Relationship between vocabulary and short-term memory in Down's syndrome.

The relationship between short-term memory and language acquisition and development in Down's syndrome. (Down's Syndrome Research Forum: Sarah Duffen Centre, Department of Psychology, University of Portsmouth les 27 et 28 avril 1995).

Key words: Down's syndrome - Verbal short-term memory - Lexical knowledge

ABSTRACT

Some neuropsychological studies of brain damaged patients and studies of typical young children lead to the conclusion that the phonological short-term memory abilities directly influence the way new vocabulary items are acquired. As Down's syndrome people generally show an impairment of phonological short-term memory and a lack in lexical knowledge, we decided to study the relationship between both variables in this population. Our results indicate that in Down's syndrome subjects, as well as in typically developing children lexical knowledge seems to be linked to the phonological short-term memory abilities and more specially to nonword repetition.

INTRODUCTION

This article aims to answer the question asked by Jarrold and Baddeley (1997) concerning a potential link between verbal short-term memory and lexical development in Down's syndrome. In their article, appeared in "Cognitive Neuropsychiatry", they showed that Down's syndrome subjects have a higher nonverbal than verbal mental age. The authors refused to conlude that Down's syndrome verbal short-term "memory problems are just the result of this general profil" (p.113) and claimed that Down's syndrome is in fact associated with a selective impairment of the phonological loop of Baddeley and Hitch's working memory model (1974). In the same article they reminded Gathercole et al. (1989, 1992, 1993) studies pointing the strong relationship in normally developping children beween verbal short-term memory and lexical development. So, they asked themselves about the same relationship in Down's syndrome. They wrote that "if Down's syndrome is associated with selective damage to the verbal short-term memory system then we would not necessarily expect to find a similar relationship. In particular, we would predict that vocabulary acquisition might proceed largely by a route other than the one mediated by phonological memory, such as age-related acquisition through repeated exposure to word-object pairings" (Jarrold and Baddeley, 1997, p.113). Finally, Jarrold and Baddeley precise that their study does not include any individuals with Down's syndrome presenting a high level of language. Refering to Rondal (1995) and Vallar and Papagno (1993), they hypothese that maybe such subjects would show a less important memory deficit than "standard" Down's syndrome. Futhermore, they added that confirming this hypothesis would

be very important for practical intervention in Down's syndrome aiming to improve phonological short-term memory.

Before describing more precisely our work, we would like to stress some important points in Gathercole and colloborators' theory concerning the influence of verbal short-term memory in lexical learning. The relationship between verbal short-term memory and learning new words was first stress by Baddeley, Papagno and Vallar (1988) in their study of a brain damaged patient (PV). Gathercole et al. studies (19889, 1992, 1993) pointed the same relationship in normally developing children. So, from a developmental point of view, they discussed the role of verbal short-term memory in native vocabulary acquisition. Baddeley, Gathercole and Papagno (1998) suggested that the phonological loop function is to help learn new words. More precisely, the phonological loop system mediates the long-term phonological learning involved new lexical items acquisition. Futhermore, the more the new phonological forms are unfamiliar, the more the role of the phonological loop is important and significant. If the phonological loop plays a

So, this paper aims to determine wether individual differences in verbal short-term memory skills have the same impact on the ability to learn new vocabulary items in Down's syndrome subjects known to have restricted memory abilities as in normally developing children.

METHOD

- Participants :

Twenty three French speaking Down's syndrome subjects were assessed. The participants were divided into three groups of age: children, adolescents and adults.

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Insert Table about 1 here

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- Procedure :

The subjects' mental age was calculated with the "Echelles Différentielles d'Efficience Intellectuelle" (E.D.E.I, Perron-Borelli & Misès, 1974). The subjects' non-verbal mental age was calculated Calculated with the Color Matrix of Raven -PM47- (Raven, 1947). Let's note that the global mental age tests are usually composed of several tasks assessing the subject's lexical abilities. In the present case, the E.D.E.I. contains both a picture naming task and a word definition task. These two tasks compose the verbal scale of the test. In contrast, the non-verbal mental age test (Color Matrix of Raven) does not imply an assessment of the subject's lexical abilities. It only involves spatial ability.

The subject' lexical knowledge was assessed with a productive vocabulary test (E.V.P. --Epreuve de Vocabulaire Productif, pilot version-- Comblain, 1994), which is a picture naming task. The subjects have to identify 732 pictures representing words from 13 semantic categories (animals, vegetables, fruits, furniture, clothes, vehicles, toys, flowers, tools, rooms, objects, instruments and actions).

Verbal short-term memory was measured by three tasks : two classical span tasks and a nonwords repetition task. In both span tests, subjects were auditorily presented with lists of increasing numbers of items (digits

or short words) to remember. Five trials were given at each length, beginning with a list length of two items. To succeed on any given trial the subject had to recall all the items presented in the correct serial order (order of presentation). Provided subjects were correct on at least three trials at each level they moved on to the next list length level. If they were correct on only two or fewer trials at a given level then the test was terminated at this length level. The list lengths increased by one as the subject move through the test. The items were presented at the rate of one per second. Lists for each trials were made up from a random selection of nine items (the numbers 1 to 9 for digit span, and nine monosyllabic and phonologically dissimilar french words for word span). The nonword repetition task was composed of 40 nonwords (1, 2, 3 and 4 syllables). Half contained single consonants and half consonants in clusters (both at the beginning, in the middle or at the end of the nonword).

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Insert Figure about 1 here

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Each nonword was orally presented. The subjects were asked to repeat each nonword immediately after the examiner (see nonwords list in Appendix).

- RESULTS:

Our data show that subjects presenting the poorer phonological short-term memory abilities are also the ones who have the lower vocabulary level. The subjects' MA and the subjects' nonverbal MA influence differently the level of lexical development. It appears that global MA is the best predictor of the subject's lexical level. It seems that phonological short-term memory abilities also explain a part of the lexical knowledge variation among subjects. Nonverbal MA is not a good predictor of the subjects' lexical level.

Correlations between lexical knowledge and memory abilities (Pearson product-moment correlation coefficient, r) are significant : 0.81 for nonwords, 0.79 for digits and 0.58 for words.

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Insert Table 2 about here

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As can be seen in Table 2, the percentage of correct naming is linked to the three memory span tasks, CA, global MA and non-verbal MA. These first results seem to confirm the existence of a strong relationship between phonological short-term memory and lexical knowledge. The link between these two variables observed in typically developing children (Gathercole and Baddeley, 1989, 1993) seems to be also present in Down's syndrome subjects.

In order to analyze the part of the lexical knowledge variance that can be explained by the subject's memory performances, mental age and chronological age, we performed stepwise regressions.

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Insert Table 3 here

The part of variance explained by digit span and word span is not significant. Nevertheless, we can note that word span explains 13.40 % of the variance [$F(2,20) = 3.10$, NS. In order to be significant at a $p < 0.05$ level,

the F value needed to be 3.13]. The part of variance explained by nonword repetition is significant. Nonword repetition explains 15.84 % of the variance of the lexical knowledge.

For the third analysis, we decided to take into account non-verbal mental age instead of global mental age. We performed stepwise regressions in order to determine the real part of the lexical knowledge variance explained by memory performance, non-verbal MA and CA .

Insert Table 4 here

In this case, it is clear that memory measures (especially nonword repetition and digit span) explain the greatest percentage of the lexical knowledge variation. Let's note that word span explains a lesser percentage of the lexical variance than digit span and nonword repetition. In this case, we see that the chronological age explains the greatest part of the lexical variance (20.25 %). Word span and mental age both explain 13.69 % of the lexical variance.

Insert Figure 2 here

Some may contest the use of global mental age in such experiments because it is constituted partly of verbal measures, especially lexical measures (see Comblain, 1996 for more details). They can assert that the existence of a significant link between lexical knowledge and global mental age is normal. This remark is correct but one can also assume that none of the measures used in this study is "pure". Effectively, if we say that the measure of global mental age is partly constituted by the subject's lexical knowledge, we can also say that short-term memory abilities are probably a component of the subject's global mental age. So, eliminating the influence of global mental age in the variance of the lexical knowledge also eliminates a part of the phonological short-term memory influence. When we see that nonword repetition (for example) only explains 15.84 % of the lexical knowledge, we can assume that this percentage is under-evaluated.

CONCLUSION

Our data, obtained with Down's syndrome subjects, also seems to confirm the above mentioned hypothesis. Subjects presenting the poorer phonological short-term memory abilities were also the ones who presented the lower lexical knowledge. Among the variables with which we have correlated the subjects lexical knowledge, we must point out the global mental age. Effectively, this variable is the one that best explains the variations in the subjects lexical knowledge. So in order to determine the real influence of other factors (such as memory skills) on language development, and especially on lexical knowledge, we must calculate the percentage of variance that remains explained by these factors once the influence of mental age has been eliminated. Doing such an analysis leads to different conclusions if we take into account the influence of global mental age or non-verbal mental age. In the first case, global mental age explains the greatest part of the lexical knowledge variation (82.08 %). The part explained by phonological short-term memory is very limited and significant in only one case

(nonword repetition: 15.84 %). In the second case, phonological short-term memory abilities are the best explanator of the lexical knowledge (nonword repetition: 59.29 % and non-verbal mental age 0.64 %). The fact that the global mental age is not a " pure " measure probably justifies the high percentage of lexical variance that it explains regarding to the little percentage of lexical variance explained by phonological short-term memory abilities. So, we think that in order to have a more correct estimate of the influence of phonological short-term memory abilities on lexical knowledge variations, the variance explained by phonological short-term abilities (measured by nonword repetition, for example) plus the one explained by the mnesic component contained in the global mental age must be taken into account. This suggestion seems to be reinforced by the fact that the influence of non-verbal mental age on lexical knowledge is inferior to the influence of global mental age.

The results of the present research do not allow us to reject Gathercole and Baddeley's hypothesis concerning the existence of a relationship between phonological short-term memory and lexical knowledge. However, we want to stress two particular points. Firstly, the present study (as the one of Gathercole & Baddeley) is mainly based on correlation analysis and, as we know, correlation does not mean causality but only reflects a link between two variables. We also want to point out that none of the studies we have described take into account an important step in childrens' lexical development: the period of fast lexicon acquisition at around 24 months. To our knowledge, no research concerning the relationship between lexical knowledge and phonological short-term memory has been performed with such young children. If there is a real link between both variables, we must find a link at this age too. Secondly, if verbal short-term memory ability of Down's syndrome subjects and typical children can be considered as a key to lexical learning ability, we must limit this "learning" to the phonological form of words. Current data do not allow us to conclude about the acquisition of semantic features associated to the words.

In conclusion, one cannot ignore the results of the numerous studies investigating the relationship between phonological short-term memory and lexical acquisition. At the same time, we recognize that more studies have to be done on this topic in order to have more precise information about this relationship. Nevertheless, it seems important to try to improve Down's syndrome people short-term memory abilities as this improvement can have a positive influence on certain aspects of language development and acquisition.

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Table 1. Details of the three groups.

Group
Children
(N=8)Adolescents
(N=6)
Adults
(N=9)Chronological age (years;months)Mean
Range
8;10
6;10-11;217;8
15;3-19;625;11
Global mental age (years;months)Mean
Range
3;5
3;1-3;95;4
3;7-7;85;0
3;6-5;11Nonverbal mental age (years;months)Mean
Range
4;9
<3;0-6;35;10
4;0-8;64;6
<3;0-7;3

Table 2. Correlations between the lexical tasks and the short-term memory tasks.

1234571. Lexicon0.43*0.77**0.52**0.81**0.76**0.58**2. Chronological age0.43*-0.10*0.220.070.043. Mental age0.57**0.77**0.81**0.50*4. Raven0.56**0.53**5. Nonwords0.54**0.59**6. Digit span0.74**7. Word span* = significant: p<0.05 ** = significant: p<0.01

F of the stepwise regression % of variance explainedMental ageF(1,21) = 95.90, p<0.000182.08 %Chronological ageF(2,20) = 0.25, NS1.25 %NonwordsF(3,19) = 3.75, p<0.0515.84 %Mental ageF(1,21) = 95.90, p<0.000182.08 %Chronological ageF(2,20) = 0.25, NS 1.25 %Word span F(3,19) = 3.10*, NS 13.40 %Mental ageF(1,21) = 95.90, p<0.000182.08 %Chronological ageF(2,20) = 0.25, NS 1.25 %Digit spanF(3,19) = 1.23, NS 5.76 %
* In order to be significant, the value should have been ≥ 3.13

Table 4. Percentage of variance explained by CA, non-verbal MA and memory measures - F of the stepwise regression and statistical level of signification (significant level accepted: p<0.05).

F of the stepwise regression % of variance explainedNonwordsF (1,21) = 39.39, p<0.000159.29 %F (2,20) = 25.36, p<0.00018.41 %Nonverbal mental ageF (3,19) = 1.08, NS0.64 %Word span F (1,21) = 10.85, p<0.00513.69 %Chronological ageF (2,20) = 25.36, p<0.00120.25 %Nonverbal mental age13.69 %Digit spanF (1,21) = 36.17, p<0.000159.29 %Chronological ageF (2,20) = 33.89, p<0.000113.69 %Nonverbal mental ageF (3,19) = 0.13, NS0.64 % Figure 1. Nonwords structure.

40 nonwords
20 with single consonants
(at the initial, middle and final of the nonwords)

20 with consonant clusters
(at the initial, middle and final of the nonwords)
1 syllabe
2 syllabes
3 syllabes
4 syllabes
1 syllabe
2 syllabes
3 syllabes
4 syllabes

Figure 2. Lexical knowledge development regarding nonwords repetition and global MA.

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Appendix. Nonwords list.

One syllable nonwordsThree syllables nonwordsbo

jou

poif

leu

uf

bro

ort

bji

icht

vloumoubano

lurissin

bipeva

takodon

gauzico

upticou

chauprouto

abrova

dzipfoba

olchavra

ignaucreuTwo syllable nonwordsFour syllable nonwordstaudon

minu

cussi

paveu

gauzi

advo

opfu

drifeu

blasto

vliroutoukoupinlan

dépéguilin

fonvopouri

paveuradi

grapodu
minbirnéné
untlodaula
advolola
ichtogoula