Role of Visual Information in Phonological Awareness Learning

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Résumé L'étude a exploré le rôle de l'information visuelle (mouvements articulatoires) dans l'apprentissage de la conscience phonologique chez les enfants préscolaires. L'objectif principal était d'identifier le format de présentation de mouvements articulatoires (bouche *vs* visage) le plus facilitateur de l'apprentissage. Le design standard pré-test, entraînement, post-test a été utilisé. 105 élèves d'école maternelle ont participé à l'étude. Ils ont été assignés à un des trois groupes différant entre eux en matériel d'entraînement audio (AO), audio-visuel "visage" (AVF) et audio-vidéo "bouche" (AVM). Les résultats montrent que la conscience phonologique s'est le plus améliorée chez les élèves du groupe AVF, particulièrement au niveau des phonèmes. Dans les deux autres groupes, l'entraînement avait une efficacité comparable, avec une tendance vers une efficacité moindre de l'entraînement AVM.

Abstract The study investigated the role of visual information relative to articulatory movements in phonological awareness learning in pre-school children. More precisely, we were interested in identifying the format of visual information presentation (mouth *vs* face) facilitating the most this type of learning. The standard design pre-test, training, post-test design was used. 105 kindergarten children participated in the study. They were assigned to 3 groups differing in training material: the audio-only (AO), the audio-visual "face" (AVF) and the audio-visual "mouth" (AVM) group. The results show that pupils' phonological awareness skills improved the most in the AVF group, particularly at the level of phonemes. In the other two groups, training had comparable efficiency, with a slight tendency of the AVM training being less effective than the AO one.

Mots-clés: conscience phonologique, syllabes, rimes, phonèmes, mouvements articulatoires, multimodalité, tableau numérique interactif (TNI), enfants d'école maternelle.

Keywords: phonological awareness, syllables, rimes, phonemes, articulatory movements, multimodality, interactive whiteboard (IWB), kindergarten children.

1 Introduction

The goal of the present study was to explore the role of visual information, relative to the articulatory movements, in pre-school children phonological awareness learning. The subject of the study was motivated by the results of one of our preliminary studies, designed to experimentally evaluate a possible contribution of interactive whiteboard (IWB) to phonological awareness teaching of pre-school children. The possible advantage of the IWB technology use in this context was supposed to be a slightly enlarged presentation of articulatory movements. However, the group using traditional classroom material during the training phase showed a greater improvement in phonological awareness skills than the IWB group. Such results could have been due to factors related to teachers' confidence and mastery of use of the support of presentation of training material (both probably lower in the IWB group), but it could have also been due to the inefficiency of the visual support used in the IWB group for phonological learning in pre-school children. The presents study was designed to further explore the latter point. More precisely, we were interested i) in whether accompanying auditory information with the visual one (multimodal learning) was facilitative of phonological awareness learning; ii) in whether the efficiency of multimodal phonological awareness learning depended on the format of articulatory movements presentation (localized presentation in context of mouth *vs* holistic presentation in context of face). Thus, we compared the effects of two multimodal learning conditions differing in format of visual information presentation (mouth *vs* face) and a unimodal learning condition (auditory presentation only) on the efficiency of a phonological awareness training.

Phonological awareness is best defined as a general sensitivity to phonological units of oral language (e.g., Goswami, Bryant, 1990; Stanovich, 1992; Treiman, Zukowski, 1996). Authors adhering to this theory consider phonological awareness as a single capacity of perceiving and manipulating different types of phonological units that develops from shallow sensitivity to larger units (words, syllables, onsets, rimes) to deep sensitivity to the smallest phonological units, phonemes. Research shows that, in children, phonological awareness is first acquired at the level of syllables, later at the level of rimes and onsets and finally at the level of phonemes (Anthony, Lonigan, Driscoll, Phillips, Burgess, 2003; Fox, Routh, 1975; Treiman, 1992). This theoretical view of phonological awareness as a single ability taking on different forms was confirmed by Anthony and Lonigan (2004) with the use of confirmatory factor analysis.

The importance of phonological awareness lies in its causal implication in reading and it is considered as a cognitive precursor of literacy development (see Kirby, Desrochers, Roth, Lai, 2009 for a review). Notably, learning to read requires the establishment of connections between graphical representations of printed words and phonological representations (Sprenger-Charolles, Colé, Lacert, Serniclaes, 2000). Furthermore, individual differences in phonological awareness skills appear in early childhood and tend to maintain stable without intervention (Lonigan, Burgess, Anthony, 2000; Speece, Ritchey, Cooper, Roth, Schatschneider, 2004). Hence, interventions in phonological awareness learning during pre-school period are of a great importance.

We consider phonological awareness to be a capacity that develops firstly on the basis of oral language perception. The research in this latter field has established that visual information, relative to the articulatory movements, plays an important role in speech perception. First, perception of verbal stimuli whose auditory modality is degraded by noise is enhanced when presentation of auditory information is accompanied by the visual one (Binnie, Montgomery, Jackson, 1974; MacLeod, Summerfield, 1987; Schwartz, Berthommier, Savariaux, 2004).

Second, the perception of verbal stimuli seems to result from a fusion between auditory and visual modalities (McGurk, MacDonald, 1976). Finally, the research in neuroscience has found evidence for association between the perception and the production of oral language on neural level (Fadiga, Craighero, Buccino, Rizzolatti, 2002; Watkins, Strafell, Paus, 2003). These results suggest that the visual information is complementary to the auditory one in speech perception. Thus, visual information could also play an important role in the development of phonological awareness and could, as such, be used in phonological awareness interventions in order to enhance their efficiency.

The present study was designed to explore the role of visual information in phonological awareness learning and to identify the format of visual information presentation that facilitates best this type of learning. There were three hypotheses in the study: i) In line with the results of the research on the role of visual information in speech perception, we hypothesize that both multimodal phonological awareness trainings (audio-visual face – AVF condition and audio-visual mouth – AVM condition) would be more efficient than unimodal one (auditory only – AO condition). Furthermore, on the grounds of the results of our preliminary study, we expect multimodal training using visual information presented in the context of whole face (AVF condition) to be more efficient than the one presenting visual information in the context of mouth only (AVM condition). ii) Since phonological awareness develops last at the level of phonemes, we expect this form of phonological awareness to be the most sensitive to instruction. Hence, we hypothesize the phonological awareness training would be the most facilitative of phonemic awareness learning. iii) Finally, we expect to find an effect of interaction between the two experimental factors, the type of training and the phonological awareness form. Precisely, we expect the greatest difference in progress made in phonological awareness skills between the AVF and the other two groups would appear at the level of phonemic awareness.

2 Methodology

2.1 Participants

5 classes of altogether 105 kindergarten pupils participated in our study. Pupils' average age was of 5 years and 9 months. Each class was recruited in a different kindergarten in the same administrative area in Paris suburbia. Classes were randomly assigned to AO, AVF or AVM group. 40 pupils were assigned to the AO group, 41 pupils were assigned to the AVM group and 24 pupils were assigned to the AVF group. (Note that one more class of about 20 pupils assigned to the AVF group dropped out of the study due to technical difficulties.) Pupils' socio-economic and linguistic backgrounds were not controlled. However, with the help of chief pedagogical inspector of the area, the care was taken to recruit the most homogenous classes on these criteria.

2.2 Material

Training exercises

Phonological awareness training consisted of 17 exercises. The exercises were presented in classroom setting with the use of IWB technology and a software developed by our research team. In the AO group, training items were presented in their auditory modality only. In the AVF and the AVM groups, training items were presented in auditory and visual (articulatory movements) modalities. In the AVF group, the articulatory movements were presented in the context of whole face; in the AVM group the articulatory movements were presented in the context of mouth. Real words and pseudo-words were used as training items. Audio and video recordings of training items were done by a native French female speaker.

The exercises were conceived upon 4 organizational principles ("Detection/Identification", "Suppression", "Rebus", "Classification"), defining the type of task and the scenario of exercise presentation within the IWB. In the exercises of "Detection/Identification" type, the pupils' task was either to detect the presence or absence of a target phonological unit, or to identify its position within an item (real word or pseudo-word). (For example, pupils were asked if the syllable "si" [si] was present in words such as "ciseau" [si-zo] (*scissors*) ("yes" trial), "cuisine" [kwi-zinə] (*kitchen*) ("no" trial), etc.) In the exercises of "Suppression" type, the pupils' task was to make a deletion of initial or final syllable of a given real word which resulted in another real word. (For example, pupils were asked to suppress the last syllable of the word "oiseau" [wa-zo] (*bird*) which resulted in the word "oie" [wa] (*goose*).) In the exercise of "Rebus" type, the pupils' task was to fuse two real words which resulted in another real word. (For example, pupils were asked to fuse words "riz" [ri] (*rice*) and "dos" [do] (*back*) which resulted in the word "rideau" [rido] (*curtain*).) Finally, in the exercises of "Classification" type, the pupils' task was to classify randomly presented items, real words or pseudo-words, on the grounds of a common phonological unit. (For example, pupils were asked to group words such as "couteau" [kuto] (*knife*), "château" [shato] (*castle*), "marteau" [marto] (*hammer*) and "vélo" [velo] (*bicycle*), "bibelots" [bibəlo] (*ornaments*), "stylo" [stilo] (*pen*), presented randomly, on the grounds of their common final syllable [to] and [lo].)

Pre- test and Post-test

Pre-test and Post-test consisted of 3 exercises each. Each exercise was meant to measure a particular form of phonological awareness. Exercise 1 (exercise "Syllables") measured phonological skills at the level of syllables, exercise 2 (exercise "Rimes") at the level of rimes and exercise 3 (exercise "Phonemes") at the level of phonemes. The pupils' task in the exercises was to detect the presence or absence of a target phonological unit (syllable, rime or phoneme) within a corresponding real word item.

Pre-test and post-test items were matched in the number of syllables and in the position of target phonological unit within the syllabic structure. Each exercise consisted of 12 trails, 6 of them were "no" trails and 6 were "yes" trails. However, since only real words known by children of about 6 years which could be represented by photographs were used, the items could not be matched on any phonological criteria (difference of sonority in vowel-consonant clusters, type of phoneme, etc.).

The tests were presented to children in pen and paper form in which items were presented by photographs. There were 6 items per page. (Graphical presentation of items was chosen in order to make it easier for children to follow the right answering order.) Below each photograph a hearing ear and a deaf (crossed out) ear icons were placed for "yes" and "no" answers respectively. Audio recordings of trails were made by a native French female speaker. The recording of each trial was presented twice in every classroom.

2.3 Procedure

The study consisted of 4 phases. The first phase consisted of 2 weeks teachers' IWB training. The second phase was Pre-test phase. It took place in the week preceding the training phase and consisted of the administration of Pre-test exercises to pupils. Each exercise was presented in a separate session. Sessions were carried out in 3 successive kindergarten days during morning classes. The third phase was the phonological awareness training phase. During this phase, teachers presented one exercise in one training session of about 30 to 40 minutes. Two training sessions were given to pupils per day (one in the morning, one in the afternoon). Since training consisted of 17 exercises, the training phase was carried out in 8 successive kindergarten days of 2 sessions and 1 day of 1 morning session. The fourth phase consisted of the administration of Post-test exercises to pupils. It took place in the week following the training phase and was carried out in the same way as the Pre-test phase. (Note that in France, there are no classes in kindergarten on Wednesday. Hence, Wednesdays were left out in the study.)

3 Results

Subjects' scores on three exercise types at pre-test and at post-test were collected in the study. The post-test – pre-test score difference was calculated for each subject. (In this paper, we use the term of "progress" to refer to a positive difference and the term of "regression" to refer to a negative difference in scores.) These data were submitted to a two-way analysis of variance with "Group" as between-subjects factor and "Exercise Type" as within-subjects factor. Paired t-tests were also conducted in order to identify conditions differing significantly from one another.

Incomplete protocols and protocols containing ambiguous responses were eliminated from the analysis. On these grounds, data of 81 subjects were analyzed: 36 from the AO group, 25 from the AVM group and 20 from the AVF group.

3.1 **Factor "Group"**

The effect of the factor "Group" was found to be significant (F=10,754; p<0,000). The most important progress in phonological awareness skills was made by the AVF group, while the AVM group presented a regression. In the AO group a small progress was noted. Paired t-test analysis revealed that the difference between the AVF and the AO group (t=-4,047; p<0,000)

and the difference between the AVF and the AVM group (t=-3,791; p<0,001) were significant. (See Table 1 for means and standard deviations for the factor Group.)

3.2 Factor "Exercise Type"

The effect of the factor "Exercise Type" was found to be significant (F=5,456; p<0,005). The most important progress in phonological awareness skills was made at the level of syllables (exercise "Syllables"); at the level of rimes (exercise "Rimes") the progress was less important, while at the level of phonemes (exercise "Phonemes") we noted an overall regression. Paired t-test analysis revealed that only the difference between the exercises "Syllables" and "Phonemes" was significant (t=2,970; p<0,003). (See Table 1 for means and standard deviations for the factor Exercise Type.)

3.3 Interaction between factors "Group" and "Exercise Type"

The interaction between experimental factors "Group" and "Exercise Type" was found to be significant (F=3,265; p<0,013). In the exercise "Syllables", the AVF group made the most important progress in phonological awareness skills, a less important progress was noted in the AO group while the AVM group presented a small regression at this level. In the exercise "Rimes", all the groups made a progress in phonological awareness skill; the most important progress was made by the AVF group and the least important one was made by the AVM group. Finally, in the exercise "Phonemes", the AO and the AVM groups presented a regression in phonological awareness skills, while an important progress was observed in the AVF group. The most important regression at this level was the one of the AVM group. In the exercise "Phonemes", the regression made by the AVM group was the most important one in the study; the progress made by the AVF group was also the most important one in the study. Paired t-test analysis revealed that the following differences were significant: in the exercise "Syllables" between the AVM and the AVF group (t=-2,214; p<0,037); in the exercise "Phonemes" between the AO and the AVF group (t=-4,241; p<0,000); in the exercise "Phonemes" between the AVM and the AVF group (t=-4,326; p<0,000); within the AO group between exercises "Syllables" and "Rimes" (t=2,404; p<0,019); within the AO group between exercises "Syllables " and "Phonemes" (t=4,972; p<0,000); within the AO group between exercises "Rimes" and "Phonemes" (t=2,053; p<0,044); within the AVM group between exercises "Rimes" and "Phonemes" (t=2,931; p<0,005). (See Table 1 for means and standard deviations for conditions resulting from crossing the modalities of the two factors. See Figure 1 for graphical presentation of results.)

	AO		AVM		AVF		TOTAL	
	M	SD	M	SD	M	SD	M	SD
SYLLABLES	0,861	1,313	-0,160	2,764	1,450	2,114	0,691	2,119
RIMES	0,028	1,612	0,400	1,658	0,550	2,139	0,271	1,761
PHONEMES	-0,722	1,485	-1,040	1,813	1,500	2,065	-0,272	2,066
TOTAL	0,167	2,261	-0,800	3,905	3,500	3,678		

Table 1. Means (M) and standard deviations (SD) per experimental conditions resulting from crossing the modalities of each experimental factor and per modalities of each experimental factor taken separately.

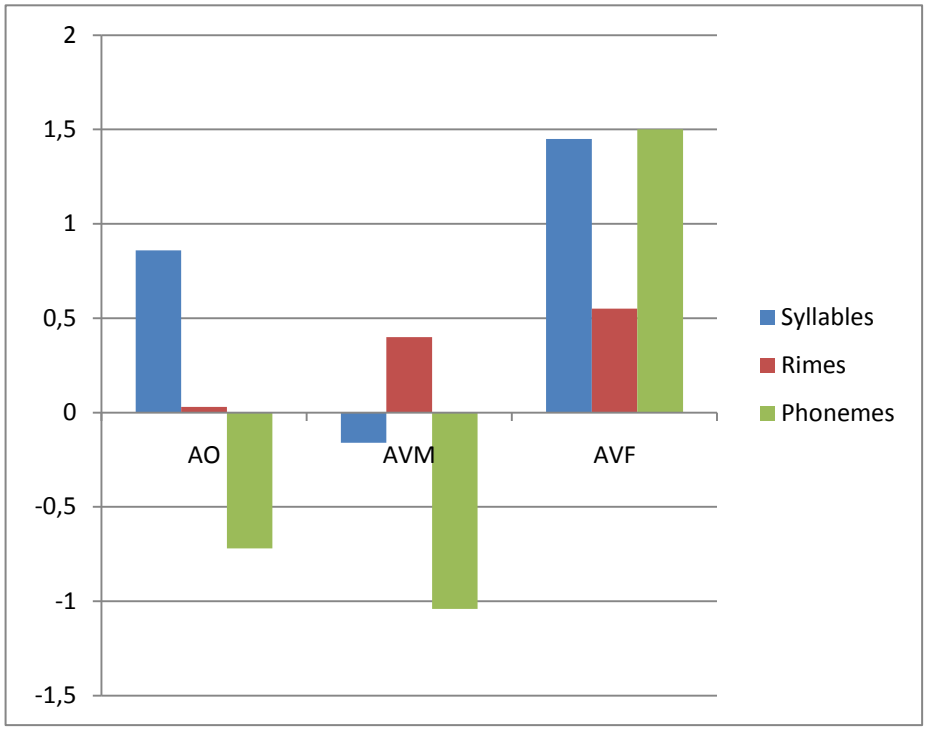

Figure 1. Mean progress/regression per Group and per Exercise Type.

4 Discussion

4.1 Factor "Group"

The effect of the factor "Group", relative to the training material, was found to be significant. The results partially confirm our initial hypothesis. In fact, the results show that the use of visual information relative to articulatory movements can indeed enhance the learning of phonological awareness skills in pres-school children, but only if articulatory movements are presented in a rather holistic context, notably the context of whole face. If articulatory movements are presented in a rather localized format, notably the one of mouth, accompanying auditory information with the visual one is not more efficient than auditory training. In fact, in our study, there was even a slight but insignificant tendency of multimodal audio-visual training with visual information presented in the context of mouth being even less efficient than the audio only training.

Our results imply that pre-school children are only able to extract phonological information which enhances oral language perception out of a rather holistic format, meaning they have a rather holistic approach to the processing of this kind of visual information. The fact the visual information presented in a context of mouth did not add anything to the audio-only version of training could therefore be interpreted by considering pre-school children as unable to adequately process articulatory movements taken out of the context of face. This can somehow be surprising since it is the mouth (with the jaw, the teeth, the tongue, the lips) that provides the most critical phonological cues. Furthermore, some of the studies (e.g., Schwartz, Berthommier, Savariaux, 2004) conducted on adults found a facilitative effect of visual information in speech perception while using mouth format of articulatory movements presentation. Thus, we think that articulatory movements processing might change during development, going from more holistic to the more localized one. A research exploring developmental factors in articulatory movements processing with the use of noise degradation paradigm is currently being carried out by our research team. It would also be interesting to explore this subject with neuro-scientific approach. Notably, the fact that the multimodal AVF training was the most efficient one while pre-test and post-test items were presented in a unimodal way (auditory information only) could suggest that the neural mechanisms supporting phonological processing were somehow modified during the training.

4.2 Factor "Exercise Type"

The effect of the factor "Group", relative to the form of phonological awareness skills measured by a particular exercise, was found to be significant. The results invalidate our initial hypothesis. Based on literature data showing that, in children, phonological awareness develops last for phonemes (e.g., Goswami, Bryant, 1990), we were expecting phonological awareness to be most sensitive to the effects of training at the level of phonemes. Thus, we were expecting that the greatest progress would be made at the level of phonemes. However, our results show that the most important progress was made at the level of syllables, while at the level of phonemes there was even a small overall regression.

Such results need to be interpreted with careful consideration of the methodology used. First, note that pre-test and post-test items were not matched on phonological criteria such as consonant type or sonority contrast between two subsequent phonemes. It is thus possible that

the post-test items were more difficult to process than the pre-test items. A negative difference between the post-test and the pre-test scores noted in the exercise "Phonemes" can therefore result from the differences in difficulty level between items and does not mean that the phonological awareness training had a counter-productive effect. Second, the reason why the greatest progress was made at the level of syllables probably lies in methodological issues concerning training exercises. In fact, the number of exercises used to train phonological awareness of syllables was much more important than the number of exercises used to train the other two form of phonological awareness. (There were 9 exercises for syllables, 2 exercises for rimes and 6 exercises for phonemes.) The amplitude of the progress at the exercise "Syllables" is therefore probably due to this methodological bias. To obtain valid results at this level, the study needs to be replicated with the use of a training method homogenous in the number of exercises and the types of tasks used for training the three forms of phonological awareness.

4.3 Interaction between factors "Group" and "Exercise Type"

The effect of the interaction between the two experimental factors was found to be significant. The results confirm our initial hypothesis – despite the methodological issues mentioned above, the greatest difference between the AVF and the other two groups was indeed found at the level of phonemic awareness. In fact, the AVF group was the only group presenting progress at the level of phonemes; the other two groups both presented relatively important regressions. Thus, accompanying auditory information with the visual one presented in the context of whole face is particularly efficient for phonological awareness learning at the level of the smallest phonological units – phonemes. This implies that pre-school children are able to extract fine phonological cues out of visual information, but only when a relatively holistic processing of articulatory movements is possible. On the contrary, multimodal phonological awareness learning, combining auditory information with the visual one presented in the context of mouth turned out to be as efficient as learning with auditory support only. The AVM training was even presenting a tendency (although insignificant) towards being the least efficient. This might be interpreted as a result of the incapacity of young children to process auditory movements presented in a rather localized context. However, since the visual support was used, some of attentional resources were probably invested in its processing, which might have resulted in a slightly less profound processing of auditory information. Hence, the efficiency of the AVM training tended to be the lowest. This is yet another subject that calls for further research.

5 Conclusion

In the present study, the role of the use of visual information to the efficiency of phonological awareness learning in pre-school children was examined. We were interested to know if visual information was facilitative of this type of learning and in the manner visual information needed to be presented in order to have the most facilitative effect. Our results showed phonological awareness learning was only enhanced by the use of visual information presented in the context of face. Its contribution was the most important at the phonemic level. On the contrary, visual information presented in the context of mouth did not improve

phonological awareness learning. In this case, audio-visual training was even slightly less efficient than the auditory only one. Such results suggest that pre-school children are able to process visual information in order to extract phonological cues it offers but only when articulatory movements are presented in a rather holistic context. If confirmed, such results could have important theoretical and practical implications. The study also rises numerous questions and problematic for further research, one of them being the developmental aspects of articulatory movements processing.

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