USE OF CONTEXT IN WORKING MEMORY IN AUTISM

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Overview & Research Questions

Previous investigations have argued that subjects with autism:

- Have **little access to organizational principles for words** for recall (Hermelin & O'Conner, 1978)
- Often have **spared or heightened visual/spatial or concrete** processing abilities (Frith, 1989)
- Show an **executive function (EF) impairment for working memory (WM)** tasks "across the board" (i.e., in visual and verbal domains) on operation span tasks involving storage and processing, (Bennetto, Pennington, & Rogers, 1996) and lack self (verbal) cueing for EF tasks (Russell, Jarrold, & Hood,1999)
- Demonstrate **less benefit from organization of visual targets** than controls (Jarrold & Russell, 1997)

Our goal was to compare working memory ability in autism across:

(1) Input modalities (visual, auditory)
(2) Types of stimuli (object words, numbers, letters, patterns, icons)
(3) Presentation modality (temporal, spatial)
(4) Tasks requiring simple WM and those requiring processing and storage (EF component of WM) (i.e., operation span)

In addition:

- If subjects with autism lack verbal rehearsal in WM tasks, then recall for words may be improved by explicitly cueing their semantic relation
- If subjects with autism are less able to use verbal rehearsal, then greater processing load at the end of a list when amount of retention is greatest may have less of an effect

Method

Table 1: Receptive and Expressive Language Age Equiv = year; month

EOWPVT= Expressive One Word Picture Vocabulary Test
ROWPVT= Receptive One Word Picture Vocabulary Test
WJ= Woodcock Johnson

Subjects	Subject2	Subject3*	Subject4	Subject5*	Subject6	Controls-7yr (n=4)	Controls-13yr (n=4)
Age, Gender	13, M	12, M	13, F	6, M	7, M	7, M	13, M
EOWPVT (Age Equiv)	10;6	3;3	11;11	6;2	9;4	11;11	18
ROWPVT (Age Equiv)	12;11	3;10	exceeded ceiling	5;5	8;4	9;7	
W-J Understand.Direct. (Age)	32/41(7;2)	12/21(4;11)	40/57 (8;1)	10/21(5;9)	36/53(7;9)	9;9	19
Philadelphia Comprehension	97/120 (.81)	88/120 (.73)	110/120(.92)	76/120(.63)	115/120(.95)		

(*could not complete Complex Span Tasks)

Tasks Included: Word List Recall
- Semantically related, Unrelated or Cued

Simple Span
- Letter, Number, Backward Digit, Spatial, Icon

Complex Span
- Letter, Sentence, Addition, Count Span

Study 1: Are lexical and non-lexical stimuli recalled differently?

Word List Recall

Procedure: Subject recalled each word in a list immediately following auditory presentation of the list
Design: 12 lists of 4-8 words each (6 lists for SR, 6 lists for UR). Length of list presented depended upon subject's digit span (DS). (4 items for lower DS, 6-8 items for higher DS group). Random list order.

- Semantically Related (SR): Same category (animals, plants, kitchen, vehicles, building-street, body parts)
- Unrelated (UR): Different categories (same words as presented in SR)
- Semantic Cued (SC): SR lists presented in isolation with instructions regarding semantic relation after 3-week delay

General Procedure (Simple and Complex Span)

- Lists varied in length from 1 to 6 (spatial) or 2 to 6 items, presented for immediate recall with 5 trials per level
- The list length was increased by 1 item if a participant achieved 3 of 5 trials correct; otherwise, the experiment was terminated at the maximum span score.

Simple Span Tasks

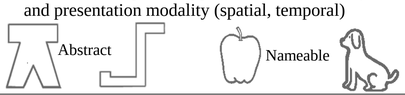
Simple digit, Backward digit, and Letter Span
- Each list was presented verbally by experimenter

Spatial Span
- Subjects presented with a filled grid on computer. After **10s** delay, required to point to previous filled location(s).

Example of level 5 stimulus:

Icon Memory

Spatial: The tester pointed to objects on a 4x4 grid.
Temporal: Stimuli presented one at a time on computer for 1.5 seconds each.
After presentation, subject placed items on a linear strip in the presented order
- 4 conditions: picture type (abstract, nameable) and presentation modality (spatial, temporal)



Study 1 Results

Word List Recall

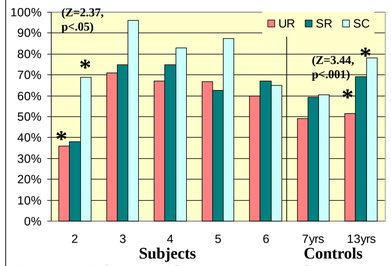


Figure 1: Subjects with autism improved in Semantic Cued (#6 behaved like controls). A primacy effect was also demonstrated in this condition.

Overall Simple Span

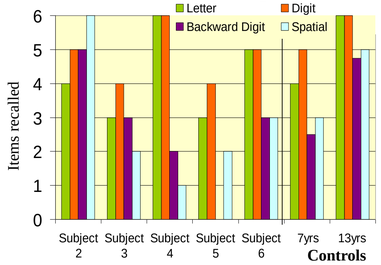


Figure 2: Less verbal subjects with autism (2, 3,5) performed better with digits than letters. Performance on backward digit was poor for all but #2.

Icon Memory-Results

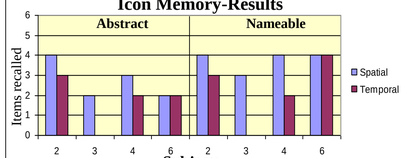


Figure 3: Spatial better than temporal memory for #2, 3, & 4. Better with nameable items than abstract.

Study 1 Conclusions

- Subjects with autism showed evidence for use of lexical organization in word and icon recall, but cueing was necessary
- Ability with numbers and spatial patterns often exceeded abilities with words, letters and temporally presented visual stimuli

Study 2: Are all operation span tasks impaired equally?

Complex (Operation) Span Tasks

- See General Procedure (2 subjects with autism could not complete)
- Required subjects to process and store stimuli simultaneously
- Each stimulus display was presented on the computer screen for 5 seconds maximum (ISI of a blank screen began with start of subject's verbal response). All examples below are from Level 3 trials.

Sentence Completion Span
- Subjects produced the final missing word of each presented sentence and later recalled completed words
- Sentences were 3-5 words long
- Most likely word based on norms established by Towse, Hamilton, Hitch, & Hutton, 2000

Example: "Moo" said the __[1000ms] Snow is the color ___[1000ms] The hammer hit the ___

Expected Response: cow, white, nail

Letter Completion Span
- Subjects produced missing letter of presented word and later recalled letters in sequence

Example:
RAI__ [1000ms ISI] BAL__ [1000ms] NOS__

Expected Response: N, L, E

Addition Completion Span
- Subjects produced answer to addition equation and later recalled each answer in the correct sequence

Example:
3+1=__ [1000ms] 2+1=__[1000ms] 3+3=__

Expected Response: 4, 3, 6

Study 2 Results

Overall Complex Span

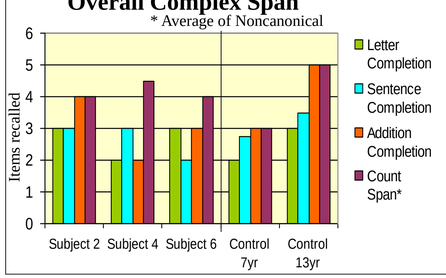


Figure 4: Subjects with autism and older control subjects performed better on count span than sentence/letter span.

Study 2 Conclusions

- Complex span ability was not impaired equally across input modalities in autism
- Count and addition abilities appeared to be spared
- Letter and sentence span may have been too difficult. Require new norms.

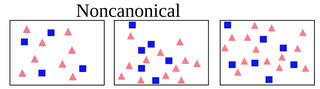
Study 3: Are spatial and/or temporal visual cues used for later recall?

Count Span (CS)

- Subjects were instructed to count the blue squares as quickly as possible (Displays had twice as many distracters)
- Results based on maximum level passed and reaction time
- Conditions: **Display Type** 1) **Canonical**, 2) **Noncanonical,** or 3) **Noncanonical** but **repeating**

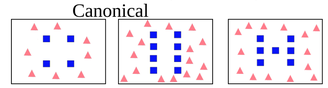
Target Size 1) Small (3-5 target squares) or 2) Large (6-8 target squares)
Final Card Size: 1) Large or 2) Small
Large Final: Last card is large (6-8 squares) and first card is small (3-5 squares)

Noncanonical



Expected Response: 4, 6, 7

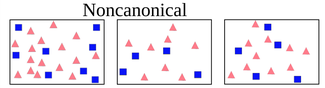
Canonical



Expected Response: 4, 8, 7

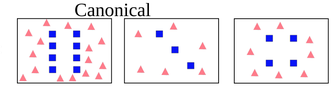
Small Final: Last card is small and first is large

Noncanonical



Expected Response: 8, 4, 5

Canonical



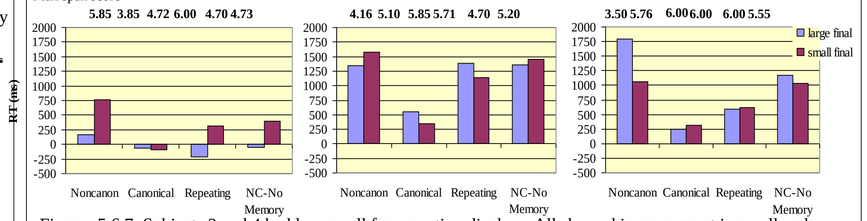
Expected Response: 8, 3, 4

•**NO memory control** task: Subject not required to recall the numbers (RT only measured)

Study 3 Results

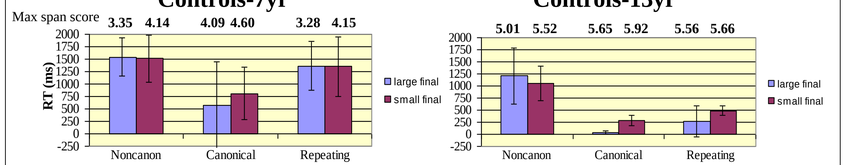
Difference between RTs for large minus small target sizes

Subject 2: age 13 **Subject 4: age 13** **Subject 6: age 7**



Figures 5,6,7: Subjects 2 and 4 had less recall for repeating displays. All showed improvement in recall and processing with canonical displays, equal to those of 13 yr controls. #2 and #4's performance on No memory control indicated that impairment on NC not due to increased verbal rehearsal with recall requirement.

Controls-7yr **Controls-13yr**



Figures 8 and 9: 7yr controls showed greater difference in all conditions in count times and standard deviation and repeating condition was no different from Noncanonical. Differences in RT had less effect on 13 yr old controls' span size than for subjects with autism. Greater load at end of lists impaired recall for all subjects but #2 for NC.

Study 3 Conclusions

- Subjects with autism were significantly better than 7yr controls in repeating and canonical conditions
- Performance on NC repeating in autism was not as good as the 13 yr old controls
- Interaction between attention/visual processing, verbal working memory and EF may explain heterogeneous count span results in autism

Overall Conclusions

- Contextual cues may not be available for all children "on-line," may require development
- Integrating information temporally for later recall appears to develop and is also impaired in autism
- Children with autism have difficulty rehearsing specifically in the auditory lexical domain

Acknowledgments

Many thanks to the families of the research subjects for their cooperation and to the Therapeutic Cognitive Neuroscience Fund. Thanks to Dr. Dana Boatman and Dr. William Badecker for discussion as well as Nancy Cook, Greg Minah, and Ashley Fitzgerald for their help with editing and data collection.