The role of literacy in the recognition of phonological units

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In this study, we analysed the relation existing between literacy and the clear representation of specific phonological structures during tasks requiring competence of phonological processes. The first question to deal with is whether the division of the spoken *continuum* into discrete units depends on the mastery of an alphabetic writing system. The second question is whether this knowledge is the display of a linguistic, or rather metalinguistic, competence, which allows us to consider language and to analyse uttered words as phonemes.

The survey was based on two experiments, respectively inquiring into phonemes and syllables in 12 sequences of laboratory speech and 12 sequences of natural speech. The survey involved two groups of Italian-speaking adults: 16 students/workers attending an evening school, experiencing great difficulty in reading and writing tasks, and 16 graduates, whose professions required both ability in and frequent use of orthographical competence.

We considered it interesting to make a qualitative analysis on this basis. Only the test for phonemic surveying was considered. Our aim was to understand if the different target phonemes analysed were equally recognized or if probably different acoustic and articulatory features made it more or less easy to recognize some phonemes rather than others.

Therefore, it is clear how important it is, during a survey, to consider different variables. These variables are extralinguistic conditions, such as literacy and illiteracy and, much more important, linguistic, phonological and lexical conditions, such as the two different kinds of material, or the consonant and vowel targets.

1. Introduction

The aim of this study is to make a contribution, through an experimental survey, to the discussion on the relation existing between literacy, on one side, and perception and recognition of specific phonological structures, on the other. The question to deal with is if the possession of abilities, such as reading and writing, has a role in the process of phonological segmentation and categorization of speech.

Dividing the spoken *continuum* into discrete units and recognizing these units are process of human mind, having no counterpart in physical reality. The question psycholinguistics has long asked is if

Rivista di Linguistica, 13.1 (2001), p. 85-98 *(ricevuto nel giugno 2001)*

this process is based, in part at least, on the mastery of an alphabetic writing system. The second question is whether this knowledge is the display of a linguistic, or rather metalinguistic, competence, which allows us to consider language and to analyse uttered words as phonemes.

We cannot completely share the methodology that assumes the speaker's phonological competence *a priori*, on the basis of explicit judgement, which is exclusively required to subjects having orthographical competences. [1]

The discussion on the subject was developed most of all in psycholinguistics. There are three lines of research in this discipline:

1. analysis on the comparison between literate and illiterate adults in phonological tasks (Morais *et al*. 1979).

2. analysis on readers of non-alphabetic writing (Read *et al*. 1986).

3. analysis on the comparison between children having normal reading abilities and dyslexic children (Laenderl *et al*. 1996).

Results coming from the three studies are coherent beyond any doubt. Illiterate people and readers of non-alphabetic writing present a low percentage of correct responses in phonological tasks. Dyslexic children (considering that dyslexia is an illness involving reading and text understanding abilities) show a high percentage of correct responses in tasks of phonemic manipulation, in which a phonological representation, not influenced by orthography, is essential. There could arise the doubt that consciousness of phonemes is not developed spontaneously, but that it is a part of the speaker's 'linguistic baggage' which derives from the experience gained through literacy.

There is another aspect to stress in order to complete a bibliographical survey. In fact, it would be a great mistake to consider phonological knowledge as something homogeneous, because numerous and irrefutable data (Morais *et al*. 1986; Treiman & Zukowsky 1991; Eimas 1999) indicate a reality on "dissociated" levels. If the absence of reading and writing education does not seem even to allow the development of an analysis into phonetical units, this does not occur for units such as rhymes and syllables. In the absence of different evidence, such an indication could be explained by the fact that, in oral cultures, poets are however capable of using assonance, alliteration and rhyme relations in their poetical works and they can build up rhythmic sequences based on the number of syllables within the line.

Therefore the hypothesis worth considering is that the basic

code, used in the strategies of segmentation and of speech perception and in the representation of lexical items, is the syllabic one. Further strategies, such as the one based on phonetic units, are 'restricted' and acquired later.

A starting point, for the Italian language, whithin the project dealing mostly, if not exclusively, with other languages, is the research by Albano Leoni *et al.* (1997). Results obtained in the phonemic survey from the two groups of people analysed (semi-illiterate/literate), on three kinds of material (natural/laboratory/structured), show a relative difficulty of completion for everyone, but a significant difference for literate people under laboratory conditions.

The hypothesis presented is that there are two active competences in communication: the linguistic competence and the metalinguistic one, the latter concerning the way in which we observe and consider language. This competence would not be available for all speakers in the same way, but defined by different experiences, among which there is contact with the learning of orthography. The string of discrete elements would be a part of this competence and it would be available only for literate people. This study is a constant point of reference for the research here presented, concerning both methodology and the choice of materials for the test.

2. Materials and methods

The data on which this study was conducted come from the cross analysis of two different tests, phoneme monitoring and syllable monitoring.

For both tasks we used the same phonic sequences, belonging to two distinct and well-defined groups:

24 sequences of natural material (12 experimental sequences and 12 fillers) taken from a recording of regional TV news. They are meaningful sentences, but characterised by a sort of prosodic, syntactic and often semantic incompleteness. Moreover, a necessary condition for the choice of materials was the single occurrence of the target event (phoneme or syllable) within every sequence.

Two list are given (respectively with phonemic and syllabic targets in bold characters and in phonemic transcription) with the 12 experimental sequences. In fact, fillers had no influence either on statistical analysis or on qualitative analysis.

Table 1

	A. Natural material	**A. Natural material**
nm1	…non accetterà **/p/**atti con i fuoriusciti	…non accetterà **/pa/**tti con i fuoriusciti
nm2	…basato su due grandi **/p/**oli	…basato su due grandi **/po/**li
nm3	…per ora ritenuto a**/d/**atto allo scopo	…per ora ritenuto a**/da/**tto allo scopo
nm4	…rinviato a **/d/**opo il venti giugno	…rinviato a **/do/**po il venti giugno
nm5	…vorrebbe tagliare **/s/**ubito il cordone ombelicale	…vorrebbe tagliare **/su/**bito il cordone ombelicale
nm6	…accade da più di un **/s/**ecolo	…accade da più di un **/se/**colo
nm7	…sembra cogliere la **/v/**oglia di andare ad uno scontro	…sembra cogliere la **/vo/**glia di andare ad uno scontro
nm8	…in cambio di posti di la**/v/**oro	…in cambio di posti di la**/vo/**ro
nm9	…anche questo ha portato alla sconf**/i/**tta	…anche questo ha portato alla scon**/fi/**tta
nm10	…per entrare a reg**/i/**me	…per entrare a re/**dʒi**/me
nm11	…fino ai pattisti di S**/e/**gni	…fino ai pattisti di **/se/**gni
nm12	…la tornata di dom**/e/**nica scorsa	…la tornata di do**/me/**nica scorsa

24 sequences of laboratory material made up of words read in acoustically controlled conditions and built up as the experiment requires.

The following list are given here (we simply refer to the experimental sequences):

Table 2

	B. Laboratory material	**B. Laboratory material**
lm1	Ha mangiato del **/p/**ane a tavola	Ha mangiato del **/pa/**ne a tavola
lm2	La notizia è nella seconda **/p/**agina del giornale	La notizia è nella seconda **/pa/**gina del giornale
lm3	Puoi avere fi**/d/**ucia in me	Puoi avere fi**/du/**cia in me
lm4	Silvia è una **/d/**onna meravigliosa	Silvia è una **/do/**nna meravigliosa
lm5	C'è grande incertezza al con**/s/**iglio comunale di Napoli	C'è grande incertezza al con**/si/**glio comunale di Napoli
lm6	Lavorano fuori **/s/**ede a Milano	Lavorano fuori **/se/**de a Milano
lm7	È stata una **/v/**era delusione	È stata una **/ve/**ra delusione
lm8	I fantini trattano i ca**/v/**alli con molta dolcezza	I fantini trattano i ca**/va/**lli con molta dolcezza
lm9	L'avvocato deve garant**/i/**re per Paolo	L'avvocato deve garan**/ti/**re per Paolo
lm10	Non può sal**/i/**re le scale	Non può sa**/li/**re le scale
lm11	Non mi hai più dato la ric**/e/**tta	Non mi hai più dato la ri**/tʃe/**tta
lm12	La notizia l'ha data il minist**/e/**ro oggi	La notizia l'ha data il minis**/tʃe/**ro oggi

The test was submitted to two groups each of 16 people. The first group was made up of 10 men and 6 women, aged between 20 and 55. They were students of a state evening school in the suburbs of Naples, attending the school for a course leading to the school-leaving certificate of the Italian middle school. They had all obtained the elementary school-leaving certificate, but the time elapsing between the current time and the last time they went to school ranged from 10 to 40 years according to their age. In spite of this, people belonging to this first group cannot be defined illiterate. They have, however, a great difficulty in reading and writing. In fact, we made certain from their teachers' comments, that they were the weakest from an educational point of view.

The second group was made up of 8 men and 8 women, aged between 23 and 50. The sixteen subjects were all graduates and worked as teachers, or university and medical researchers requiring ability and frequent use of reading and writing skills for their jobs.

The two groups of people, who were first tested on phoneme monitoring and then, after a week, on syllable monitoring, performed the following test.

Sitting in front of a computer, the person hears a bip warning him/her of the beginning of the experiment. After a pause of 2000/ms, a message arrives, informing the person of the target event (phoneme or syllable), then another pause of 500/ms and finally the phonic sequence. As soon as the person recognizes the target, the person has to push the spacebar on the computer keyboard, the sequence stops and another one immediately begins as before.

3. Results

3.1. Interrelation among variables

The conditions of literacy/semi-illiteracy relative to subjects, the laboratory/natural kind of materials, the phoneme/syllable recognition for targets are to be considered three independent variables, that is to say, controlled by the experimenter. Reaction times and errors are, instead, to be considered two dependent variables. The values of the variables are not established beforehand, but depend on the test performed by each subject.

Therefore, we will consider the interaction among variables from

the more general to the more detailed level and we will firstly refer to reaction times and then to the number of errors.

After an initial analysis, the mean recognition times concerning phonemes and syllables shows a higher rapidity in the recognition of syllables when compared to phonemes. The difference of 244/ms in reaction times for the two tests is in fact significant from a statistical point of view:

Table 3

	Phonemes	**Syllables**
Half-illiterate/literate	1626 ms.	1382 ms.

More precisely, in the condition of semi-illiteracy, the improvement from phoneme recognition to syllable recognition is much more evident, with a difference of 300 ms (approximately), when compared with the 200 ms (approximately) used by graduates. Moreover, literate subjects are quicker in recognising both phonemes and syllables, but with a more significant advantage in the first test.

Table 4

	Literate	**Semi-illiterate**
Phonemes **Syllables**	1569 1373	1683 1391

Concerning the different nature of the materials used, we could note that in phoneme monitoring, involving exclusively the laboratory material, there occurred a significant improvement of literate subjects when compared with semi-illiterate subjects.

Concerning errors analysis, we noted, in general, a better performance in recognising syllables compared with phonemes, both by graduates and by students/workers. Students/workers reveal, however, a more remarkable improvement when compared to graduates, together with reaction times. We also noted a significant difference between laboratory conditions and natural conditions as for errors, with an advantage for laboratory conditions in the phoneme monitoring test for literate subjects.

The following conclusions can be drawn from the above data. If we suppose in the speaker's mind two ways of lexical completion, a phonic icon with a low resolution (cfr. Albano Leoni *et al*. 1997) and what we can define an orthographical lexicon, the prototype which can be drawn presents a two-way relation between these two systems. We want to confirm that interference could only be possible if people have an orthographical lexical structure acquired by the learning of reading and writing. A crucial point is to establish when this interaction could occur.

The hypothesis supported in this study is that the appropriate form of lexical representation is not the primary step in decoding the acoustic message. The recognition of natural speech would occur prevalently because of cognitive resources available for each speaker (syntax, semantics, context). When these resources are not sufficient, in cases of misunderstanding, speakers turn to metalinguistic resources. According to what has been stated up to now, these resources cannot be activated for everybody in the same way. Speakers who are able to use them because they have a good orthographical competence, will turn to the support given by the phonemic code (in the case of use of alphabetical writing). People who cannot use them, instead, will use a syllabic code that, as we have already said, seems more easily accessible for all subjects. Perception and recognition of phonemes and syllables can be seen, in this way, in terms of a balanced interaction between linguistic and metalinguistic activities. On the contrary, given the difficulty of establishing a two-way relation among acoustic manifestations of natural speech and the appropriate representation of linguistic units, it would be difficult even to imagine these linguistic units as directly and immediately involved in the understanding of natural speech.

The results stressed seem to lead to the same direction. It should be emphasized that the general difficulty in recognizing phonemes when compared with syllables for both groups of people confirms the greater naturalness of syllables in metalinguistic tasks (Morais *et al*. 1986; Treiman & Zukowsky 1991; Eimas 1999). The emphasis on the gap between the two groups in the availability of a metalanguage, which becomes more and more perfect in proportion to the level of literacy, can be explained by two considerations. The former is the remarkable improvement of illiterate people during the passage from the phonemic recognition task to the syllabic one when compared with literate people. The latter consideration is the greater difference presented in phoneme monitoring rather than syllable between gra-

duates and students/workers. In the phoneme test, which is common to this study and to that by Albano Leoni *et al.* (1997), an interesting agreement of the data is to be noted. In this test we can observe a significant improvement for literate people in laboratory conditions. An equally significant improvement is not to be seen for semi-illiterates, neither in the natural condition of the same task nor, for both kinds of materials, in the syllabic recognition, relative to the most recent test only.

These data would indicate a strong activation of the cognitive burden for both groups of people in recognizing natural speech, which would not leave any space for the activation of the phonemic code. In laboratory speech where the required cognitive burden is smaller, there would be the possibility to use a phonemic representation, even if only for the subjects able to use it. If the task requires a syllabic recognition, differences are smaller, even where the cognitive burden for the recognition of the stimulus is less urgent because the use of the (syllabic) code itself is possible for all subjects.

3.2. Qualitative analysis

A qualitative analysis was also made on the target phonemes of experimental materials. The intention was to understand if, and to what extent, some specific phonemes were recognized better than others, and if the fact that a word belongs to a certain part of the discourse rather than to another can have influenced the recognition of the phonemes. To give an example, a table is shown, in which, for each word containing a target, the average of reaction times and the total number of errors are reported without any distinction concerning either subjects or kind of materials, but with distinction of their grammatical class. It did not seem appropriate to make further considerations because the number of elements of the four classes is not perfectly balanced in order to allow a significant analysis.

Table 5

Names	Times	Mist.	Adj.	Times	Mist.	Verbs	Times	Mist.	Adverbs	Times	Mist.
pane	1496,8	4									
pagina	1471,5	6									
fiducia	1559	12									
donna	1522,7	8									
consiglio	1866,10										
sede	2115	4									
			vera	1505,9	7						
cavalli	1461,13										
						garantire	1471,9	14			
						salire	1517,9	13			
ricetta	1148,5	15									
ministero	1425,6	13									
patti	1636,4	7									
poli	1405,1	8									
			adatto	1491	13						
									dopo	1674	9
									subito	2160	9
secolo	2111	6									
voglia	1483	6									
lavoro	978	28									
sconfitta	1344,11	12									
regime	1315,611	19									
Segni	1278,625										
Domenica	1378	24									

Concerning the kind of phonemes, we kept apart the two conditions of literacy vs. illiteracy of the subjects and two different groups were formed.

In the former case, the six kinds of phonemes are separated whereas the variable relative to the kind of material is unified. Below are the tables of reaction times and errors made concerning the two groups considered:

Table 6. Semi-illiterate

	times		**errors**
p	1526,049	**p**	23
d	1577,29	**d**	33
s	2092,825	**s**	24
v	1458,08	**v**	39
i	1434,524	**i**	43
e	1359,769	**e**	51

Table 7. Literate

	times		**errors**
p	1473,726	**p**	2
d	1558,782	**d**	9
s	2055,254	**s**	5
v	1454,286	**v**	15
i	1390,551	**i**	15
e	1276,095	**e**	22

The first difference we want to underline is between consonants and vowels.

Concerning vowels, reaction times are much lower when compared to consonants, both for semi-illiterate and for literate subjects. This does not mean automatically that vowels are recognized better than consonants because, in the case of errors, we observe a completely opposite situation.

For both groups, in fact, vowels are also the targets on which the greatest number of errors concentrates. A trade-off is to be observed in the recognition of vowels, according to which the subjects are quicker, but pay less attention to their task. The contrary happens for consonants.

Concerning consonants, among the four analysed, the consonant

/v/ seems to show a situation similar to that of vowels: a low reaction time and a high number of errors, both for literate and semi-illiterate people. However, a deeper analysis on single target sequences with their relative stimuli casts new light on the situation noted above.

Below, a table is shown, summarizing times and errors of each sequence for both groups of people.

Table 8

		Illiterate		**Literate**	
		Averages	**Errors**	**Averages**	**Errors**
LM1	**p**	1532,583	4	1461,188	0
LM2	**p**	1517,6	6	1425,5	0
LM3	**d**	1611,333	10	1506,714	2
LM4	**d**	1611,333	7	1434,133	1
LM5	**s**	1822	9	1910,867	1
LM6	**s**	2192,167	4	2037,938	0
LM7	**v**	1552,444	7	1459,375	0
LM8	**v**	1449,75	12	1474,2	1
LM9	**i**	1565	11	1378,923	3
LM10	**i**	1586,2	11	1449,786	2
LM11	**e**	1076	12	1221,154	3
LM12	**e**	1610,833	10	1240,538	3
NM1	**p**	1742,444	7	1530,375	0
NM2	**p**	1331,9	6	1478,429	2
NM3	**d**	1350	10	1632	3
NM4	**d**	1662,6	6	1685,462	3
NM5	**s**	2183,2	6	2136,846	3
NM6	**s**	2074,636	5	2147,4	1
NM7	**v**	1486,3	6	1481,438	0
NM8	**v**	909	14	1047	14
NM9	**i**	1315	9	1373,231	3
NM10	**i**	1291	12	1340,222	7
NM11	**e**	1236	13	1321,25	8
NM12	**e**	xxxx	16	1378	8

The sequence nm8 (natural material), containing one of the four stimuli /v/, is not recognised 14 times out of 16 by both groups of subjects. On the contrary, in case of recognition, the reaction times are very low. It is evident that this failed recognition is a feature linked to the stimulus and not to the kind of target. This assumption is supported by the fact that the second element /v/ of the couple of natural material (nm7) is recognized at its best by literate subjects and with few errors compared to the average of illiterate people. Through a deeper analysis of the acoustic spectrum, the target /v/ in

nm8 in the word *lavoro* 'job' is performed more as a labiodental approximant and, for this reason, much closer to vowels in its phonic substance. [2]

The question concerning the other three kinds of consonants is different. The unvoiced occlusive shows reaction times which are lower when compared to the voiced occlusive and the unvoiced fricative, but differently from what happened in the comparison between the two groups of consonants and of vowels, it shows a clear advantage of recognition even when errors are concerned.

In the latter case, phonemes are grouped without any discrimination between the presence or absence of voice sonority. Three groups of phonemes (occlusive-fricative-vowels) were taken into consideration. The reaction times and number of errors of these phonemes remain separate according to the nature of material (natural *vs.* laboratory). Two tables are presented below, summarizing respectively the reaction times and errors of semi-illiterate and literate subjects.

Table 9. Semi-illiterate

		Times			**Errors**
p/d	lm	1560,459	**p/d**	lm	27
	nm	1535,057		nm	29
s/v	lm	1838,469	**s/v**	lm	32
	nm	1858,606		nm	31
i/e	lm	1486,25	**i/e**	lm	44
	nm	1291,214		nm	50

Table 10. Literate

		Times			**Errors**
p/d	lm	1455,623	**p/d**	lm	3
	nm	1576,982		nm	8
s/v	lm	1721,5	**s/v**	lm	2
	nm	1864,935		nm	18
i/e	lm	1325	**i/e**	lm	11
	nm	1355,474		nm	26

The tendency is one-way both for natural material and for laboratory material: short times and remarkable errors for the subgroup i~e; a marked advantage of recognition for the subgroup p~d when compared to the subgroup s~v both concerning reaction times and

errors. Finally, we want to stress that the only detectable difference between literate and semi-illiterate subjects during the recognition test is a better performance of the former group on laboratory material in all the three subgroups of phonemes. These results are in compliance with the tendency noted in the statistical analysis discussed in the preceding paragraph.

So, there are two conclusions to draw.

1. Concerning the different behaviour of consonants and vowels in the recognition strategy, the following hypothesis is proposed. The poor attention paid to vowels by the subjects, which is evident from the number of errors, could depend on the fact that vowels physically act as a support for consonants. If they are taken off from a sequence, they would not cause particular difficulties in decoding the sequence itself. So, paying greater attention to the surveying of consonants would be part of the recognition mechanism. Besides, vocalic tones tend to be confused much more than specific phonetic features of consonants, making the identification of vowels themselves more difficult to perform. Vowels, in fact, are often exposed to reduction, in spite of the phonetic context in which they are found. It rarely happens, instead, that events such as a shift towards fricative or voiced consonants occur outside specific sequences of phonemes.

2. Concerning the recognition of consonants, it was found that the unvoiced occlusive is the more easily recognized phoneme. If it is true that the addition of phonetic features increases the markedness of an element, the advantage on reaction times and errors concerning /p/ seems coherent with the situation that shows the unmarked parts as more natural. These parts are, in fact, more frequent, more spread within the various phonological systems in the world and the first to be acquired in linguistic development (the occlusive /p/ in fact lacks voice).

The preceding reflections would need to be, in any case, further verified during experiments that take into consideration a greater quantity of data and allow also a statistical analysis of the materials under examination.

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Note

[1] For example, M. Nespor (1993:20-ff.): "…Concentrandosi sull'aspetto fisico del suono, la fonetica si distingue perciò dalla fonologia che…si concentra sull'aspetto mentale, cioè sul sistema che governa la competenza fonologica del parlante nativo. Se per esempio chiediamo a un parlante nativo dell'italiano qual è la composizione sonora di una parola come vento, molto probabilmente dirà che questa parola contiene cinque suoni, tre consonantici e due vocalici…"

[2] The non-fricative nature of the 'phone' [v] in the context VCV was taken into consideration, for example, in a work by Rispoli & Savy published in 1993. In this work, the 'phone' is defined, according to specific spectro-acoustic features (such as the lack of noise and the formantic structure), as a labiodental approximant.

Bibliographical References

ALBANO LEONI Federico, Francesco CUTUGNO & Alessandro LAUDANNA (1997), "L'attivazione di rappresentazioni fonetiche durante il riconos cimento del parlato: una risorsa metalinguistica?", in Benincà e altri (1997:35-52)

BENINCÀ Paola e altri, eds. (1997), *Fonologia e morfologia dell'italiano e dei dialetti d'Italia,* Roma, Bulzoni

BRADY S. A. & D. P. SHANWEILER, eds. (1991), *Phonological Process in Literacy,* Hillsdale, Lawrence Erlbaum

EIMAS Peter D. (1999), "Segmental and syllabic representation in the perception of speech by young infants", *Journal of Acoustical Society of America* 105:1901-1911

LAENDERL Karin, Uta FRITH & Heinz WIMMER (1996), "Intrusion of orthographic knowledge on phoneme awareness: Strong in normal readers, weack in dyslexic readers", *Applied Psycholinguistics* 17:1-14

MORAIS Josè, Paul BERTELSON, Luz CARY & Jesus ALEGRIA (1986), "Literacy training and speech segmentation", *Cognition* 24:45-64

MORAIS Josè, Luz CARY, Jesus ALEGRIA & Paul BERTELSON (1979), "Does awareness of speech as a sequence of phones arise spontaneously?", *Cognition* 7:323-331

NESPOR Marina (1993), *Fonologia*, Bologna, Il Mulino

PERETTI A.& Franco FERRERO, eds. (1993), *Atti del XXI Convegno Nazionale*, Padova, A.G.P.

READ Charles, Yun-Fei ZHANG, Hong-Yin NIE & Bao-Quing DING (1986), "The ability to manipulate speech sounds depends on knowing alphabetic writing", *Cognition* 24:31

RISPOLI Gianpiero & Renata SAVY (1993), "Alcune considerazioni spettroacustiche sulla [v] italiana", in Peretti A., Ferrero F. (1993:91-94)

TREIMAN Rebecca & Andrea ZUKOWSKY "Levels of Phonological Awareness", in Brady S. A. & Shanweiler D. P (1991:67-83)