Mindless Math: the Finesse of Fluency

M. Asher Lawson, Rick Larrick & Jack Soll
The Fuqua School of Business, Duke University

Introduction

How many cubic feet of dirt are there in a hole that is 3' deep x 3' wide x 3' long? [5]

What is your intuitive response to the above problem?
- 84% of an mTurk sample responded with a variety of intuitive answers involving calculations [5].
- When faced with numeric information, our intuitive response can be to start performing mathematical operations.
- But what about when math cannot help us to reach a correct answer?

Mindless math
- We explore problem solving situations where there is task-relevant numeric information, but the cued operations inhibit reaching a correct answer.
- We call performing these irrelevant mathematical operations *mindless math.*
- Our research question is how and why does fluency affect the performing of *mindless math*?

Literature
- Disfluency can stimulate analytical reasoning (but not necessarily accuracy) [1]
- Answer fluency predicts Feelings of Rightness (FOR) judgments, which predict time spent on additional System 2 processing [4].

Hypothesis generation
- Retrieving simple mathematical operators (e.g. addition) is fluent from learned association.
- Yet overly simple calculations can serve as a cue that a problem is incorrectly represented.
- Hence, the fluency with which an answer is reached might predict further System 2 processing.
- In H1 we test the effect of increasing numeric demands (decreasing 'mindless math' answer fluency) on 'correct' and 'mindless math' responding.
- Our belief is that the harder calculation will blind respondents to the nature of the problem.
- We think that this is a corrective process, in that most participants are initially tempted by the 'mindless math' answer.
- Hence, we believe that under time pressure more respondents will return the 'mindless math' answer.
- We test this assertion in H2.

Hypotheses:
H1: *Moving from the 'easier' to the 'harder' numeric demands will decrease the rate of 'correct' responding and increase the rate of 'MM' responding.*

H2: *Moving from 'none' to the 'fast' time pressure condition will decrease the rate of 'correct' responding and increase the rate of 'MM' responding.*

Methods

Participants.
In Study 1 (2) we recruited 450 (602) participants from Amazon's Mechanical Turk Platform.

Dependent Variables.
DV1: 'correct' – responding correctly
DV2: 'MM' – responding with *mindless math*

Experimental design

Study 1.
1 IV between-subjects: **numeric demands** of study items. (easier / harder)
Controls: CRT [3], numeracy [2]

Study 2.
2 x 2 between-subjects: **numeric demands** x **time pressure** (none / fast).

Materials and procedure.
In Study 1 (2) participants were asked to respond to four (three) study items. The response format was numeric entry. Participants faced all study items in the same condition. In Study 1 (2), the four study item were separated by non-conflict filler questions (participants answered three study items with no filler). The study items used in both studies:

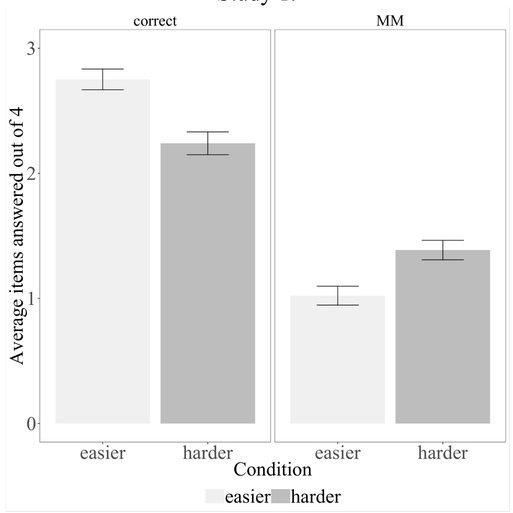
Q	'easier' condition	'harder' condition
1	On my way to the Himalayas, imagine I met a man with his wife going the opposite direction. His wife was carrying a sack and the sack had a cat in it. How many living creatures, in total, were going to the Himalayas?	On my way to the Himalayas, imagine I met a man with four wives going the opposite direction. Each wife was carrying a sack and each sack had two cats in it. How many living creatures, in total, were going to the Himalayas?
2	Imagine Joey is going to the store to buy a pack of chips. A bottle of water costs $3.00, a pack of chips costs $1.00 and a pack of gum costs $2.00. How much does he spend in total? (in dollars)	Imagine Joey is going to the store to buy a pack of chips. A bottle of water costs $1.05, a pack of chips costs $0.75 and a pack of gum costs $1.70. How much does he spend in total? (in dollars)
3	Imagine 5 candles stand burning in a dining room. A strong breeze blows in through an open window and extinguishes 2 of them. Assuming the wind doesn't extinguish any more candles, how many candles do you have left in the end?	Imagine 17 candles stand burning in a dining room. A strong breeze blows in through an open window and extinguishes 8 of them. Assuming the wind doesn't extinguish any more candles, how many candles do you have left in the end?

Participants' responses were recoded into 'correct' and 'MM' answers (e.g. $1.00 and $6.00 in the 'easier' condition of Q1). The coding schemes were pre-registered.

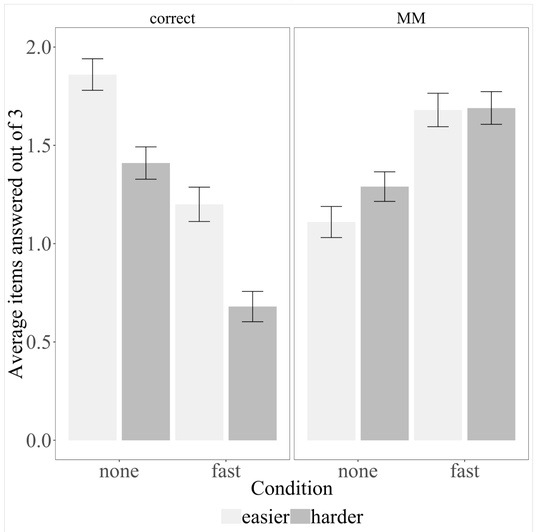
Modelling
To analyze Study 1 (2), logistic regression models were estimated using Generalized Estimation Equations, clustering standard errors by participant. Position and item terms were included.

Results

Study 1.



Study 2.



Results.
Study 1.
- One-way ANOVA tests with numeric demands against 'correct' and 'MM' statistically significant at $p < 0.001$ (H1).
- CRT and BNT significantly predict 'correct' and 'MM' responding.
- In predicting 'MM' responding, coefficients for harder X CRT and harder X BNT *marginally* significant $p = 0.059$, $p = 0.078$.

Study 2
- Numeric demands has significant main effect (H1)
- 'fast' has negative main effect on likelihood of 'correct' responding $p < 0.001$ and positive main effect on likelihood of 'MM' responding $p < 0.001$ (H2)

Conclusions

- Our results serve as a boundary condition of the relationship between answer fluency and FOR judgments.
  - Respondents can reach the 'mindless math' answer quicker with easier numeric demands.
  - This is supported by timing data and difficulty ratings.
  - This higher fluency in reaching the (incorrect) *mindless math* answer is associated with a higher likelihood of reaching the correct answer.
- Under time pressure, people are more likely to respond with the 'mindless math' answer than the 'correct' answer.
  - Both 'harder' numeric demands and 'fast' time pressure lead to a substitution to *mindless math*, rather than just introducing noise.
  - This suggests that *mindless math* is an intuitive process that we have to correct.

Future directions
- We believe that one reason why 'correct' responding is higher in the 'easier' numeric demands condition could be that the easier calculation does not meet people's expectations of task difficulty.
- Understanding the role of expectations in this paradigm is an important next step.
- Additionally, we want to understand the contexts in which *mindless math* could hurt people.
- Is *mindless math* limited to standardized test situations, or does it affect decision-making?

References

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