A training study to enhance verbal short-term memory performance in individuals with Down syndrome

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Down syndrome

- Down syndrome (DS) is the most prevalent genetic developmental disorder worldwide (Parker et al., 2010)

- Associated with general learning difficulties

- However, beyond this, there are specific difficulties in the verbal short-term memory domain often observed in the Down syndrome population (Jarrold & Baddeley, 1997)
Verbal short-term memory

- Specific deficit

- Verbal short-term memory plays a role in vocabulary development and comprehension

- Important to address these difficulties and provide individuals with support
Intervention for individuals with DS

• Need to consider the source of the verbal STM difficulties, such that training can be targeted appropriately

• It is also important to consider specific patterns of strengths and weaknesses in this population, with regards to where they need support, and what they are currently capable of with regards to verbal STM tasks
Influence of LTM knowledge

Evidence of phonological coding

Verbal short-term memory in DS

Both item and order memory problems

Poor encoding of temporal context

Visual benefits
• We considered these findings in the planning of a training study....

20 participants with Down syndrome
Randomly allocated to training group or active control group
Training study

- Train participants to use associative cues

- (1) Rhyme: Enhance awareness of phonology
- (2) Semantics: To encourage individuals to maximise their use of semantic (LTM) associations

Increase participants’ attention to these components of the input, encourage strategies to support item recall

Also support order memory
Verbal items are associated with the picture at the corresponding serial position

E.g. Phonological Trial: Skate, Key, Hat, Mop
E.g. Semantic Trial: Open, Leaves, Dog, Money
If active control = subsequently repeat all stages in training condition
• Reliability of memory span measure: $\alpha = .917$

• Average performance during training compared to average performance at that trial length during pre and post training memory span sessions
Both groups displaying significant performance gains during training/active control (T/C)

Benefits due to visuospatial positions rather than the pictorial cues
Phonological compared to semantic phase benefit

Semantic stage benefit compared to phonological phase benefit not significantly larger for the training group
Semantic stage - words were significantly higher in concreteness, familiarity and imageability
Analysis of errors

- Significantly more rhyme vs non rhyming errors in the training group compared to the control group. Interaction: $p = .02$
Analysis of errors

• Significantly more semantic vs non semantically related errors in the training group compared to the control group. Interaction, $p = .03$
Median split

- Median percentage for performance during T/C = 45.31%
- The effect of T/C performance (above/below median) was significant, $t = -2.27, p = .04$
Summary of training study results

- Significantly better performance during T/C compared to pre and post T/C memory span performance

- HOWEVER, benefit observed in both the training group AND the active control group

- Factor common to both groups: Visuospatial aid

- Indicates that individuals with Down syndrome benefit from having an aid to support spatial representations of verbal memoranda
• Training group not experiencing a significantly larger benefit than the control group

• Suggests that they are not using explicit associations to enhance recall

• However, unlike the control group, the errors that the training group made tended to rhyme with or were semantically related to the corresponding visual cue

• Individuals with DS are using the visual cues (i.e., the associations), but not selecting correct associated item for given trial
• 1. Visuospatial benefits

• 2. Difficulties retrieving correct associated items based on cue

• Part 2: Follow up…
Follow up: Visuospatial benefits

To explore the nature of visuospatial benefits in individuals with DS

Are benefits transferable to other tasks?

Does spatial representation play a role during encoding?

Are benefits specific to those with DS or not?
Is spatial presentation beneficial in simple computerized tasks?

- Presentation of items: Centre of screen OR spatial (left to right)

- Either verbal presentation: spatial component = location of squares that flash up, simultaneous to verbal label

- Or verbal plus visual presentation: spatial component = location of pictures of items, presented simultaneous to verbal label
Verbal Central:
Visual spatial:
Recognition phase

• Are individuals with DS particularly prone to phonological or semantic errors?
Recognition phase

Phonologically similar

Semantically related

Control
• 20 participants with Down syndrome
• 20 typically developing children for comparison
• Vocabulary scores measured using the BPVS

• DS: mean age = 18 years, 0 months (SD: 6yr, 9mo)
  mean vocab age: 6 years, 9 months (SD: 1yr, 5mo)
• TD: mean age = 8 years, 5 months (SD: 2yr, 0mo)
  mean vocab age: 8 years, 4 months (SD: 1yr, 6mo)

• 24 trials, each with 4 items
Results: Presentation effects

Significant benefit of spatial presentation in the DS group, $p = .04$
Presentation format x population: $p = .06$
Population x Item type ($p < .01$)
Both groups choose target item more so than all other types of items, but more target selections in TD group.
• Is poor recognition in the Down syndrome group due to poorer recall performance previously?
Recognition errors for only previously recalled items

No interaction of error type x population (i.e., when removed target item from analysis)
Percentage of each error type (Without target)
• Analysis of target recognition and previous presentation format (verbal vs visual), (central vs spatially):

• Significant effect of verbal vs visual presentation across populations, $p < .05$. More target items correctly selected for items that were previously presented in visual format.
Accounting for vocabulary variance

• It was not possible to fully match the two groups on vocabulary, additionally ran a linear mixed effect model:

• Model 1 (identical to Anova): Presentation location x presentation format x population

• Model 2: Vocabulary (and it’s interactions) added into the model
Accounting for vocabulary variance

- Model 2 accounted for significantly more variance

- The main effect of population remained significant ($p<.01$)

- The interaction of population x vocabulary was significant ($p<.01$)

- Vocabulary is a stronger predictor of serial recall performance in the TD group; this difference reflects the verbal STM deficit in the DS group, whereby verbal STM does not increase with vocabulary level in a typical fashion
Accounting for vocabulary variance

- Relatively close to significance was the interaction of population x presentation location x vocabulary (p = .08).

- DS: Effect of vocabulary not significant

  Interaction of presentation location x vocabulary was significant - vocabulary is a stronger predictor of performance in the spatial condition compared to the central condition.
TD: Interaction of presentation location x vocabulary was not significant
Whereas the effect of vocabulary was significant

-Vocabulary predicts a significant amount of variance in serial recall performance in the TD group regardless of central vs spatial presentation
Summary

• Significant benefit of spatial presentation in the DS group
  No interaction: pattern is not significantly different to that of
  TD group (i.e., not benefitting $sig.$ more)

• But there is stronger trend that is significant in the DS
  group, and fits with the previous findings
• Spatial benefits larger if responses are spatial as well
  But the follow up study indicates that spatial encoding plays a
  role

• Spatial benefit across verbal and visual presentation
Summary

- Individuals with DS experience a small overall benefit as a result of the pictures at presentation, whereas TD group do not.

- Would have expected TD individuals to also benefit, and would expect a sig. benefit in those with DS: Coloured, vivid images may be more beneficial than black and white pictures.

- Both populations were better at recognizing the target (picture) when it was previously presented in picture format.
Summary: Recognition

• Main effect of item type: both groups show a trend to select target items more than any other non-targets

• Interaction of item type x population: The TD group were much more likely to select targets than non-targets, i.e., more errors in the DS group

• Again, when analysing only previously recalled items that individuals will therefore have encoded, those with DS are less accurate than the TD group
No differences in the types of errors made in either population

Thus, poor recognition in the DS group does not appear to be particularly caused by phonological or semantic confusions, rather poor encoding efficiency…memory traces not retained.
Conclusions

• Extremely poor serial recall performance for purely verbal memoranda in individuals with DS
• Spatial benefits regardless of verbal or visual format of memoranda

• Spatial support may be helpful for individuals with DS
• A spatial component during both encoding and retrieval likely to result in largest benefits

• Relatively poor item recognition in individuals with DS, even for previously recalled items, suggests weaker memory trace encoded, thus association strategies may be needed at encoding, rather than only retrieval
Implications

• Consideration of individual differences in classroom
• Presentation of materials,
  e.g., language learning, tasks to remember in order
• Tools to support learning

• Focus on individuals actively using verbal memory
• Other additional routes needed