TRAINING THE REHEARSAL STRATEGY IN DOWN SYNDROME AND NORMAL CHILDREN: EFFECTS ON MEMORY SPAN, WORD-LENGTH AND PHONOLOGICAL SIMILARITY EFFECT.

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Abstract

Verbal short-term memory skills of Down's syndrome subjects are very poor. As in normal children, it seems possible to increase memory span by using a rehearsal training strategy. Memory span tasks have been proposed to two experimental groups (Down's syndrome subjects / normally developping children) and two control groups (Down's syndrome subjects / normally developping children). The experimental groups were intensively trained to rehearse during 8 weeks. Two post-tests were proposed to the subjects: 1] directly after the training session and 2] six weeks after the training session. We observe an increase of the experimental groups' memory span. The weak modifications of word-length effect and phonological similarity effect seem to confirm that these effects are not due to the rehearsal strategy use.

SUBJECTS

- 24 Down's syndrome subjects french speaking from Liège 's area (Belgium).

	Mean Chronological Age (CA)	**Mean Developmental Age (MA)**
Children (n = 8)	8 years old	3;5 years old
Teenagers (n = 8)	16;7 years old	4;4 years old
Adultes (n = 8)	26;11 years old	4;3 years old

The subjects subdivised into two groups: an experimental group (n = 12) and a control group (n = 12). Each of these groups contained 4 children, 4 teenagers and 4 adultes. The mean MA (and the mean CA) in both groups are not significantly different.

- 24 normally developping children subdivised into two groups experimental group (n = 12) and a control group (n = 12):
  - ° Experimental group's mean CA: 4;9 years old (from 4;5 years old to 5;3 years old).
  - ° Control group's mean CA: 4;8 years old (from 4;3 years old to 5;2 years old).

METHODOLOGY

- Subvocal rehearsal training

* **Training method**: is inspired by the one used by Hulme & Mackenzie (1992) and partly from the one used by Broadley & MacDonald (1993) (see also Comblain, 1994, 1996).

* **Training procedure**:
  - ° 8 weeks (30 minutes / weeks)
  - ° 8 progressive steps (4 steps: visual and oral presentation of the items / 4 steps: oral presentation)

- Memory measures
  1. Short word span -phonologically dissimilar- (SW)
  2. Short word span -phonologically similar- (PSW)
  3. Long word span (LW)
  4. Digit span (D)

RESULTS

1. REHEARSAL TRAINING EFFECT'S ON THE SHORT-TERM MEMORY SPAN

- ***DOWN'S SYNDROME SUBJECTS***

Pré-test (before the training session)	**SW**	**PSW**	**LW**	**D**
Experimental group	2.25 (0.75)	1.42 (0.79)	1.00 (1.04)	2.08 (0.67)
Control group	2.08 (0.67)	1.25 (0.87)	0.92 (0.90)	2.00 (0.60)
Post-test1 (directly after the training session)	**SW**	**PSW**	**LW**	**D**
Experimental group	3.58 (0.51)	1.92 (0.67)	2.00 (0.74)	2.83 (0.39)
Control group	2.00 (.60)	1.17 (.58)	1.33 (.65)	1.33 (.65)
Post-test2 (6 weeks after the training session)	**SW**	**PSW**	**LW**	**D**
Experimental group	2.67 (0.49)	1.75 (0.62)	1.75 (0.62)	1.75 (0.62)
Control group	1.92 (0.51)	1.17 (0.58)	1.17 (0.58)	1.17 (0.58)

Pre-test: the memory performances of the experimental group identical are to the one of the control group (t of Student, significant level $p<0.05$)

	SW	**PSW**	**LW**	**D**
t value	0.573 (NS)	0.492 (NS)	0.209 (NS)	0.209 (NS)

- **Post-test 1: Experimental group vs Control group**

	SW	**PSW**	**LW**	**D**
t value	3.42 $p<0.005$	3.32 $p<0.005$	3.36 $p<0.005$	3.58 $p<0.002$

- **Post-test 2: Experimental group vs Control group**

	SW	**PSW**	**LW**	**D**
t value	3.68 $p<0.002$	2.38 $p<0.05$	2.38 $p<0.05$	3.68 $p<0.002$

- **Experimental group: Pre-test vs Post-test 1 vs Post-test 2** (cf. general table of performance)

→ **repeated mesures ANOVAS**: variable "testing moment" (3 level: pre-test, post-test 1, post-tes 2)

- Significant effect of the variable "testing moment":

SW: $F(3,33) = 56.69$, $p<0.0001$ LW: $F(3,33) = 14.79$, $p<0001$

PSW: $F(3,33) = 3.85$, $p<0.05$ D: $F(3,33) = 13.91$, $p<0.0001$

→ **t of Student**:

	SW	**PSW**	**LW**	**D**
Pre-test vs Post-test 1 (t value)	- 9.38 p<0.0001	- 2.57 p<0.05	- 4.06 p<0.002	- 4.18 p<0.002
Pre-test vs Post-test 2 (t value)	- 2.80 p<0.02	- 1.77 (NS)	- 4.18 p<0.002	- 3.92 p<0.002
Post-test 1 vs Post-test 2 (t value)	11.00 p<0.0001	1.00 (NS)	1.91 (NS)	1.48 (NS)

- **Control group: Pre-test vs Post-test 1 vs Post-test 2** (cf. general table of performance)

→ **repeated mesures ANOVAS**: variable "testing moment" (3 level: pre-test, post-test 1, post-tes 2)

- Significant effect of the variable "testing moment":

SW: F(3,33) = 1.00, NS LW: F (3,33) = 3.94, p<05

PSW: F (3,33) = 0.19, NS D: F (3,33) = 0.48, NS

→ **t of Student for LW**

Pre-test vs Post-test 1: t = -2.80, p<0.02

Pre-test vs Post-test 2: t = - 1.39, NS

Post-test 1 vs Post-test 2 : t = 1.48, NS

- ***NORMALLY DEVELOPPING CHILDREN***

Pre-test (before the training session)	**SW**	**PSW**	**LW**	**D**
Experimental group	3.08 (0.51)	2.83 (0.39)	2.25 (0.45)	3.58 (0.51)
Control group	3.08 (0.51)	2.67 (0.49)	2.42 (0.51)	3.42 (0.67)
Post-test1 (directly after the training session)	**SW**	**PSW**	**LW**	**D**
Experimental group	3.92 (0.67)	3.33 (0.49)	3.17 (0.58)	4.25 (0.45)
Control group	3.08 (0.51)	2.67 (0.49)	2.42 (0.51)	3.42 (0.67)
Post-test2 (6 weeks after the training session)	**SW**	**PSW**	**LW**	**D**
Experimental group	3.75 (0.45)	2.83 (0.39)	2.83 (0.58)	4.33 (0.49)
Control group	3.58 (0.51)	2.67 (0.65)	2.50 (0.52)	3.50 (0.52)

Pre-test: the memory performances of the experimental group identical are to the one of the control group (t of Student, significant level $p<0.05$)

	SW	**PSW**	**LW**	**D**
t value	-*	0.920 (NS)	- 0.842 (NS)	0.684 (NS)

* = identical performances in both experimental and control groups

- **Post-test 1: Experimental group vs Control group**

	SW	**PSW**	**LW**	**D**
t value	3.42 p<0.005	3.32 p<0.005	3.36 p<0.005	3.58 p<0.002

- **Post-test 2: Experimental group vs Control group**

	SW	**PSW**	**LW**	**D**
t value	0.94 (NS)	0.76 (NS)	1.48 (NS)	4.02 p<0.001

- **Experimental group: Pre-test vs Post-test 1 vs Post-test 2**

→ **repeated mesures ANOVAS**: variable "testing moment" (3 level: pre-test, post-test 1, post-tes 2)

- Significant effect of the variable "testing moment":

SW: $F(3,33) = 9.63$, $p<0.001$ LW: $F(3,33) = 9.22$, $p<002$

PSW: $F(3,33) = 6.60$, $p<0.01$ D: $F(3,33) = 13.61$, $p<0.001$

→ **t of Student**:

	SW	**PSW**	**LW**	**D**
Pre-test vs Post-test 1 (t value)	- 3.46 p<0.01	- 2.57 p<0.05	- 4.75 p<0.001	- 3.55 p<0.005
Pre-test vs Post-test 2 (t value)	- 4.69 p<0.001	0.00 (NS)	- 2.55 p<0.05	- 4.18 p<0.002

Post-test 1 vs Post-test 2 (t value)	0.80 (NS)	3.32 p<0.01	1.48 (NS)	- 1.00 (NS)

- **Control group: Pre-test vs Post-test 1 vs Post-test 2**

→ **repeated mesures ANOVAS**: variable "testing moment" (3 level: pre-test, post-test 1, post-tes 2)

- Significant effect of the variable "testing moment":

SW: F(3,33) = *, NS LW: F (3,33) = 0.83, NS

PSW: F (3,33) = 0.73, NS D: F(3,33) = 11.00, p<0.0005

* = memory span is identical for both moment of evaluation considerated

→ **t of Student for D**

Pre-test vs Post-test 1: t = *, NS

Pre-test vs Post-test 2: t = - 3.32, P<0.01

Post-test 1 vs Post-test 2 : t = - 3.32, P<0.01

2. REHEARSAL TRAINING'S EFFECT ON THE PHONOLOGICAL SIMILARITY EFFECT'S SIZE

- ***DOWN'S SYNDROME SUBJECTS***

EXPERIMENTAL GROUP	**PSW**	**SW**	**EFFECT'S SIZE**
Pre-test	1.42 (0.79)	2.25 (0.75)	+ 0.83
Post-test 1 (directly after the end of the training)	1.92 (0.67)	3.58 (0.51)	+ 1.66
Post-test 2 (6 weeks after the end of the training)	1.75 (0.62)	2.67 (0.49)	+ 0.92

CONTROL GROUP	**PSW**	**SW**	**EFFECT'S SIZE**
Pre-test	1.25 (0.87)	2.08 (0.67)	+ 0.83
Post-test 1 (directly after the end of the training)	1.17 (0.58)	2.00 (0.60)	+ 0.83
Post-test 2 (6 weeks after the end of the training)	1.17 (0.58)	1.92 (0.51)	+ 0.75

→ **repeated measures ANOVA** (significant level $p<0.05$): variable "effect's size" (3 levels: effect's size at the pre-test/ post-test 1/ post-test 2)

1. In the experimental group:

significant effect of the variable "effect's size": $F(2,22) = 9.91$, $p<0.01$

→ in order to detect the moment at which the phonological similarity effect increases: t of Student

→ comparison of the effect's size at the pre-test, post-test 1 and post-test 2

effect's size post-test 1 > effect's size pre-test: $t = -3.08$, $p<0.02$
effect's size post-test 1 > effect's size post-test 2: $t = 5.74$, $p <0.01$

2. In the control group:

no significant effect of the variable "effect's size"

→ the effect's size is similar at pre-test, post-test 1 and post-test 2

- ***NORMALLY DEVELOPPING CHILDREN***

Why three post-test ?

- increase in AC → developmental increase in memory performance → if we observed an increase of the phonological similarity effect, it can be due to a developmental change in memory functioning and not to the rehearsal training.

EXPERIMENTAL GROUP	**PSW**	**SW**	**EFFECT'S SIZE**
Pre-test	2.83 (0.39)	3.08 (0.51)	+ 0.25
Post-test 1 (directly after the end of the training)	3.33 (0.49)	3.92 (0.67)	+ 0.59
Post-test 2 (6 weeks after the end of the training)	2.83 (0.39)	3.75 (0.45)	+ 0.92
Post-test 3 (6 months after the end of the training)	2.50 (0.52)	3.75 (0.45)	+ 1.25
CONTROL GROUP	**PSW**	**SW**	**EFFECT'S SIZE**
Pre-test	2.67 (0.49	3.08 (0.51)	+ 0.41
Post-test 1 (directly after the end of the training)	2.67 (0.49)	3.08 (0.51)	+ 0.41
Post-test 2 (6 weeks after the end of the training)	2.67 (0.65)	3.58 (0.51)	+ 0.91
Post-test 3 (6 months after the end of the training)	2.50 (0.52)	3.17 (0.72)	+ 0.67

→ **repeated measures ANOVA** (significant level $p<0.05$): variable "effect's size" (3 levels: size zt the pre-test, size at the post-test 1, size at the post-test 2)

1. In the experimental group:

significant effect of the variable "effect's size": $F(2,22) = 6.29$, $p<0.002$

→ in order to detect the moment at which the phonological similarity effect increases: t of Student

→ comparison of the effect's size at the pre-test, post-test 1 and post-test 2

effect's size post-test 2 > effect's size pre-test: t = - 4.69, p <0.001

2. In the control group:

significant effect of the variable "effect's size": $F(2,22) = 3.67$, $p<0.05$

→ in order to detect the moment at which the phonological similarity effect increases: t of Student

→ comparison of the effect's size at the pre-test, post-test 1 and post-test 2

effect's size post-test 2 > effect's size pre-test: t = - 2.57 p <0.05

3. REHEARSAL TRAINING'S EFFECT ON THE WORD LENGTH EFFECT

- ***DOWN'S SYNDROME SUBJECTS***

EXPERIMENTAL GROUP	**LW**	**SW**	**EFFECT'S SIZE**
Pre-test	1.00 (1.04)	2.25 (0.75)	+ 1.25
Post-test 1 (directly after the end of the training)	2.00 (0.74)	3.58 (0.51)	+ 1.58
Post-test 2 (6 weeks after the end of the training)	1.75 (0.62)	2.67 (0.49)	+ 0.92
CONTROL GROUP	**LW**	**SW**	**EFFECT'S SIZE**
Pre-test	0.92 (0.90	2.08 (0.67)	+ 1.17
Post-test 1 (directly after the end of the training)	1.33 (0.65)	2.00 (0.60)	+ 1.33
Post-test 2 (6 weeks after the end of the training)	1.17 (0.58)	1.92 (0.51)	+ 0.75

→ **repeated measures ANOVA** (significant level $p<0.05$): variable "effect's size" (3 levels: effect's size at the pre-test/ the post-test 1/ post-test 2)

1. In the experimental group:

significant effect of the variable "effect's size": $F(2,22) = 13.39$, $p<0.0002$

→ in order to detect the moment at which the word length effect increases: t of Student

→ comparison of the effect's size at the pre-test, post-test 1 and post-test 2

effect's size post-test 1 > effect's size pre-test: $t = -4.06$, $p<0.002$
effect's size post-test 1 > effect's size post-test 2: $t = 4.69$, $p <0.001$

2. In the control group:

no significant effect of the variable "effect's size"

→ the effect's size is similar at pre-test, post-test 1 and post-test 2

- ***NORMALLY DEVELOPPING CHILDREN***

Why three post-test ? (see phonological similarity effect)

EXPERIMENTAL GROUP	**LW**	**SW**	**EFFECT'S SIZE**
Pre-test	2.25 (0.45)	3.08 (0.51)	+ 0.83
Post-test 1 (directly after the end of the training)	3.17 (0.58)	3.92 (0.67)	+ 0.75
Post-test 2 (6 weeks after the end of the training)	2.83 (0.58)	3.75 (0.45)	+ 0.92
Post-test 2 (6 months after the end of the training)	2.67 (0.49)	3.75 (0.45)	+ 1.08
CONTROL GROUP	**LW**	**SW**	**EFFECT'S SIZE**
Pre-test	2.42 (0.51)	3.08 (0.51)	+ 0.66
Post-test 1 (directly after the end of the training)	2.42 (0.51)	3.08 (0.51)	+ 0.66
Post-test 2 (6 weeks after the end of the training)	2.50 (0.52)	3.58 (0.51)	+ 0.58
Post-test 2 (6 ùonths after the end of the training)	2.67 (0.49)	3.17 (0.72)	+ 0.50

→ **repeated measures ANOVA** (significant level $p<0.05$): variable "effect's size" (3 levels: effect's size at the pre-test/ post-test 1/ post-test 2)

1. In the experimental group:
   no significant effect of the variable "effect's size"

2. In the control group:

significant effect of the variable "effect's size": $F(2,22) = 6.10$, $p<0.005$

→ in order to detect the moment at which the word length effect effect increases: t of Student

→ comparison of the effect's size at the pre-test, post-test 1 and post-test 2

effect's size post-test 2 > effect's size pre-test:	$t = -2.80$, $p<0.02$
effect's size post-test 2 > effect's size post-test 1:	$t = -2.80$, $p<0.02$
effect's size post-test 2 > effect's size post-test 3:	$t = -3.92$ $p<0.005$

CONCLUSIONS

- ***Concerning the effects of the training on memory span*:**

* The training of the subvocal rehearsal strategy → increase of memory abilities of both Down's syndrome subjects and normally developping children

* What can we observed ?

1. Important increase of short-term memory abilities directly after the end of the training session of memory
2. Clear signs of rehearsing in all experimental subjects after 8 weeks of training → lips or finger movments
3. The decrease of memory performance as well as the disparition of lips and finger movments a few weeks after the end of the training suggest that subjects progressively stop using rehearsal or that rehearsal is less systematic and less efficient that directly after the training.

- ***Concerning the phonological similarity effect and word length effe ct***

* Hulme & Mackenzie (1992): phonological similarity effect and word length effects depend on subvocal rehearsal → training the rehearsal strategy must influence the size these effects

∅ that's what we observed in the experimental Down's syndrome group directly after the training but at post-test 2, the size of the effect return at its basic level (Pre-test's size and control group's size)

→ If we assume that this phenomenon is due to the progressive surrender of the rehearsal strategy's utilization

WHY don't the effect's size increase systematically in normally developping children ?
do the memory performance of Down's syndrome subjects at post-test 2 remain superior to the one at the pre-test ?

* We agree with Henry (1991) and Gathercole et al. (1994) that phonological similarity effect and word length effect are not due to the subvocal rehearsal for the following reasons:

1. the increase of memory performance after the rehearsal training without systematic increase of the effects' size (see the previous experiments).
2. the absence of links between articulatory rate and short-term memory span in young normally developping children (Gathercole et al., 1994) and in Down's syndrome subjects (Comblain, 1995, 1996).
3. the presence of these effects at the pre-test in all groups of subjects (experimental and control, Down's syndrome and normal children) → we are sure that at this moment the subjects did not use a subvocal rehearsal strategy.

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