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ABSTRACT

A study investigated how skills involved in phonological processing (phonological awareness, verbal working memory, and lexical access) are related to reading achievement when a child learns to read in a language not spoken at home. Subjects were 151 English-speaking children in a French immersion program, initially in grades 1, 3, and 5 in 1995. Subjects were tested in the winter semester of those grades, and again in the following winter semester (1996). At each testing, measures were taken of phonological awareness and reading achievement in French and English, and of nonverbal reasoning, speed naming, and pseudo-word repetition in English only. Initial testing indicated that phonological awareness in either French or English was equally predictive of reading achievement in French, suggesting a transfer of learning between the home language and formally taught language. Speed naming and verbal working memory did not make a unique contribution to the prediction of reading achievement in French or English beyond the effects of phonological awareness. Further analysis will measure maintenance of this pattern of results over time. (Author/MSE)

LONGITUDINAL RELATIONSHIPS AMONG PHONOLOGICAL AWARENESS, VERBAL WORKING MEMORY, LEXICAL ACCESS, AND READING ACHIEVEMENT IN ENGLISH-SPEAKING CHILDREN PLACED IN FRENCH IMMERSION

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Little is known about how skills involved in processing phonological are related to reading achievement when a child learns to read in a different language than the one spoken at home. Research with unilingual children has shown the distinctive roles of the three sets of skills related to phonological processing in learning to read, phonological awareness, verbal working memory, and lexical access. English speaking children (n = 151) who were attending French immersion classes in grades 1, 3, and 5 were tested during the Winter semester of 1995 and they were retested in the Winter semester of 1996 while they were in grades 2, 4, and 6. On both times of measurement, the children were tested individually on measures of phonological awareness and reading achievement in French and English as well as on measures of nonverbal reasoning, speeded naming, and pseudoword repetition in English only. Analyses on the 1995 tests showed initially that phonological awareness in either French or English was equally predictive of reading achievement in French, $\Delta R^2 < .10$, $F(1, 144) = .87$, $p > .05$, and English, $\Delta R^2 < .01$, $F(1, 143) = .07$, $p > .05$. This suggests a transfer in learning between a formally taught language, French, and a language acquired at home, English. It was also found that speeded naming, β's < -.10, t's (144) <-1.140, p's > .15, and verbal working memory, β's < .05, t's (144) < 1.20, p's > .25, did not make unique contribution to the prediction of reading achievement in French or English beyond the effects of phonological awareness. Further analyses will test wether this pattern of results is maintained across time (longitudinal relationships). These results will be discussed in terms of inter-language transfer and in terms of the role of each one of the three sets of skills related to phonological processing in learning to read in two languages.

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The purpose of this study is to examine the roles of skills in phonological processing in reading development in children learning to read in immersion classes. A large number of studies have shown the distinctive influences of phonological awareness, verbal working memory and lexical access on reading achievement in unilingual children (Ellis & Large, 1987; Wagner & Torgesen, 1987; Wagner, Torgesen, Laughon, Simmons, & Rashotte, 1993; Wagner, Torgesen, & Rashotte, 1994). This wealth of knowledge has not been extended to the study of children exposed to two languages.

Similar phonological processes may be involved in learning to read in different languages provided that these languages are phonologically based (yet different). According to Wagner and Torgesen's (1987) model, phonological awareness, verbal working memory, and lexical access are related and they form the set of phonological processing skills related to reading development. This model is presented in figure 1.

FIGURE 1

Phonological awareness is the awareness that a person has of the sounds that compose words. Studies indicate that this ability can be measured by different tasks. Some involve the counting of syllables, others involve the recognition of rhymes. These two types of tasks are relatively easy in that they do not relate to reading achievement when they are administered past the first grade of education (Bradley & Bryant, 1985; Bryant, MacLean, Bradley, & Crossland, 1990, Ellis & Large, 1987). Phonological awareness can also be measured by auditory analysis tasks, which involve the manipulation of sounds in words (e.g.: how does "cat" sound without /k/?). These tasks are relatively harder than the syllable and rhyme tasks and they correlate with reading achievement past grade 1 (Cormier, MacDonald, Grandmaison, & Lebel-Ouellet, 1995; Rosner & Simon, 1971).

Verbal working memory is what allows people to maintain in memory phonological information in order to manipulate it (Baddeley, 1992). While the information is stored, the recoding of phonemes to corresponding words is carried on. According the Baddeley model, this ability can be measured with pseudoword repetition tasks (Gathercole & Adams, 1993).

Recoding in lexical access is the efficiency with which a person can associate the letter and phonological sounds to the corresponding words (Crowder & Wagner, 1991). It is usually measured by rapid naming tasks (Denckla & Rudel, 1974; Wagner & Torgesen, 1987).

The literature presently offers little information on how these three phonological processing skills are related to reading achievement in immersion classes, that is with children who learn to read in a different language than the one that is primarily spoken at home. The few studies that exist in this area of research

(Durgunoglu, Nagy, & Hancin-Bhatt, 1993; Service, 1993) support the expectation that phonological processing skills play a role in the prediction of reading achievement in a second language. But the studies carried with bilingual populations are incomplete according to the Wagner and Torgesen (1987) model in that none of them take into account all three phonological processing skills at one time. Two of them (Cisero & Royer, Durgunoglu et al.) examined the influence of phonological awareness on reading only while the Service study examined the influence of lexical access and verbal working memory. It is important to study all three phonological skills at once because their relative influence on reading achievement may differ according to age, linguistic context, etc.

A critical aspect of the relation between phonological processing and reading development is that it should be studied longitudinally to delineate the causal nature of this relationship. In unilingual children, longitudinal studies on phonological processing abilities have shown that measuring these skills at one point in time give a good indication of reading achievement at a later time (Bryant, MacLean, Bradley, & Crossland, 1990, Ellis & Large, 1987, Tornéus, 1983). Cisero and Royer (1995) extended this to performance on phonological awareness tasks in Spanish and in English: phonological awareness in the native and second language at time 1 was found to contribute significantly to the prediction of second language performance on phonological awareness tasks 6 months later. This is the only known longitudinal cross-language transfer study of phonological awareness. The present study offers a longer longitudinal delay, the examination of the influence of phonological awareness on reading in both languages, and in the presence of other skills related to phonological processing.

In short, the present study is an examination of the relationships (both cross-sectional and longitudinal) of the three phonological processing skills with reading achievement of English-speaking children placed in French Immersion classes.

Hypotheses

1) Since English and French are both phonological codes, the relation between phonological awareness and reading achievement will be of the same strength for the two languages.

2) Of the three phonological processing skills, phonological awareness will remain the best predictor of reading achievement even in a bilingual situation at both times of measurement.

3) Measuring the phonological processing skills at time 1 will help predict reading performance both in native and second language one year later.

Method

Subjects

The data of 134 children in French Immersion classes in the Moncton area were analyzed. They were tested twice, once in 1995 while they were in grades 1, 3, and 5, and once a year later, in 1996. An additional 20 subjects were tested both times but were not included in the analyses because they either dropped from French Immersion, repeated a grade, or received pedagogical help. A further 16 subjects were tested initially at time 1 but could not be located again at time 2.

Table 1

Material

Two auditory analysis (phonological awareness) measures:

- Rosner and Simon (1971) auditory analysis test (in English)
- Test d'analyse auditive en français (Cormier, Godin, Grandmaison, Lebel-Ouellet, & Hebert, 1994) (in French)

To complete these tasks, the child is asked to pronounce what is left of a word after a sound has been taken out. (ex: say "trail" without /t/.)

A non-word repetition task (verbal memory) (Comeau, 1995)

The child is asked to repeat some pseudowords that follow regular grammar and spelling rules (e.g.: repeat "vunhip, bufty"). These pseudowords varied in length (1 to 3 syllables) to have a proper level of difficulty for the ages represented in this study.

A lexical access measure, the Rapid Automatized Naming Test (Denckla & Rudel, 1974).

The child has to name as rapidly as possible 50 printed digits, letters, colors, and familiar objects.

Two reading measures:

- Canada French Immersion Achievement Test (Wormeli & Arnadaz, 1987) - French reading
- Word decoding from the Wide Range Achievement Test (Jastak & Wilkinson, 1993) - English reading.

The child is asked to read printed isolated words.

A measure of intellectual functioning, the Test of Non Verbal Intelligence-2 (TONI-2) (Brown, Sherbenou, & Johnsen, 1990).

The child chooses among a group of stimuli the one that would best complete a visual pattern. The level of difficulty pattern completion varies from visual completion to visual analogy.

Procedure

The children were tested individually in two sessions of about 30 minutes each. The measures are administered semi-randomly with the two phonological awareness and the two reading measures being administered in separate sessions in order to keep the child from getting fatigued by tasks similar in format. The instructions were carried out in the language that the children identified as their preferred language (mostly English).

Results

Hypothesis 1: Are the relation between phonological awareness and reading achievement of the same strength for the two languages?

Table 2 shows the strength of the relations between phonological awareness and reading achievement in both French and English when using the separate measures or a combined measure of phonological awareness. Only when predicting reading achievement in French at time 2 does using separate measures of phonological awareness improve the prediction af reading achievement.

Table 2

Hypothesis 2: Does phonological awareness remain the best predictor of reading achievement even in a bilingual situation?

Table 3 provides the results of the analysis at time 1. The three control variables help predict 75% of reading achievement in English, $F(3, 130) = 129.9$, $p < .01$, and 63% of reading achievement in French, $F(3, 130) = 72.25$, $p < .01$ (Table 3 model 1). The next step is to measure the effects of verbal working memory and the recoding in lexical access. These variables improve by 4% the prediction of reading achievement in English, $F(2, 128) = 12.43$, $p < .01$, and by 3% that in French $F(2, 128) = 5.44$, $p < .05$ (Model 2). By adding the combined score for the phonological awareness measures to the list of variables, the prediction of reading achievement is improved by 6% in English, $F(1, 127) = 47.21$, $p < .01$, and by 9% in French, $F(1,127) = 47.40$, $p < .01$ (Model 3).

Table 3

As can be seen in table 4, the results at time 2 are similar to those at time 1. Model 1 predicts 71% of the total variance in English, $F(3, 130) = 106.79$, $p < .01$, and 58% in French, $F(3, 130) = 58.89$, $p < .01$. Model 2 improves by 3% in English, $F(2, 128) = 7.47$, $p < .05$, and by 4% in French, $F(2, 128) = 7.45$, $p < .05$. Model 3 improves by 4% in English, $F(1, 127) = 25.02$, $p < .01$, and by 8% in French, $F(1, 127) = 34.99$, $p < .01$.

Table 4

Hypothesis 3: Does measuring the phonological processing skills at time 1 help predict reading performance both in native and second language one year later?

Table 5 indicates that the longitudinal results are similar to the ones at time 1 and at time 2. The predictor variables taken at time 1 are now used to see which one explains the most variance in reading achievement at time 2. We want to verify if a relation that exists cross-sectionally will also exist longitudinally. Model 1 explains 68% of the variance in English, $F(3, 130) = 92.91$, $p < .01$, and 56% in

French, $F(3, 130) = 54.88$, $p < .01$. Model 2 improves by 6% the prediction in English, $F(2, 128) = 14.07$, $p < .01$, and by 7% in French, $F(2, 128) = 11.24$, $p < .01$. Model 3 improves the prediction by 5% in English, $F(1, 127) = 31.07$, $p < .01$, and by 8% in French, $F(1, 127) = 36.11$, $p < .01$.

Table 5

Longitudinal effects of the individual predictor variables

Another longitudinal verification is to measure the contribution of each phonological processing variable taken separately at time 1 and at time 2. This is to examine if the contribution of a variable at time 2 is significant when the effect of that same predictor variable is controlled at time 1. Table 6 shows the results of these analyses. The first model is the same as model 1 table 5 and it accounts for 68% of the total variance in English, $F(3, 130) = 92.91$, $p < .01$, and for 56% of the variance in French, $F(3, 130) = 54.88$, $p < .01$.

Table 6

To these lists of predictors is added phonological awareness at time 1 (Model 2a) This model improves by nearly 9% the prediction of reading achievement in English at time 2, $F(1, 129) = 52.78$, $p < .01$, and by nearly 14% that of reading achievement in French, $F(1, 129) = 57.42$, $p < .01$. Phonological awareness at time 2 is next introduced (Model 3a). This leads to a non-significant improvement in the total variance explained in English, $F(1, 128) = 2.87$, $p > .05$, and a significant improvement of 1% in variance explained in French, $F(1, 128) = 4.53$, $p < .05$.

The next step is to verify the contribution of the verbal working memory at time 1 and 2. When adding the score of the verbal working memory at time 1 (Model 2b), the prediction over Model 1 is improved by .8% in English $F(1, 129) = 3.08$, $p > .05$ and by 1.9% in French $F(1, 129) = 5.73$, $p < .05$. With the measure of working memory at time 2 added (Model 3b), the total variance explained does not improve significantly in English and French with improvements of .4%, $F(1, 128) = 1.88$, $p > .05$, .3%, $F(1, 128) = 0.98$, $p > .05$, respectively. The contribution of verbal working memory is significant only when using the verbal working memory measure at time 1 to predict French reading at time 2.

The final step is to verify the contribution of the recoding in lexical access. Model 2c contains the results when this measure is added at time 1. The total variance explained, when compared to Model 1, is improved by 5% in English, $F(1, 129) = 27.97$, $p < .01$, and by 6% in French, $F(1, 129) = 20.35$, $p < .01$. When recoding in lexical access is added at time 2 (Model 3c), the explained variance is improved by .5% in English, $F(1, 128) = 2.27$, $p > .05$, and by .4% in French, $F(1, 128) = 1.66$, $p > .05$. Both of these improvements are not significant.

Discussion

The present study on English speaking children attending French Immersion classes showed that:
1) When English and French are the languages involved, phonological awareness in English and in French are equal predictors of reading achievement in either English or French.
2) Phonological awareness is of the three phonological processing skills the better predictor for reading achievement in French and in English.
3) These two patterns of relationship hold both cross-sectionally and longitudinally.

The present results indicate that there is a cross-language transfer of phonological processing skills. This effect is mainly observed with phonological awareness and recoding in lexical access. Measuring these skills in one language helps predict future reading achievement in another language. These results concord with those found in other studies using phonological processing skills in the prediction of reading achievement in a second language (Cisero & Royer, 1995; Durgunoglu et al., 1993; Service, 1992).

These results extend what is observed in a unilingual situation between the phonological processing skills and reading achievement to the immersion situation. These skills are thus good predictors of reading achievement (Ellis & Large, 1987; Wagner & Torgesen, 1987). Also, of the three skills, phonological awareness is the best predictor of reading achievement over the prediction of verbal working memory and recoding in lexical access (Wagner et al., 1993, 1994), and this is so both in English and in French as well as cross-sectionally and longitudinally.

When examining separately the contribution of each phonological processing skill in the longitudinal relationships, the contribution of each skill at time 2 was almost never significant when the skill at time 1 was accounted for. Thus, knowing the performance on a skill at an early point in time is a good predictor of future reading achievement. There was however additional variance in predicting French achievement when using phonological awareness at time 2. This could be a chance (random) finding or may result from a greater improvement in French reading than in English since the subjects were English-speaking children learning solely French in a formal context for the first three years of their curriculum. Since the phonological awareness measure is the best predictor of reading achievement, it may account for this greater development of French reading skills.

Just like Wagner et al. (1993, 1994), the contribution of verbal working memory was the weakest of the three phonological processing skills. These results replicated across two research groups (Wagner's and ours) and different measures of verbal working memory, they then cast some doubt as to how important this skill is to reading development (Baddeley, 1992). They also highlight that an evaluation of the relationship between verbal working memory and reading cannot be done without taking into account phonological awareness (Service, 1992).

Finally, the cross-language transfer observed in this study is a further argument in favor of the specific relation between phonology and reading. Learning to read seems to evolve from some individual resources tapping auditory-phonological information. That this is observed across socio-economic contexts as different as Spanish speaking children learning English in the United States (Cisero & Royer, 1995; Durgunoglu et al., 1993) and English-speaking children learning French in Canada is also indicative of the fundamentally auditory nature of this relationship.

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Figure 1
The Wagner and Torgesen (1987) model.

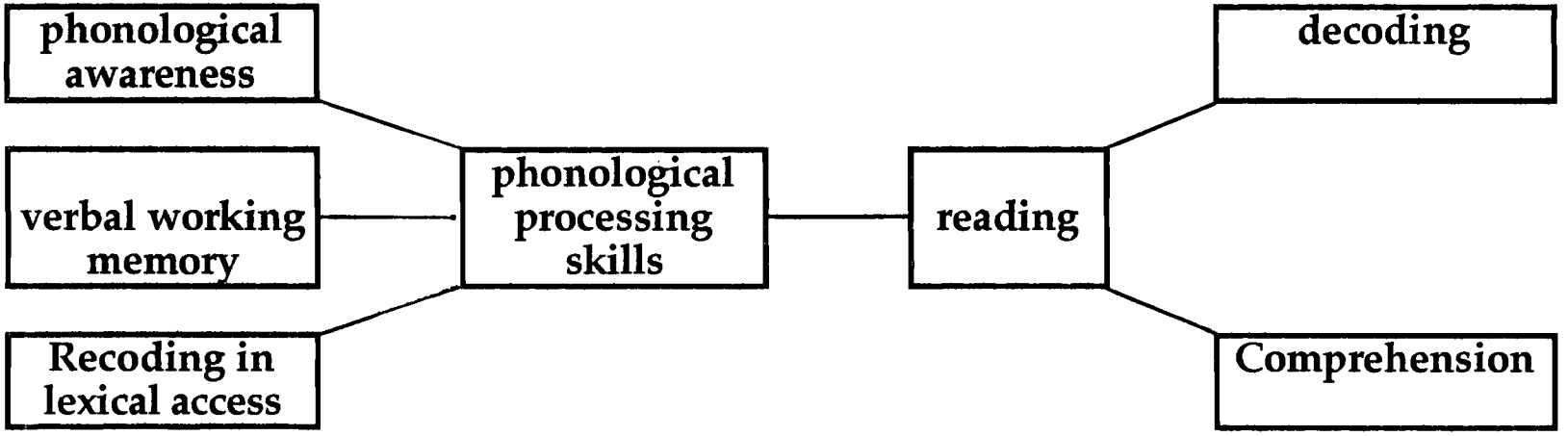

Table 1

Sex and mean age of subjects at time 2 according to school level

School level	sexe	N	Mean	Stand deviation
2	boys	15	93,13	3,27
	girls	29	92,83	3,02
4	boys	13	116,15	4,08
	girls	34	116,41	3,31
6	boys	14	140,50	3,21
	girls	29	141,72	3,08

Table 2

Total reading achievement variance explained when using seperate or combined measures of auditory analysis.

	Reading achievement	
Predictors	English	French
English auditory analysis and French auditory analysis at time 1	76,498	69,249
Auditory analysis time 1	76,154	69,201
English auditory analysis and French auditory analysis at time 2	62,584	61,118
Auditory analysis time 2	61,146	58,704
English auditory analysis and French auditory analysis at time 1	Time 2 71,335	Time 2 66,203
Auditory analysis time 1	Time 2 70,752	Time 2 66,125

Table 3

Total reading achievement variance explained by the predictor variables at time 1.

	Reading achievement	
Model - Predictors	English	French
Model 1: age, sex, intelligence	74,985**	62,508**
Model 2: age, sex, intelligence, recoding in lexical access, working memory	79,054*	65,446*
Model 3: age, sex, intelligence, recoding in lexical access, verbal working memory, phonological awareness	84,730**	74,838**

* p<,05 ** p<,01 Indicates change according to the previous model. For model 1 the previous model is the null hypothesis.

Table 4

Total reading achievement variance explained by the predictor varaibles at time 2.

	Reading achievement	
Model - Predictors	English	French
Model 1: age2, sex, intelligence2	71,136**	57,610**
Model 2: age2, sex, intelligence2, recoding in lexical access, working memory	74,151*	62,030*
Model 3: age, sex, intelligence, recoding in lexical access, verbal working memory	78,405**	70,232**

* p<,05 ** p<,01 Indicates change according to the previous model. For model 1 the previous model is the null hypothesis.

Table 5

Total reading achievement variance explained at time 2 using the predictor variables at time 1.

	Reading achievement at time 2	
Model - Predictors	English	French
Modèle 1: age, sex, intelligence	68,194**	55,878**
Model 2: age, sex, intelligence, recoding in lexical access, working memory	73,926*	62,467*
Model 3: age, sex, intelligence, recoding in lexical access, verbal working memory	79,052**	70,446**

* p<,05 ** p<,01 Indicates change according to the previous model. For model 1 the previous model is the null hypothesis.

Table 6

Total longitudinal variance by each phonological processing variable taken separately

Model - Predictors	Reading achievement at time 2	
	English	French
Model 1: age, sex, intelligence	68,194**	55,878**
Model 2a: age, sex, intelligence, auditory analysis1	77,412**	69,469**
Model 3a: age, sex, intelligence, auditory analysis1, auditory analysis2	77,907	70,513*
Model 2b: age, sex, intelligence, working memory1	68,935	57,753*
Model 3b: age, sex, intelligence, working memory1, working memory2	69,385	58,074
Model 2c: age, sex, intelligence, recoding in lexical access1	73,863**	61,890**
Model 3c: age, sex, intelligence, recoding in lexical access1, recoding in lexical access2	74,317	62,379

* p<,05 ** p<,01 Indicates change according to the previous model. For model 1 the previous model is the null hypothesis.

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XIVth Biennial Meetings of the International Society for the Study of Behavioural Development (Quebec City, Quebec, August 12-16, 1996).

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August 16, 1996

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Sincerely,

Karen E. Smith
Acquisitions Coordinator