RESEARCH ARTICLE

REVISED Pictures over words: a cross-sectional study reporting short term memory abilities in children [version 2; peer review: 2 approved with reservations]

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Abstract

Background: An impressive amount of research has been conducted studying the modality effect on multimedia information in children from higher elementary school to college. In the present study, we aimed to examine the modality effect in the recall of multimedia information among children between the age range of 6 years to 9 years 11 months.

Methods: The study followed a cross-sectional design and comprised of 80 participants between the ages of 6 years to 9 years 11 months. An animated story was shown to the children, following which a word recall task was performed. In this task, children were asked to recall the words mentioned in the story from a pictorial array.

Results: One-way analysis of variance revealed a significant difference in the overall recall abilities of children. The recall performance was strongly related to the modality of the presentation of words. A marginal difference was observed for the recall of auditory-visual words in comparison to recall of words in the auditory modality; wherein older children recalled better in comparison to younger children. The findings of the study could be attributed to the "visual superiority effect", "encoding specificity principle of memory" and "multimedia effect."

Conclusion: Recall abilities were observed to increase with age, with the existence of asynchrony in the auditory-visual and auditory recall scores indicating the firm reliance on the modality of presentation of word. The study implications emphasize on the use of visual stimuli for teaching new vocabularies, skills, and concepts in younger children. These findings also highlight the use of visual stimuli while assessing speech, language, and cognitive skills in younger children.

Keywords

Cognitive communication, Recall, Short Term Memory, Stories

Open Peer Review

Approval Status

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version 1		
19 May 2020		

1. Ramesh Kaipa , Oklahoma State University, Stillwater, USA

2. Raju Sapkota , Anglia Ruskin University, Cambridge, UK

Any reports and responses or comments on the article can be found at the end of the article.

This article is included in the **Manipal Academy of Higher Education** gateway.

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Author roles: **Rooha A:** Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Validation, Writing – Original Draft Preparation; **Anil MA:** Conceptualization, Data Curation, Formal Analysis, Project Administration, Resources, Supervision, Validation, Visualization, Writing – Review & Editing; **Bhat JS:** Conceptualization, Methodology, Project Administration, Resources, Supervision, Validation, Visualization, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: The author(s) declared that no grants were involved in supporting this work.

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REVISED Amendments from Version 1

The manuscript was revised by incorporating the suggestions provided by the reviewers. The background section of the abstract has been modified and updated. The introduction section has been strengthened by discussing relevant existing literature. Minor modifications were made to the method section as suggested. The results of the Pearson correlation test were added to the results section and discussed as suggested.

Any further responses from the reviewers can be found at the end of the article

Introduction

Short term memory (STM) skills are dependent on the modality of presentation of stimuli (Goolkasian & Foos, 2002; Paivio *et al.*, 1975). Research on short term memory skills has been examining the effect of bimodal and unimodal presentation of information on the recall performance. Frick (1984) studied the effect of modalities on digit span duration task and found superior span duration for bimodal presentation when compared to unimodal. Pillai & Yathiraj (2017) studied the effects of modality on four different memory skills (memory score, sequence score, memory span and sequence span). The study revealed the effect of modality only for the memory score. It was observed that memory scores were higher for auditory modality and combined (auditory-visual) modality when compared to visual modality, with no significant difference between the auditory and combined modality.

Similarly, research exists on the modality effect in multimedia learning. Moreno & Mayer (1999) found that students performed better on retention, transfer and matching tests when the auditory stimuli (narration) were combined with the visual stimuli (texts or animation) rather than presenting the visual stimuli alone. Various other studies (Brünken *et al.*, 2004; Mayer & Moreno, 1998; Mousavi *et al.*, 1995) have also supported the notion of modality effect in multimedia learning. The modality effect observed is supported by the cognitive theory of multimedia learning (Mayer, 2001), which states that presenting information through two channels reduces cognitive overload as the working memory capacity is limited. However, most of these studies focus on college students and little is known about the modality effect on multimedia learning in school going children.

Mann *et al.* (2002) using an experimental design studied the modality effect on 12-year-old children, where participants were assigned into one of the two conditions (animations with visual information or animation with auditory information). The study did not find any difference between the two experimental conditions revealing absence of modality effect in children. Witteman & Segers (2010) assessed the modality effect in sixth-grade children (mean age 11.8 years). The participants were assigned to either of the two conditions (pictures with auditory condition or pictures with text condition) and were assessed for retention and knowledge transfer. The evaluation was done immediately after intervention, the following day and a week later. The study did not find any modality effect in children, rather found a

reverse modality effect for retention directly after the intervention, and for transfer questions one day later. Research on modality effect in multimedia information in children has focused mostly on children from higher elementary years.

In the present study, the authors explored the modality effect in multimedia information among primary school children. With computers and digital media starting to gain momentum in the educational system, the finding of the present study may help identify whether using multimedia information is advantageous or not for young children. The present study aimed to examine the modality effect in recall of multimedia information among children between the age range of 6 years to 9 years 11 months.

Methods

Study design

The study followed a cross-sectional design that was approved by the Institutions Ethics Committee (Ethical Reference Number - IEC KMC MLR 11-18/463). The study was conducted between December 2018 and January 2020. The study was conducted within the classroom setting of the approached school. Written informed consent was procured from parents of children who agreed to take part in the study.

Participants

English medium schools affiliated to the Central Board of Secondary Education (CBSE), Mangalore city, were approached, after obtaining authorization from the Block Education officer, to recruit participants for the study. Those schools that provided permission to conduct the study were considered for data collection. Typically developing children who passed the WHO Ten-Question Disability Screening Checklist (Singhi *et al.*, 2007) were recruited for the study. Children with a history of any transfer from more than one school; a history of any shift in the medium of instruction; or a history of academic failures were excluded from the study.

A sample size of 80 was determined with respect to the study done by Appose & Karuppali (2018) using the formula: $n = Z\alpha^2\sigma^2/d^2$ where, $Z\alpha = 1.96$ at 95% confidence level, $d = 20\%$ of the mean and, σ = standard deviation. The 80 participants were assigned equally into four groups (Group I: 6 years – 6 years 11 months; Group II: 7 years – 7 years 11 months; Group III: 8 years – 8 years 11 months; and Group IV: 9 years – 9 years 11 months).

Data collection

A story, “The Wooden Box” (copyright © 2019, Anil and Bhat), was constructed as animated stimuli and a “Word Recall” task (Extended data (Rooha *et al.*, 2020)) was formulated based on the story to assess the recall ability. The final modified task included 12 pictorially represented words that had an equal number of words from the story (Gold coins, Cupboard, Keys, Traffic), words thematically related (Hut, Chair, Diamond, Bag), and words unrelated to the story (Apple, Chair, Frock, Flower). Among the four words from the story, two of the words were presented in the auditory-visual modality (Gold coins, Cupboard), while the other two words were presented in auditory modality alone (Traffic, Keys). Each of these words

appeared only once in the story. The task was to identify the pictures representing the words from the story. The recall accuracy was calculated by giving a score of 1 for each word correctly recalled.

The animated story as well as the formulated task was content validated by three speech-language pathologists and three primary school teachers of CBSE. The suggestions provided included using Indian names for the characters of the story, to modify the instructions and to modify certain words in the formulated task. These suggestions were incorporated in the preparation of the final stimuli.

Each child was evaluated individually in a classroom. The animated story was presented on a laptop screen, immediately followed by the administration of the word recall task. The examiner presented the task verbally, and the child's responses were scored simultaneously.

Data analysis

The responses were subjected to statistical analysis using SPSS software version 16.0 and significance was set at the 0.05 level ($p < 0.05$). Descriptive statistics were used to obtain the mean and standard deviation of the data. A frequency measure was done to analyse the percentage of children recalling each of the words from each of the groups. One-way analysis of variance (ANOVA) test was used to test the difference in recall performance across the age groups. The Bonferroni post-hoc test was done to assess the pair-wise differences in performance between the groups. Further, Pearson correlation

test was done to assess the relationship between the recall performance and age.

Results

The results of the descriptive statistics revealed a steady increase in performance across the age groups (Figure 1). Group IV obtained the highest scores, followed by Group III, Group II, and Group I.

The results of one-way ANOVA revealed a statistically significant difference in the Word Recall task [$F(3,76) = 8.387$, $P = 0.000$] across the groups. Bonferroni Post-hoc results revealed that only Group I differed significantly from other groups, as depicted in Table 1. Frequency measure of children who recalled each of the words across the four age groups is depicted in Figure 2, which reveals that words 'Gold coins' and 'Cupboard' were recalled by almost all children. However, recall of words 'Key' and 'Traffic' increased with age, with drastic changes in the recall of word 'Traffic'. Lastly, the Pearson correlation test revealed a moderate positive correlation between the recall performance and age, $r(78) = 0.48$, $p < 0.01$.

Discussion

The results revealed that the recall ability increases significantly with age. The findings agree with the study done by Belacchi *et al.* (2017), where they concluded that the word recall scores increased significantly from 6 to 12 years. While there exists an effect of age on the recall performance, the results of the Pearson's correlation test revealed that only 40% of the time age is the contributing factor. The findings of

Figure 1. Mean scores of performance in word recall task across primary school-aged children. Group I – 6-6.11 years, Group II – 7-7.11 years, Group III – 8-8.11 years, and Group IV – 9-9.11 years.

Table 1. Post hoc results of word recall task in primary school-aged children. Group I – 6-6.11 years, Group II – 7-7.11 years, Group III – 8-8.11 years, and Group IV – 9-9.11 years.

Groups	I – II	I – III	I – IV	II – III	II – IV	III – IV
p - value	0.039*	0.004*	0.000*	1.000	0.271	1.000

*Significance at the 0.05 level

Figure 2. Percentage of primary school-aged children who recalled each of the words correctly in a word recall task. Group I – 6-6.11 years, Group II – 7-7.11 years, Group III – 8-8.11 years, and Group IV – 9-9.11 years.

the study can be associated to other factors. The study observed a difference in recall of the words ‘Gold coins’ and ‘Cupboard’ in comparison to the words ‘Keys’ and ‘Traffic’. The differences in the recall can be attributed to the inherent characteristic of the words, as the words ‘Gold coins’ and ‘Cupboard’ were presented in auditory-visual modalities in the story. In contrast, the words ‘Key’ and ‘Traffic’ were presented in auditory modality alone. Thus, it can be observed that auditory-visual recall was superior to auditory recall in these children. From these results, it can be considered that there exists a modality effect in recall of multimedia information in children. The findings of the present study can be attributed to various reasons which are discussed ahead.

Visual superiority effect

Younger children are fascinated by the illustrations of the story, and focus more on visual animations in comparison to the auditory narration of the story. Attention thereby forms a critical prerequisite to encode, store, and subsequently recall information. Reduced attention to auditory information may have contributed to poorer recall of words presented in the auditory modality. Hayes & Birnbaum (1980) observed similar behaviour and termed it as the “visual superiority effect,” i.e., younger children are more inclined to “look and not listen.”

Further, there exists a difference in processing the two types of sensory information. For the items to be stored in the STM, the brain has to cognitively create ‘mental images’ of these items, which are pictorial representations of words inside one’s mind. When processing visual stimuli, the brain functions to discover a ‘mental image,’ but when processing auditory stimuli, the brain has to create a mental image of the heard word for correct recall (Hilton, 2001). These brain functions are mediated by higher cognitive skills, which develop only with age. This could have contributed to better recall of auditory-visual words when compared to auditory words.

Encoding specificity principle of memory

This principle states that recall of memory is optimal when the retrieval conditions replicate the conditions present when memory was created (Tulving & Thomson, 1973). In the current study, recall of auditory-visual memory was superior because the retrieval condition duplicated the conditions when the memory was formed, i.e. children had to identify the same pictures as seen in the story. However, the retrieval of auditory stimuli did not duplicate the conditions when the memory was formed, i.e. children had to identify pictures of words heard in the story, which could have contributed to poorer performance.

Multimedia effect

It is claimed that presenting multimedia information, i.e. presentations of material using words and pictures (Mayer, 2002) results in deeper comprehension (Boerma *et al.*, 2016), subsequently improving recall. This can be considered as a contributing factor for better recall of auditory-visual words.

Lastly, Ferrara *et al.* (2017) reported that detailed visual memory capacity is present in children as young as six years of age, as a result of faster maturation of visual memory than the auditory memory. This can be considered as a contributing factor for observing no differences in auditory-visual recall performance across the age group.

These evidences supports the findings of the present study; an increase in STM skills with age, the existence of asynchrony in the auditory-visual and auditory recall scores, and recall performance strongly relating to the modality of presentation of information. These findings provide implications for the use of visual stimuli while teaching new vocabularies, skills, and concepts in younger children. These findings also highlight the use of visual stimuli while assessing speech, language, and cognitive skills in younger children as it will serve as a

framework for maintaining their attention while evaluating various communicative skills.

Data availability

Underlying data

Harvard Dataverse: Replication Data for: Short Term Memory abilities in Children, <https://doi.org/10.7910/DVN/LLGPOX> (Rooha *et al.*, 2020).

This project contains the following underlying data:

- DATA 1.tab (Analysis data with raw scores for each participant)

Extended data

Harvard Dataverse: Replication Data for: Short Term Memory abilities in Children, <https://doi.org/10.7910/DVN/LLGPOX> (Rooha *et al.*, 2020).

This project contains the following extended data:

- Word Recall task.docx (Stimulus – Formulated task)

Data are available under the terms of the [Creative Commons Zero "No rights reserved" data waiver](#) (CC0 1.0 Public domain dedication).

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Open Peer Review

Current Peer Review Status: ? ?

Version 2

Reviewer Report 28 October 2020

<https://doi.org/10.5256/f1000research.29224.r71334>

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Raju Sapkota

Vision and Eye Research Institute, School of Medicine, Anglia Ruskin University, Cambridge, UK

1. While the discussion is mainly around specific concepts of modality difference, nonetheless, it will be useful to understand why a larger discrepancy was noted for (gold coin, cupboard vs. traffic, key) for group I compared to group IV (Figure 2).
2. I note the following in the last para - 'These evidences supports the findings of the present study; an increase in STM skills with age,' how? The description provided in the method section does not detail about how STM was tested or tapped on.

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 25 Dec 2020

Malavika Anil, Kasturba Medical College, Manipal Academy of Higher Education, Manipal, India

While the discussion is mainly on specific concepts of modality difference, nonetheless, it will be useful to understand why a larger discrepancy was noted for (gold coin, cupboard vs. traffic, key) for the group I compared to group IV (Figure 2).

- The larger discrepancy for the recall of words 'traffic' and 'key' across the age groups were because these two words were presented in auditory modality alone. On the contrary, the remaining two words - 'gold coin' and cupboard were presented in the auditory-visual modality and because of the contribution of visual modality (which is reported to have faster maturation of as young as 6 years of age) had a lesser discrepancy in recall across the age groups.

- The suggestion raised is already addressed in the last but one paragraph of the research article as a justification for the finding;
- “Lastly, Ferrara *et al.* (2017) reported that detailed visual memory capacity is present in children as young as six years of age, as a result of faster maturation of visual memory than the auditory memory. This can be considered as a contributing factor for observing no differences in auditory-visual recall performance across the age group.”

I note the following in the last para - 'These evidences supports the findings of the present study; an increase in STM skills with age,' how? The description provided in the method section does not detail about how STM was tested or tapped on.

The quoted line has been corrected as
“These evidences supports the findings of the present study; an increase in recall ability with age” in the third version of the article

Competing Interests: No competing interests were disclosed.

Reviewer Report 07 October 2020

<https://doi.org/10.5256/f1000research.29224.r71335>

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Ramesh Kaipa

Department of Communication Sciences and Disorders, Oklahoma State University, Stillwater, OK, USA

Thank you to the authors for addressing my comments. My only comment would be for the authors to address the limitations of the current study. But otherwise this papers will be a decent contribution to the existing literature.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Speech and Language Learning

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 25 Dec 2020

Malavika Anil, Kasturba Medical College, Manipal Academy of Higher Education, Manipal, India

The study limitations are added in the discussion section of the new version as suggested.

Competing Interests: No competing interests were disclosed.

Version 1

Reviewer Report 24 July 2020

<https://doi.org/10.5256/f1000research.25805.r65393>

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Raju Sapkota

Vision and Eye Research Institute, School of Medicine, Anglia Ruskin University, Cambridge, UK

The major issue with this article is that the background is poorly developed. There is abundant evidence in literature on the effect of visual, auditory or cross-modal effects in STM.

Also, while the authors associate the findings to aging effect, it could well be that the effects are merely the effect of learning, since children become more experienced learners with age.

The findings are not discussed adequately in context of the existing literature. I suggest addressing these issues before the article is accepted for indexing.

Is the work clearly and accurately presented and does it cite the current literature?

No

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

Partly

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Partly

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Visual short-term memory, cross-modal binding, early dementia, aging effects in human visual short-term memory

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 29 Jul 2020

Malavika Anil, Kasturba Medical College, Manipal Academy of Higher Education, Manipal, India

Pictures over words: a cross-sectional study reporting short term memory abilities in children

Rooha A, Anil MA and Bhat JS

INTRODUCTION:

The major issue with this article is that the background is poorly developed. There is abundant evidence in the literature on the effect of visual, auditory or cross-modal effects in STM

INTRODUCTION:

- The paper was designed considering a word limit of 1000 words, hence an extensive literature review was not included in the Introduction. However, the authors have built the need by citing relevant literature to peruse the study in the introduction.

DISCUSSION:

Also, while the authors associate the findings to the aging effect, it could well be that the effects are merely the effect of learning since children become more experienced learners with age.

DISCUSSION:

- While the 'aging effect' and 'more learning experience with age' can be associated with memory performance, the authors have discussed majorly on the difference in recall between the modalities. The discussion revolves around specific concepts of modality difference.

DISCUSSION:

The findings are not discussed adequately in the context of the existing literature. I suggest addressing these issues before the article is accepted for indexing.

DISCUSSION:

- The findings are related to the concepts of existing literature. The review of the existing literature has not been added to the manuscript as the paper was designed considering a word limit of 1000 words. However, we have tried to discuss in light of major contributing studies.

Competing Interests: No competing interests were disclosed.

Reviewer Report 18 June 2020

<https://doi.org/10.5256/f1000research.25805.r63646>

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Ramesh Kaipa

Department of Communication Sciences and Disorders, Oklahoma State University, Stillwater, OK, USA

Introduction:

I don't really understand what the rationale is for the current study? The authors do not build an appropriate case for pursuing this line of study. I would like to see some extensive review of previous literature. The authors also need to mention how would the current study contribute to the empirical body of knowledge.

Methods:

I would like to see a detailed explanation of how the test was administered. The authors mentioned it was presented using a laptop but I would like to see specific information on how long each of the stimuli appeared on the screen. How long were the participants allowed to wait before providing a response? Was there a penalty if the participants waited for an extended period of time before they provided a response?

Discussion

The authors make a case that words such as "gold coins" and "cupboard" were recalled by more number of participants. I wonder is it because the participants are exposed to these stimuli items more than the other items that were presented to them? I wish the authors had performed a familiarity rating on each of the stimuli items. Currently, it is unknown what played a role in better identification of specific words over others? This is a major confound of the current study,

Is the work clearly and accurately presented and does it cite the current literature?

No

Is the study design appropriate and is the work technically sound?

Partly

Are sufficient details of methods and analysis provided to allow replication by others?

No

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

No

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Speech and Language Learning

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 29 Jul 2020

Malavika Anil, Kasturba Medical College, Manipal Academy of Higher Education, Manipal, India

Pictures over words: a cross-sectional study reporting short term memory abilities in children

Rooha A, Anil MA and Bhat JS

INTRODUCTION:

I don't really understand what the rationale is for the current study? The authors do not build an appropriate case for pursuing this line of study. I would like to see some extensive review of previous literature. The authors also need to mention how would the current study contribute to the empirical body of knowledge.

INTRODUCTION:

- The paper was designed considering a word limit of 1000 words, hence an extensive literature review was not included in the Introduction. However, the authors have built the need by citing relevant literature to peruse the study in the introduction.
- The contribution of the present study to the empirical body of knowledge has been discussed in the concluding paragraph of the discussion section.

METHOD:

I would like to see a detailed explanation of how the test was administered. The authors mentioned it was presented using a laptop but I would like to see specific information on how long each of the stimuli appeared on the screen. How long were the participants allowed to wait before providing a response? Was there a penalty if the participants waited for an extended period of time before they provided a response?

METHOD:

- As the study focused only on the accuracy of the recall and not the reaction time measures, time-related aspects were not considered in the methodology section.

DISCUSSION:

The authors make a case that words such as “gold coins” and “cupboard” were recalled by more number of participants. I wonder is it because the participants are exposed to these stimuli items more than the other items that were presented to them? I wish the authors had performed a familiarity rating on each of the stimuli items. Currently, it is unknown what played a role in better identification of specific words over others? This is a major confound of the current study,

DISCUSSION:

- The story included words that are familiar to children, ascertained through a textbook analysis of vocabulary.
- Content validation was also done by primary school English teachers who approved the familiarity of the words considered in the story by all students.
- The words considered were all nouns, having only a single frequency of occurrence in the whole story which was also content validated by primary school English teachers and Speech-Language Pathologist.

Competing Interests: No competing interests were disclosed.

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