phrasing are closely linked. In the prosodic structure, the intonation phrase constitutes an intermediate level between the syllable, the word and the intonation unit. The intonation phrase is a stretch (or chunk) of spoken material that has its own intonation pattern. In a nutshell, intonation and phrasing are parts of the linguistic prosody both in speech and reading.

In contrast, expressivity is something more subtle. A reader can read with appropriate phrasing and intonation but with no expressivity. His reading will be understandable but probably really boring for the listener. In fact expressivity is linked to paralinguistic prosody (Wennerstrom, 2001). Like intonation, it is encoded through multiparametric variations, i.e. pitch, rhythm, intensity as well as timbre. It will bring more implicit information about the text. Authors using the term expressivity generally refer to F0 and intensity amplitude or slope (e.g. Álvarez-Cañizo et al., 2017; Cowie et al., 2002). It can also be cued by punctuation, e.g. exclamation mark. But punctuation is not sufficient enough to translate expressivity in written language so the reader has to infer it from the textual content (Martin, 2011; Erikson, 2010). Erikson (2010) notably insists on the fact that expressive reading implies that the reader has a deep understanding of the text but also infers the emotional state of the character given the context of the story or dialog. This can be explicitly written (e.g. “the boy is mad and he shouts”) or not, and then should be inferred from context.

Intonation and expressivity are not always easy to infer from the text alone, and are also very speaker’s specific, across language and individuals. So that part of prosody is the most difficult to teach and acquire by beginners, and also the most difficult aspect of reading assessment.

2.3 Assessing reading prosody

Reading prosody assessment is an issue for both teachers and researchers. The evaluation protocol and rated dimensions have to be clearly defined to give reliable results. Rating scales have been used and improved since the 90’s. Generally this assessment is subjective and relies on expert listener’s perceptual judgments. More recently, acoustic parameters have been used to perform automatic scoring.

2.3.1 Subjective scales

The first rating scales taking into account prosody were fluency scales trying to go beyond reading rate. Such an example is given in Figure 1a. They were unidimensional scales rating both decoding, phrasing intonation and expressivity (e.g. Pinnell et al., 1995; Zutell and Rasinski, 1991). These scales were mostly developed for teachers to assess pupils. The first three levels focus on the grouping skills. Expressivity appears in the 4th level, assuming that grouping precedes expressivity in the acquisition of reading prosody. Moreover the term “expressivity” is not clearly defined, leaving room for each assessor’s interpretation. These unidimensional scales assess several skills in the same level, neglecting the potential variability of development among these skills in children. Consequently, to place a child in a unidimensional scale can be quite difficult .

Score	abilities
4	Read with appropriate rate, phrasing and expression
3	Read in small group phrasing, no expression
2	Read in small groups, inappropriate phrasing
1	Read word by word

(a) unidimensionnal scale by [Pinnell et al. \(1995\)](#)

Dimension	1	2	3	4
Expression	non existent	poor	mostly correct	adapted interpretation
Phrasing	monotonic	small inappropriate	run-on and pauses	appropriate
Smoothness	frequent pauses	several rough spots	occasional breaks	smooth
Pace	laborious	slow	fast and slow	conversational

(b) multidimensionnal scale by [Rasinski \(2004\)](#)

FIGURE 1 – Exemples of a subjective scales used to evaluate reading fluency.

To improve and facilitate fluency assessment, [Zutell and Rasinski \(1991\)](#) proposed a multi-dimensional scale, still conceived for the use of teachers. [Rasinski \(2004\)](#); [Rasinski et al. \(2009\)](#) further updated this multidimensional scale (see Figure 1b) which allows to separately assess four different features : pace, smoothness, phrasing and expression. Each feature is rated on a 4 points scale, from poor to correct performance. However, if pace and smoothness seem quite easy to evaluate, phrasing and expression could be more difficult to assess. Indeed, these features have a large variability along the text and they are very listener-dependent. Assessors may in fact be influenced by their own reading strategies. Moreover, without a clear definition of expression, the expectations that the assessors have from a good reader with appropriate expressivity affect the ratings. Actually, when several assessors evaluate the same students, the inter-rater agreement can be satisfactory (i.e. $>.70$) as long as the raters get a proper group training (e.g. [Paige et al., 2014](#); [Moser et al., 2014](#)). But without training, the inter-rater agreement tends to be weaker (e.g. [Godde et al., 2017](#)).

After having investigated the inter-rater consistency of fluency assessment in literature using the two scales previously presented, [Haskins and Aleccia \(2014\)](#) pointed out a lack of transparency in their use and reliability. They tested their own multidimensional scale to rate fluency. It was a 4 points scale assessing 6 key prosodic features, grouped into two categories : phrasing and expression. Phrasing combines smoothness and punctuation, while expression combines vocal emphasis, inflection, intonation and voice. These features are rated from 1 (no use) to 4 (correct use throughout the entire reading). They asked 83 teachers to rate the prosody of video-recorded children reading the same text. The raters had no training on the scale. Correlation coefficients between random paires of raters revealed a range from low (.30) to moderate (.53). [Benjamin et al. \(2013\)](#) proposed an acoustically-grounded multidimensional scale detailed in the following paragraph. Using assessments made by 3 raters, all experts in children reading assessment, they still found a moderate inter-rater reliability on exact agreement (even if the reliability on adjacent agreement was better). As a whole, these results attest a lack of reliability of subjective scales, which could be used with caution. For example, [Moser et al. \(2014\)](#) defends the use of at least 2 passages to have a reliable rating of the pupils.

To conclude, primarily dedicated to in-class assessment, subjective multidimensional scales can be useful for teachers. However, they may not be reliable enough to be used for screening and research purposes.

Furthermore,

2.3.2 Objective acoustic markers

For research, it is interesting to look at the acoustic markers of child reading prosody. An additional benefit would be to further correlate this objective characterization with subjective ratings in order to predict performance from signals without the need of costly listening tests [Cowie et al. \(2002\)](#) measured 40 different acoustic markers in the recordings of 8-10 years readers. They related these acoustic markers to subjective ratings of these recordings. It appears that the acoustic correlates of fluency and expressiveness are the one expected by the very definition of the terms. That is to say, fluency is mainly correlated to the basic temporal organization : pause duration, pause frequency, syllabic rate and pitch movement frequency. Expressiveness is mainly linked to pitch variation, i.e., pitch movement magnitude and duration and their variation from one sentence to another. However, if fluency markers are primarily linked to temporal organization, they are also linked – to a lesser extent – with expressiveness and vice-versa. So even if some acoustic markers seem to reliably characterize fluency and expressiveness, the one-to-one correspondence

Paper	Language	Grade	Measures			Impact of reading fluency	
			SR	AA			
				pause	pitch		intensity
(Álvarez-Cañizo et al., 2017)	Spanish	3, 5, adults		X	X	X	
(Benjamin and Schwanenflugel, 2010)	English(US)	2, adults		X	X		X
(Cowie et al., 2002)	English(UK)	4, 5	X	X	X	X	X
(Lopes et al., 2015)	Portuguese	2, 3	X				X
(Miller and Schwanenflugel, 2008)	English(US)	1 to 2		X	X		
(Miller and Schwanenflugel, 2006)	English(US)	3, adults		X	X	X	
(Paige et al., 2017)	English(US)	1, 2, 3	X				X
(Paige et al., 2014)	English(US)	9	X				
(Ravid and Mashraki, 2007)	Hebrew	4		X	X		
(Schwanenflugel et al., 2004)	English(US)	2, 3, adults		X	X		X
(Schwanenflugel et al., 2015)	English(US)	3			X	X	X
(Schwanenflugel and Benjamin, 2016)	English(US)	3			X		
(Young and Bowers, 1995)	English(Can)	5	X*				X

TABLE 1 – Synthesis of the main features of the different studies conducted on reading prosody development, presented in alphabetic order ; AA for acoustic analysis, SR for subjective ratings.

between objective features and subjective judgment is not that simple. In fact expressiveness, often linked to pitch variation, also depends on fluency skills. Young readers need minimal fluency skills – such as automaticity – to develop expressiveness skills. These observations on acoustic markers have been confirmed by several other studies (see below, section 3).

Benjamin et al. (2013) evaluated the correlation between a new subjective multidimensional scale and acoustic markers of prosody in 2nd and 3rd graders reading assessments. They extracted distributions of several characteristics of the children prosody: inter-sentential pause lengths, intra-sentential pause ratio, sentence final pitch declination for declarative sentences and pitch contours. A principal component analysis of the objective cues leads to 2 potential distinct prosodic features interpreted as expressive intonation, i.e. pitch variation variables, and natural pausing, i.e. pause variables. It is to be noted that pause variables also showed secondary relations with expressive reading (as in Cowie et al., 2002) for the same reasons as already stated. Features associated to skilled readers (i.e. level 4 of the subjective scale) are larger pitch drops at the end of declarative sentences, and more and more appropriated pitch variation inside the sentences. Features associated with poor readers (i.e. level 1 of the subjective scale) are flat or inappropriate intonation contours and end of sentence pitch variations that are inappropriate with regards to punctuation. Characteristics of intermediate levels (levels 2 and 3 of the subjective scale) are less clear because medium readers showed a mix of upper and lower level (e.g. they are expressive but not along the whole text).

To conclude, these two studies highlight the difficulty to objectively assess the expressiveness of a reader, especially a medium reader, because of the intra- and inter- reader variability. The use of subjective scales, even acoustically grounded, should be used with a precise training of the raters and carefully interpreted. When coming to research, the use of acoustic parameters to describe reading prosody gives interesting insights in the development of reading prosody.

3 Reading prosody development in young readers

Unlike decoding and automaticity acquisition, reading prosody development has been understudied (see Table 1 for an overview). Indeed, we counted only a few global studies on reading prosody development including and comparing children of different ages (Álvarez-Cañizo et al., 2017; Miller and Schwanenflugel, 2008; Lopes et al., 2015). Other more specific works (Schwanenflugel et al., 2004, 2015; Benjamin and Schwanenflugel, 2010; Schwanenflugel and Benjamin, 2017; Cowie et al., 2002; Paige et al., 2017) studied the acquisition of given prosodic features (e.g. focus, text complexity, link between fluency and prosody).

3.1 Main characteristics of the studies

We found 13 studies published in English on reading prosody development with an extensive search in Google scholar with the keywords "reading+prosody+development" and by investigating the quotation of Kuhn et al. (2010), who first introduced reading prosody.

The main features of the 13 studies are summarized in Table 1. Most of the studies are interested in the earlier development of reading prosody during the first years of primary school : 9 out of these 13 studies involve pupils between 1st and 3rd grade. A common observation of these studies

	Low Fluency	High Fluency
Pauses	intra and inter sentential pauses	long
	complex text	more pauses, more ungrammatical
	long text	increased discontinuities
Expressivity	sentence F0 contour	flat
	F0 rise in interrogative and exclamative sentence	low
	fit to context	weak
	complex text	
	long text	weakening
		high
		strong
		more expressivity
		F0 contour more adult-like

TABLE 2 – Synthesis of the differences observed between fluent (high reading rate) and less fluent (low reading rate) readers of the same age.

is that pupils first need to acquire decoding and automaticity to be able to further add prosody to their reading. Only one study (Paige et al., 2014) got interested in middle school pupils and the late development of prosody. The studies concerning a single grade often describe the difference of performance between fluent and less fluent readers in each of the acoustic parameters assessed.

Concerning the diversity of acoustic parameters, most of the studies are interested in the pause frequency and duration, both intra- and inter-sentential (see Table 1). Grammatical pausing is also an issue (Schwanenflugel et al., 2004; Benjamin and Schwanenflugel, 2010; Miller and Schwanenflugel, 2008), especially with young children. Pitch variation is of great interest when considering sentence type – in particular sentence-initial and final pitch movements (Schwanenflugel et al., 2004; Benjamin and Schwanenflugel, 2010; Álvarez-Cañizo et al., 2017; Cowie et al., 2002; Miller and Schwanenflugel, 2008). The alignment of the F0 contour with reference to an adult contour is also often used as a cue for estimating reading development (Schwanenflugel et al., 2004; Miller and Schwanenflugel, 2006; Benjamin and Schwanenflugel, 2010; Ravid and Mashraki, 2007). Intensity is rarely mentioned. Except for Cowie’s exploration of reading prosody (Cowie et al., 2002), only one study on focus marking (Schwanenflugel et al., 2015) considers intensity variation.

Since all studies focused on a single language – mostly English, but also Portuguese and Hebrew –, inter-languages comparison and hypotheses are rarely developed. Only Álvarez-Cañizo et al. (2017) hypothesized about a possible difference between languages. Indeed decoding acquisition is expected to be language-dependent. As an example, transparent languages with a straightforward grapheme-phoneme correspondence, are quickly decoded, whereas opaque languages, with irregular grapheme-phoneme mapping, take longer to learn to decode (Seymour et al., 2003). Then, an hypothesis is that children may acquire prosodic reading earlier in a transparent language (Álvarez-Cañizo et al., 2017). Some language specificities may also impact the development of reading prosody. For example, in Spanish, interrogative and exclamatory punctuation marks are presented both at the beginning and at the end of sentences, e.g. ”¿Cuándo es la fiesta?” (When is the party?). Álvarez-Cañizo et al. (2017) then hypothesized that the pitch contour specific to interrogatives should appear sooner in Spanish than in other more opaque languages.

3.2 Main results gathered in the literature

As a whole, these 13 studies give an overview of the general development of reading prosody among grades. The evolution of acoustic markers of prosody are summarized in Figure 2. Some of the studies also describe prosodic specificities of poor readers in comparison with good readers of the same grade level, as synthesized in Table 2. Our review evidences four important landmarks that pave the development of reading prosody : the acquisition of fluency, the planning of appropriate pauses, the correct choice of intonation contours, the final development of expressivity. We finally quote the large variability of inter- and intra-reader performance and finally give insights into the few models of reading prosody development proposed so far.

3.2.1 Fluency

The first main conclusion of these studies is the importance of fluent reading, i.e. decoding and automaticity, as a prerequisite for the acquisition of reading prosody. Children become expressive only once they have acquired reading automaticity (e.g. Lopes et al., 2015; Miller and Schwanenflugel, 2008; Paige et al., 2017). Indeed automaticity reduces the overall cognitive load, thus enabling

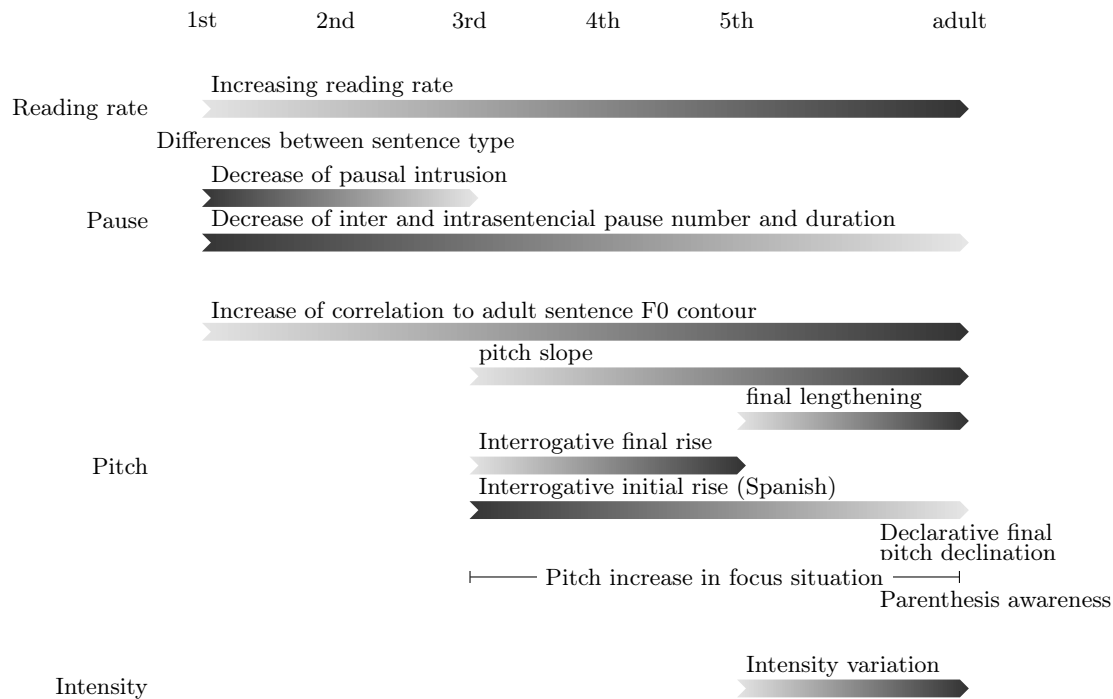


FIGURE 2 – Hypothesized time-chart of the development of the reading prosody skills as evidenced by actual studies.

more attention and cognitive resources – inter alia – to be devoted to expressivity. Consequently, the acoustic markers of appropriate prosody are systematically lower for less fluent readers than for more fluent ones (Figure 3).

3.2.2 Pauses

Another trend evidenced by several studies is the reduction of all kinds of pauses when the reading skills increase (Schwanenflugel et al., 2004; Benjamin and Schwanenflugel, 2010; Álvarez-Cañizo et al., 2017; Miller and Schwanenflugel, 2008; Cowie et al., 2002; Ravid and Mashraki, 2007). This trend appears both when comparing children from different levels and same-level children with various reading skills. Young and poor readers pause more often, during longer time and in a more ungrammatical way. Also, the durations of punctuation pauses decrease. Miller and Schwanenflugel (2008) hypothesize that children tend to feel less and less driven to stop at punctuations as their reading skills improve. Effectively, adults tend to rely less on punctuation (Chafe, 1988). Ravid and Mashraki (2007) showed that adult-like pausing pattern in Hebrew – that uses a large set of punctuation marks (e.g. sof pasuq, paseq, maqaf. . .) – appears earlier than intonation, in 4th grade.

3.2.3 Intonation

Concerning intonation, it's difficult to have conclusions as clear as for pausing. It however seems that some features are acquired quite early in reading acquisition, e.g. initial or final rise in interrogative sentences are already present in 3rd graders (Álvarez-Cañizo et al., 2017; Miller and Schwanenflugel, 2006). Nonetheless, it's not yet adult-like and still evolves. On the other hand, some other features, such as final lengthening or pitch declination in declaratives, appear later, or are still absent at fifth grade (See Álvarez-Cañizo et al., 2017, for Spanish). This implies that intonation still evolves after the fifth grade. Concerning language differences, intonation for interrogative and exclamative sentences doesn't appear earlier in Spanish (Álvarez-Cañizo et al., 2017) than in English (Schwanenflugel et al., 2004), despite the fact that Spanish punctuation marks give strong cues concerning the sentence type.

Finally the correlation between the F0 contour of children and adult constantly increases from 1st to 5th grade (Álvarez-Cañizo et al., 2017; Schwanenflugel et al., 2004; Miller and Schwanenflugel,

2006; Benjamin and Schwanenflugel, 2010; Ravid and Mashraki, 2007) but is still not very high in 5th grade, confirming that the acquisition of some aspects of reading prosody continues after the 5th grade.

3.2.4 Expressivity

Few expressivity features have been studied on children, probably because it is the most difficult aspect of reading prosody to acquire and to assess, as we highlighted above. Nevertheless, Schwanenflugel et al. (2015) noticed that 3rd graders are able to emphasize words that are focused in various ways : direct quote, exclamation point or contrastive context. However children seem unable to deal with parentheses.

3.2.5 Variability

Most studies, focusing on one grade level showed that there is a huge variability in the use of prosody by children of that level. The expressiveness strategies are different from one child to another. For example, different pitch contours can lead to equally expressive readings, leading some authors to say that acoustic markers roughly evaluate expressiveness skills (Cowie et al., 2002). The variability is particularly visible between children with different reading skills (see Table 2) (e.g. Lopes et al., 2015; Cowie et al., 2002; Schwanenflugel et al., 2004). The difference observed between skilled and less skilled readers are the same as between children and adults (Binder et al., 2013). Less skilled readers make more pauses, appropriate or not. They rely more on punctuation. Regarding pitch, their F0 contour is more flat. They also provide poor cues of modalities, e.g. no declination lines nor falling/rising boundary tone for declarative/interrogative sentences. Cowie et al. (2002) pointed out that pitch variations are all the more important as the readers become fluent. Less fluent readers have poor pitch variations between sentences. Moreover, Variability between fluent and less fluent readers also depends on text complexity and length (e.g. Benjamin and Schwanenflugel, 2010). When the texts are more complex or longer, the variability between fluent and less fluent readers tends to increase, especially regarding expressivity and ungrammatical pausing (Benjamin and Schwanenflugel, 2010).

3.2.6 Developmental model

Two studies explored the links between different markers of prosody in order to describe potential dependencies between them. In a longitudinal study, Miller and Schwanenflugel (2008) examined the relationship between pauses (pausal intrusion rate) and pitch (F0 contour match to an adult reference), both measured in 1st and 2nd grade. Unsurprisingly, they found that pauses and pitch recorded in 1st grade are respectively correlated to pauses and pitch measured one year later. More importantly, the pausal intrusion rate in first grade is also related to the F0 match in second grade. Indeed, the children making fewer pausal intrusions in first grade present a more adult-like F0 contour in second grade. This result suggests that a decrease of pausal intrusion is a precursor of an improvement of intonation.

In the same study, Miller and Schwanenflugel (2008) also tested the contribution of pausal intrusion, F0 match and word reading skills recorded in 1st and 2nd grade as predictors of the 3rd grade reading fluency. As expected, word reading skills in 1st and 2nd grade are related to reading fluency skills in 3rd grade. However, both F0 match in 1st and in 2nd grade are significant predictors of reading fluency in 3rd grade, once early reading skills were taken into account. Thus, the early development of intonation contour seems to be crucial in the development of later fluent reading. Schwanenflugel et al. (2015) also examined the relationship between reading rate, accuracy and different prosodic features in 3rd grade. This study confirmed that, during development, reading rate and accuracy are correlated to reading prosody markers such as intra-sentential pausing or pitch change.

3.3 Discussion

This review of studies focusing on reading prosody of children, provides a general overview of the main rules governing reading prosody acquisition, such as 1) that fluency – mostly automaticity – is necessary to begin to enhance prosody, 2) that an early decrease of pausal intrusions permits

to enhance later intonation, or 3) that the early ability to read with appropriate intonation and expressivity predicts later reading skills.

However, there is some limitations to the developmental synthesis proposed here. First, there is a lack of data from various sources because several of the 13 studies come from the same teams and are part of the same project. Also, reading prosody is rarely studied for itself, but most of the time as a mediator to others skills such as fluency or comprehension, and is then often assessed only with subjective scales.

The lack of data also comes from the fact that all studies except one focus on primary school, although data seem to show that prosody development further continues during secondary school. For example sentence-final boundary tones seem to appear after the end of the primary school. In secondary school fluency in general – and in particular prosody – is rarely addressed. However some recent studies from [Paige et al. \(2012\)](#) and [Rasinski et al. \(2005\)](#) tend to show that reading skills have still an impact on pupils' literacy achievement, particularly for struggling readers. Then ,it would be worth exploring the acoustic markers of prosody produced by secondary school pupils.

The comparison between English and Spanish studies suggests that language transparency and punctuation style have little impact on prosody acquisition. It would be interesting to further explore prosody acquisition in more various languages. Moreover, the impact of curriculum on reading prosody development should be explored. In the US, prosody has been part of fluency assessment for a long time (e.g. [National Reading Panel, 2000](#)), and thus is explicitly trained. Conversely, in France, fluency is still measured with a reading rate, confining assessment to accuracy and automaticity. Prosody is thus rarely trained. It could be interesting to develop reading prosody trainings in various languages and to compare reading prosody development in the same language, in children with different curriculum.

This review reveals several important missing points concerning reading prosody development, which certainly merit further investigation. One of them is the role of syntactic awareness, which could be an important prerequisite of prosody development. Fluency, word reading, accuracy are often used as predictors of prosody development. However to produce appropriate phrasing, pupils also need to be able to parse the text into meaningful units ([Young and Bowers, 1995](#)). Another interesting point that deserves more attention is the coordination of breathing and reading ([Lalain et al., 2014](#); [Grosjean and Collins, 1979](#); [Bailly and Gouvernayre, 2012](#); [Bailly et al., 2013](#)). As mentioned above, breathing is one – indispensable – motivation for pausing. When poor readers increase their reading speed, breathing becomes more anarchic and induces ungrammatical pausing, disturbing reading prosody. It could also be interesting to investigate when children manage to produce relevant breath pauses, i.e. manage to coordinate breathing and reading.

Finally, these studies have well characterized the relation between fluency and prosody, with different levels of text complexity. The fact that text complexity enhance prosody in good readers, refer to the implication of prosody in reading comprehension. This issue is discussed in the next section.

4 Reading prosody and comprehension

According to [Schreiber \(1991\)](#) and [Morgan and Demuth \(2014\)](#), children rely on the regular prosodic patterns of speech to perform a shallow syntactic parsing of utterances. When coming to read, they have to reverse this process and rely on syntactic parsing and online comprehension to produce adequate prosody and fluent reading. [Meisinger et al. \(2009\)](#) warn about the intensive training of the reading rate. It often improves at the detriment of other reading skills, like prosody and comprehension. It creates what they named “word callers” who can read fluently but with no understanding of the text read. Actually, a strong relation between syntax, prosody and reading comprehension is expected because syntactic grouping seems essential to understand utterances, and a fortiori, text. This relation has been studied in several languages, on adults and children. The correlation between reading prosody and reading comprehension is significant in most studies. But when coming to developmental issues, this relation raises the question of the causal link between prosody and comprehension. Does prosody enable children to understand the text? Or Does the text comprehension enable them to adopt the good prosody while reading aloud?

4.1 Prosody and comprehension in adult readers

As mentioned earlier in section 2, prosody is a central part of speech comprehension. [Frazier et al. \(2006\)](#) underline the importance of prosodic phrasing in speech comprehension. Two studies, conducted respectively with French and German adults, tend to extend that observation from speech to both oral and silent reading. [Dodane and Brunellière \(2006\)](#) and [Kentner and Vasishth \(2016\)](#) showed that adults covertly recreate prosody when reading silently when confronted to complex or ambiguous sentences. The word reading time in silent reading is correlated to the word lengthening in aloud reading ([Dodane and Brunellière, 2006](#)). Kentner et al's results reveal a strong interaction between text disambiguation and prosodic cues – i.e. local sentence rhythm and global context comprehension – in silent and aloud reading. Both team hypothesized then that readers covertly recreate in silent reading the prosodic accentuation of aloud reading needed to process complex sentences.

Another cue of the importance of prosody for comprehension is the relationship between syntactic structure, pausing and comprehension. [Koriat et al. \(2002\)](#) hypothesized that prosody is a tool for early syntactic extraction. Their study, conducted with Hebrew-speaking students, reveals that the extraction of prosodic structure precedes the analysis of meaning. In this study, reading prosody is linked to the syntactic structure, independently from semantic coherence. In the same way, [Binder et al. \(2013\)](#) showed that skilled readers don't use pauses so much as less-skilled readers. Low-skilled adults readers tend to make more pauses, especially at commas where they always produce long pauses, whereas skilled readers don't pause when commas are used to separate a list of adjectives, but pause when comma separate two clauses. This study showed that comprehension and pausing pattern, number, placement and duration are linked.

Looking at all those results, it seems that prosody, particularly pause placement and phrasing, are essential to expert reading comprehension.

4.2 Link between prosody and comprehension in young readers

During reading acquisition, several literacy skills develop simultaneously : accuracy, automaticity, reading rate, prosodic skills and comprehension. As presented in section 2, these skills are interdependent, but what is the exact role of comprehension in the acquisition of literacy skills? Comprehension is often presented as the ultimate goal of reading acquisition. Nevertheless, the link between comprehension and the development of other literacy skills is not that simple. Numerous studies questioning the relation between fluency and comprehension have been conducted. The interest in the relation between prosody and comprehension is more recent.

The first hints in favor of a link between prosody and comprehension in child reading come from the comparison between aloud and silent reading. Several studies report that, in young and poor readers, reading comprehension is better in oral reading than in silent reading (e.g. [Prior et al., 2011](#); [Dickens and Meisinger, 2016](#); [Price et al., 2016](#)), while comprehension scores in both conditions are the same for middle-school and skilled readers. [Paige et al. \(2014\)](#) reported an impact of prosody on silent reading comprehension by 9th graders. They suggest that prosody serves as a mediator between automaticity and comprehension. They hypothesize that oral reading benefits to young readers because prosody helps them to understand the content. Nevertheless, the results may be biased by the fact that the reading rate is significantly faster in silent reading compared to oral reading (e.g. [Prior et al., 2011](#)). So the comparison between oral and silent reading may not be the best way to study the relation between prosody and comprehension.

Another hint in favor of a link between prosody and comprehension is the effect of text complexity on reading prosody. [Benjamin and Schwanenflugel \(2010\)](#) studied the impact of text complexity on reading prosody with 3rd graders. It appears that children tend to accentuate prosody while reading complex texts, both using pausing and pitch variation. This effect is particularly salient with good readers. [Miller and Schwanenflugel \(2006\)](#) observed the same trend with 3rd graders who accentuated prosody in the case of complex sentences. [Young and Bowers \(1995\)](#) also showed that phrasal knowledge – measured by the ability to parse a text with meaningful boundaries between phrases or clauses – significantly explains reading fluency and prosody, in particular with difficult text and long sentences. These three studies with children stressed a possible support of prosody for comprehension.

We looked for studies conducted to explore reading prosody and comprehension in elementary children from several languages. A search with "reading+prosody+comprehension" in Google

Paper	Language	Grade	Measures		
			SR	AA	
				pause	pitch
Álvarez-Cañizo et al. (2015)	Spanish	3, 6		X	X
Arcand et al. (2014)	French	3	X		
Calet et al. (2015b)	Spanish	2, 4	X		
Lopes et al. (2015)	Portuguese	2 to 3	X		
Miller and Schwanenflugel (2006)	English (US)	3, adults		X	X
Paige et al. (2017)	English(US)	1, 2, 3	X		
Ravid and Mashraki (2007)	Hebrew	4		X	X
Schwanenflugel et al. (2004)	English (US)	2, 3		X	X
Veenendaal et al. (2014)	Dutch	4	X		
Yildirim et al. (2018)	Turkish	4, 5, 6, 7, 8	X		
Yildiz et al. (2014)	Turkish	5	X		

TABLE 3 – Synthesis of the main features of the different studies exploring a link between reading prosody and reading comprehension, presented in alphabetic order ; AA for acoustic analysis, SR for subjective ratings. The subjective ratings used multidimensional fluency scale ([Rasinski, 2004](#)).

Scholar and the investigation of the quotations of [Rasinski \(2004\)](#) – who has introduced the Multidimensional Fluency Scale widely used to study prosody-comprehension link – enabled us to find the studies linking reading fluency and comprehension. We kept only 11 studies investigating specifically the reading prosody-reading comprehension link (see table 3), and 5 longitudinal studies (see table 4).

In the studies involving early readers ([Lopes et al., 2015](#); [Schwanenflugel et al., 2004](#)), the correlation between reading prosody and reading comprehension is weak. It seems that, in 1st and 2nd grades, comprehension is mainly related to decoding speed and accuracy. At these grade levels, a low reading rate has a strong impact on comprehension. However, [Paige et al. \(2017\)](#) found a mediating role of prosody in the relationship between automaticity and reading comprehension in early reading acquisition. One hypothesis about reading comprehension of young readers is that they understand the text by listening to themselves ([Kuhn et al., 2010](#); [Schreiber, 1991](#)). With this hypothesis, several studies screened pauses, in particular the proportion of inappropriate pauses and their relation with reading comprehension. For example, [Arcand et al. \(2014\)](#) highlight the impact of inappropriate pauses in reading comprehension in 3rd graders, independently from reading rate and accuracy. They confirms the importance of appropriate pausing for reading comprehension. It is to be noted that, even if less investigated with young readers, pitch variation seems also linked with comprehension ([Schwanenflugel et al., 2004](#); [Álvarez-Cañizo et al., 2015](#)).

After the 3rd grade, the direct correlation between reading prosody and reading comprehension seems to strengthen. This trend was found in various languages : e.g. Dutch ([Veenendaal et al., 2014](#)), Spanish ([Álvarez-Cañizo et al., 2015](#)), or Turkish ([Yildirim et al., 2018](#)). A strong correlation between inappropriate pausing and comprehension is also confirmed with elder pupils and in several languages : with Spanish 3rd and 6th graders ([Álvarez-Cañizo et al., 2015](#)), with 4th graders in Dutch ([Veenendaal et al., 2014](#)), as well as in Hebrew ([Ravid and Mashraki, 2007](#)). The correlation between pitch and comprehension is also present in elder pupils ([Álvarez-Cañizo et al., 2015](#)). Studies monitoring middle school pupils – from 4th to 8th grade – observed that prosody predicts a larger part of reading comprehension as the grade level gets higher ([Yildiz et al., 2014](#); [Yildirim et al., 2018](#)).

To summarize, the relation between prosody and reading comprehension seems weak for young readers, probably because of the importance of reading rate and decoding skills in comprehension at this age. But when children acquire better reading skills, this relation seems to get stronger.

4.3 Prosody and comprehension : causal links ?

As sketched in the previous section, the link between reading prosody and comprehension is observed in many languages and is strengthened by increased reading performance. However the causal relationship between reading prosody and comprehension in development – if any – is not clear in the studies previously mentioned. One question is the direction of this causal relationship. Some data suggest that children relies on prosody to ease their comprehension, particularly when facing complex texts. The use of emphasis when reading complex texts or ambiguous sentences is

Author	Language	Grade	Assessment	Measures	Causal links		
					No	Unidirectional	Bidirectional
(Fernandes et al., 2018)	Portuguese	2 to 3 4 to 5	3 times	MDFS with 6 levels	4 to 5		2 to 3
(Klauda and Guthrie, 2008)	English(US)	5	2 in 3 months	Subjective scale 5 dimensions	X		
(Lai et al., 2014)	English(US)	2	3 times	NAEP scale	X		
(Lopes et al., 2015)	Portuguese	2 to 3	4 times	Subjective assessment	X		
(Veenendaal et al., 2016b)	Dutch	4 to 6	3 times	MFDS		changing with grades	

TABLE 4 – Synthesis of the different longitudinal studies exploring a causal relationship between reading prosody and reading comprehension, presented in alphabetic order ; prosody was measured with subjective ratings using MDFS for multidimensional fluency scale ((Rasinski, 2004) and NAEP scale (National Reading Panel, 2000) ((National Reading Panel, 2000)

observed in both adults (e.g. Kentner and Vasishth, 2016; Koriat et al., 2002; Binder et al., 2013) and children (e.g. Miller and Schwanenflugel, 2006; Benjamin and Schwanenflugel, 2010; Schimmel and Ness, 2017; Frazier et al., 2006). As observed by Schreiber (1991), children are still relying on prosodic patterns of speech to infer syntax of sentences when beginning to read. Their understanding is better when reading aloud (Frazier et al., 2006). An interpretation of these studies is that good readers rely on prosody to understand the text and so tend to emphasize difficulties when the complexity increases. These observations seem to favor to a causal link from prosody to comprehension. Nevertheless this effect is particularly salient with high skilled readers, which suggests that this trend may depend on reading skills and so on the stage of reading development (Calet et al., 2015a).

Longitudinal studies are surely one of the best ways to examine causal relationships during development. To our knowledge, only five longitudinal studies tried to better explored the bidirectional links between reading prosody and reading comprehension (see Table 4).

The results are mitigated : 2 studies out of 5 did not observe any link between prosody and comprehension. Lopes et al. (2015) screened prosody and comprehension of 98 children four times during 2nd and 3rd grades. The correlation between the ratings of these two dimensions was very low. One shortcoming of that study, mentioned by the authors, was the short term follow-up and the repetitive use of the same text at relatively short intervals of time. Lai et al. (2014) conducted a longitudinal one-year study with 2nd graders and didn't find any relation between reading prosody and comprehension. But considering that comprehension is mostly link to fluency in early readers, a possible explanation is that second graders were not fluent enough to observe an impact of prosody on comprehension at this age.

Nevertheless a bidirectional link was observed in the other 3 studies. Klauda and Guthrie (2008) were the first to explore the possibilities of a bidirectional relations between fluency – in particular prosody – and comprehension. They indeed found an influence of prosody on comprehension and vice versa, with 5th graders at a 3 months interval. This study has paved the way for longer term studies. Veenendaal et al. (2016a) studied pupils from 4th to 6th grade in Dutch and proposed a bidirectional model that fits well their data. In this model, comprehension at the 4th grade is positively correlated to prosody at the 5th grade. Then the link is reversed and the prosody at the 5th grade is positively and significantly correlated to comprehension at the 6th grade. They also noticed that the different components of fluency – i.e. reading rate, phrasing, intonation and expressivity – have changing correlations to comprehension over time and reading skills. This bidirectional link was also observed in Portuguese between the 2nd and 3rd grades (Fernandes et al., 2018). They also found a predictive effect from prosody to effortless comprehension (text vs. word reading) but no evidence for a bidirectional relation between the 4th and 5th grades anymore. According to them, the relation depends on grade level and may be strongly influenced by the orthographic transparency of the language. Indeed Portuguese has an intermediate level of orthographic depth, compared to Dutch which is transparent, leading to a bidirectional link for Dutch (Veenendaal et al., 2016a) but not for their Portuguese data.

4.4 Discussion

This link between prosody and comprehension is well established by several studies. Once automaticity is in place, this link get stronger. However the causal relation is less clear. The link may be bidirectional and change over time and reading skills. But there are too few studies interested in the possible causal relations between prosody and comprehension in reading to get a clear picture. The few ones conducted did not give converging results for multiple reasons : age differences

between cohorts, difference of language transparency, methodological variations are ones of the many possible causes of divergence. We could add other possible reasons like difference of grammatical complexity between languages or difference of reading curricula between countries. More longitudinal studies on prosody and comprehension development should be conducted. Indeed a better knowledge of the direction of this link could provide new interventions to support readers with poor comprehension.

Syntactic awareness was measured only by [Veenendaal et al. \(2016a\)](#) and [Klauda and Guthrie \(2008\)](#). It appears that syntactic awareness is one of the significant predictors of comprehension. However the link between syntactic awareness and oral reading prosody has not been directly studied. Given the use of syntactic awareness to parse the discourse correctly – essential for adequate phrasing – it could be worth investigating the link between syntactic awareness, phrasing and comprehension.

5 Conclusions

Oral reading prosody is a recent area of interest in the reading curriculum. It can be assessed either with subjective scales or by screening acoustic parameters. Subjective scales provide researchers and teachers with a rapid and easy way to assess reading prosody, but these are mostly designed for classroom use and their reliability depends on the availability of multiple trained assessors. To study prosodic parameters more in details, and the development of the language-specific spatio-temporal patterns, an analysis framework has to be established that takes into account current prosodic models and theories of intonation.

The development of reading prosody begins with the development of the other reading skills. The studies reported here in different languages sketch the timeline of prosody development. Phrasing is the first skill to develop with the reduction of number and lengths of pauses. Once automaticity is acquired, young readers can focus on the appropriate placement of the pauses, the appropriate intonation and also add expressivity to their readings. The development begins in early years of reading acquisition and continues until adulthood. Some prosodic features are in fact not yet managed at the end of primary school. More studies with elder pupils and in various languages could be useful to have a wider and more complete view of reading prosody development.

Prosody is linked to comprehension, both in speech and reading. The direction of the link between reading prosody and reading comprehension hasn't been enough studied yet to provide a clear picture of prerequisites, if any. Nevertheless, this bidirectional link seems to evolve with fluency skills and grade level. A plausible hypothesis is that the pupils need to understand the text to adjust their prosody to its content in the early stages of reading acquisition. As the reading skills increase, pupils rely back on prosody to ease their comprehension of the text. As for development, more studies would be useful to precise the nature of the relation between prosody and comprehension. They should also examine if particularities of the language – orthographic, linguistic as well as phonological – have an impact on the prosody-comprehension link.

Future research precisising reading prosody development and comprehension-prosody link would be useful to design new intervention methods. Indeed, if the bidirectional link is confirmed, improving reading prosody could lead to an implicit improvement of comprehension. The specific training of reading prosody – e.g. with repeated reading methods or tutoring – could be a way to help fluent-readers/poor-comprehenders. A more precise development scheme would help deciding the best time to work on reading prosody in order to have a maximal impact on comprehension.

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