Explaining the *Mathematical Word Problem* Performance of Multilingual Children from Government Schools in Hyderabad, India

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BACKGROUND

The **MultiLila Project** was a four-year project (2016 – 2020) in Government schools in three states of India: Hyderabad, Delhi, and Bihar. It involved the collection of a wide range of data, including academic and cognitive tasks, school observations, and child questionnaires. The overarching aim of the project was to investigate why multilingual children in India often do not experience the same cognitive advantages of bilingualism that children in other contexts do (Tsimpli et al. 2019).

Within classrooms in India, it is common for children to receive education in a medium of instruction (Mol) that they do not speak at home (Mohanty, 2010). However, classroom observation data indicates that significant amounts of language use in mathematics classrooms is not in the Mol, especially in the case of English Mol schools (Lightfoot et al. 2020).

Mathematical Word Problems (MWP) present linguistic, cognitive and mathematical demands, and require children to process a hypothetical scenario. They usually comply with a three-part structure (Gerofsky, 1996), detailed below:

1. *Establishment of a scenario*
2. *Items of information*
3. *One or more question/s*

Existing research on MWPs and mathematical reasoning has found associations with literacy, numeracy, cognitive abilities, and SES, but has been concentrated in the Global North. Very little research has been conducted with children in highly multilingual environments, such as India.

RESEARCH QUESTIONS

1. To what extent do number knowledge and arithmetic abilities explain MWP performance?
2. How do linguistic, cognitive, and environmental factors influence the MWP performance of multilingual children?
3. How do elements of the children's multilingual environment, such as home language status and Mol, influence their MWP performance?
4. How does the presentation of items of information (visual vs. verbal) within MWPs impact performance?

VARIABLES

- Multilingual environment
 1. Home language status (monolingual or bilingual)
 2. Mol (English or Telugu)
 3. Mol Overlap (match or mismatch with a language spoken at home)
- Linguistic Diversity and SES (composite scoring systems; Tsimpli et al. 2020)
- Raven's Coloured Progressive Matrices (fluid intelligence; Raven, Raven, & Court, 2008)
- 2-back task (working memory; Kirchner, 1958)
- Mol Literacy (ASER)
- MWPs (adapted from TIMSS, 2011; Panda, Mohanty, Nag, & Biswabandan, 2011)
- Numeracy (ASER Numeracy Task for Grade 2 rural learners)
 1. Number recognition
 2. Subtraction
 3. Division

PARTICIPANTS

- 314 participants, aged between 8 and 15 years

- Group comparisons found no statistically significant differences in MWP performance based on the following binary groupings: gender, age status, school site, Mol, Mol overlap, and home language.

RESULTS

- MWP scores and subtraction scores were statistically significantly correlated.
- Subtraction and number recognition scores were statistically significant predictors of MWP task performance, but only explained a small amount of variance.
- Children showed stronger performance on the problems with verbal presentation of essential information, than on those with visual presentation.
- Overall visual cluster scores were not correlated with verbal cluster scores.
- Correctly answering all visual problems was a statistically significant predictor of performance on the verbal cluster.
- Subtraction was a statistically significant predictor of performance on the verbal cluster.
- Males outperformed females on the verbal cluster.
- Children who incorrectly answered every problem on the task were not academically or cognitively weaker than other participants.
- 4 of the 6 children who correctly answered every visual problem answered every problem on the task correctly.

RESULTS

Task	Mean
Medium of Instruction Literacy (%)	72.64
Subtraction (%)	55.77
Number Recognition (%)	92.09
Division (%)	12.26
MWPs (%)	35.93
2-back (A prime)	0.67
Raven's (%)	45.39

CONCLUSIONS

- Subtraction and number recognition scores were the only statistically significant predictors of overall MWP task performance.
- Home language environment, Mol, and Mol overlap did not statistically significantly influence MWP performance.
- Children showed weaker performance on problems with visual presentation of essential information, but this was not attributed to academic, cognitive, or environmental factors.
- Children may have found the MWPs difficult due to unfamiliarity with the genre or with the scenarios presented but performed remarkably well considering the complex nature of the task.

FUTURE DIRECTIONS

Future research is required in highly multilingual environments and should focus on the proximity to reality of the scenarios presented in problems to the realities of children in linguistically and culturally diverse settings. It should also look to identify central explanatory variables in the performance of these children, and to disentangle the possible explanations of low classroom exposure to MWPs as a genre and unfamiliarity with the scenarios presented within the problems.

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EXAMPLE MWP

Adil went to buy some apples from the bazaar. The shopkeeper put the apples on the weighing scale to calculate the price. How much do the apples weigh in grams, as shown in the scale below?

METHODS

Correlation Analyses (Kendall tau)

Multiple Linear and Ordered Logistic Regressions

Item Response (Difficulty)

Qualitative Clustering of MWP 'Type'