Distance Classification: A NOVEL COMPARISON OF OVERT AND COVERT NUMERICAL DISTANCES

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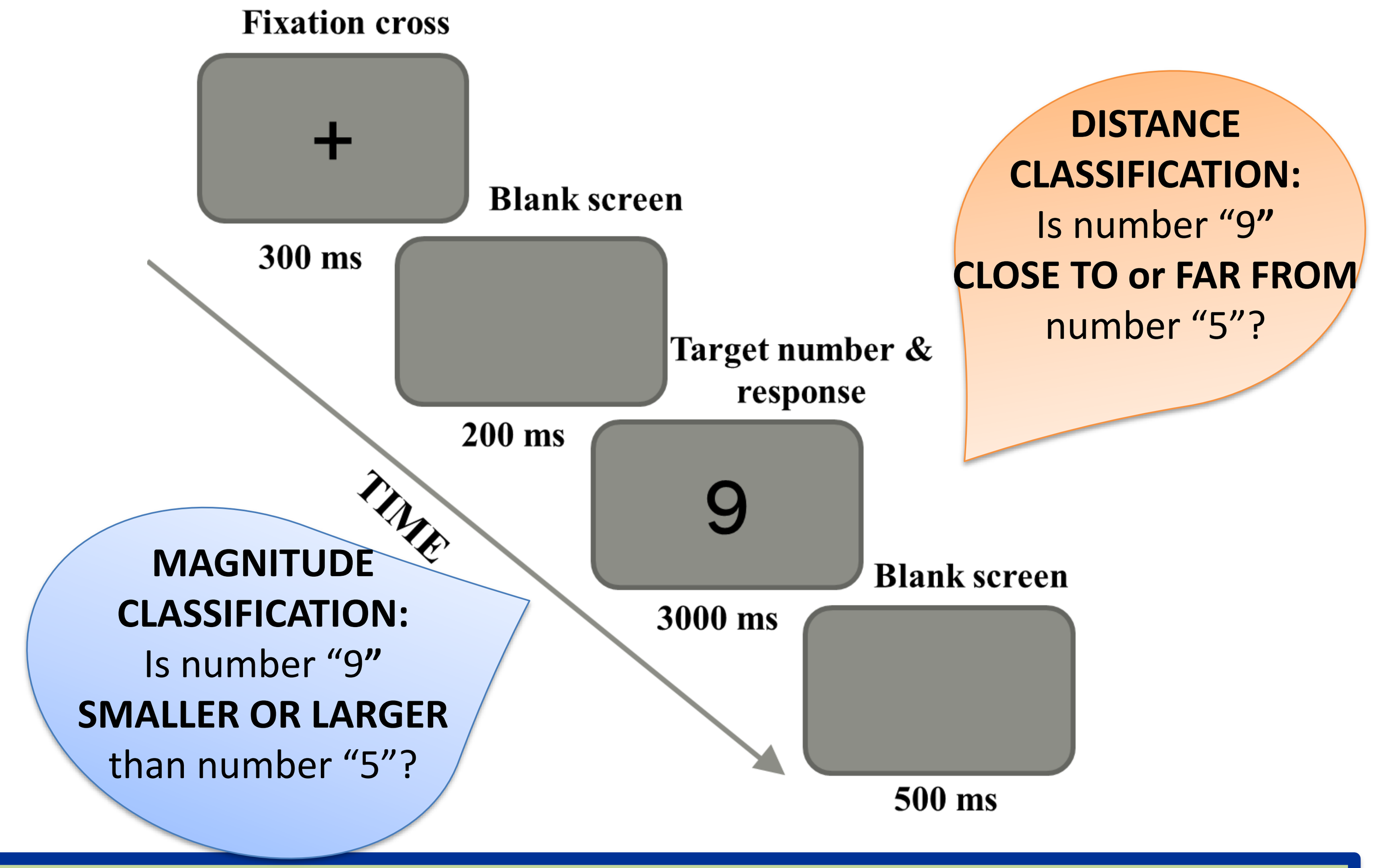
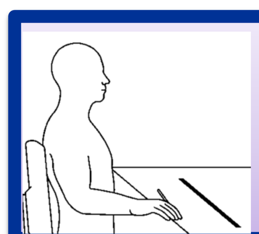


Background

A hallmark in numerical cognition is the *Distance effect* (DE), describing better performance when comparing the magnitude of numbers that are numerically far rather than close to each other [1]. The DE signals analogue magnitude representations, it is robust across ages and cultures [2], it persists in professional mathematicians [3], and it is modulated by task requirements [4].

Unlike other signatures of numerical cognition, so far, the DE has been investigated only in an implicit way, with numerical distance as non-salient task property [4,5]. Thus, it is currently unknown whether it can be observed also when numerical distance is task-relevant. To fill this gap, we introduce the *Distance classification* task that requires explicit judgment of numbers as close or far from a reference. We explore this new measure along horizontal and radial dimensions to assess its reliability and strength.



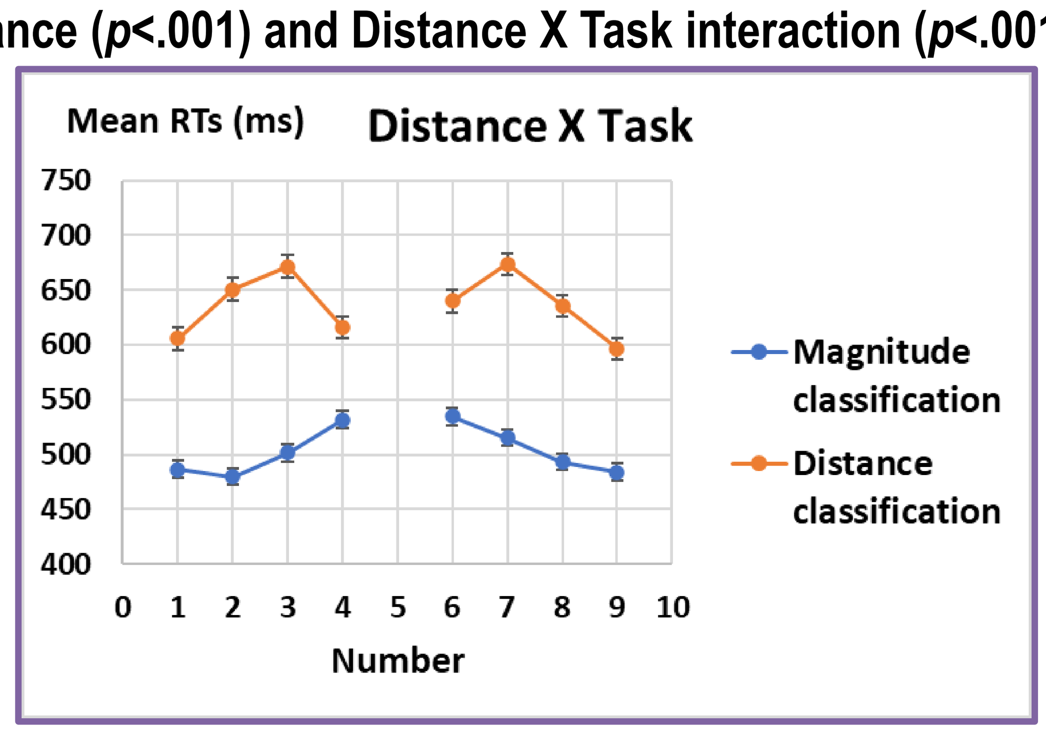
Experiment 1: Horizontal dimension (37/44 participants)

Method: Participants classified numbers 1-9 either by numerical magnitude (Magnitude classification task) or by numerical distance (Distance classification task) compared to the reference "5", by pressing the "*D*" and the "*K*" buttons on the keyboard.

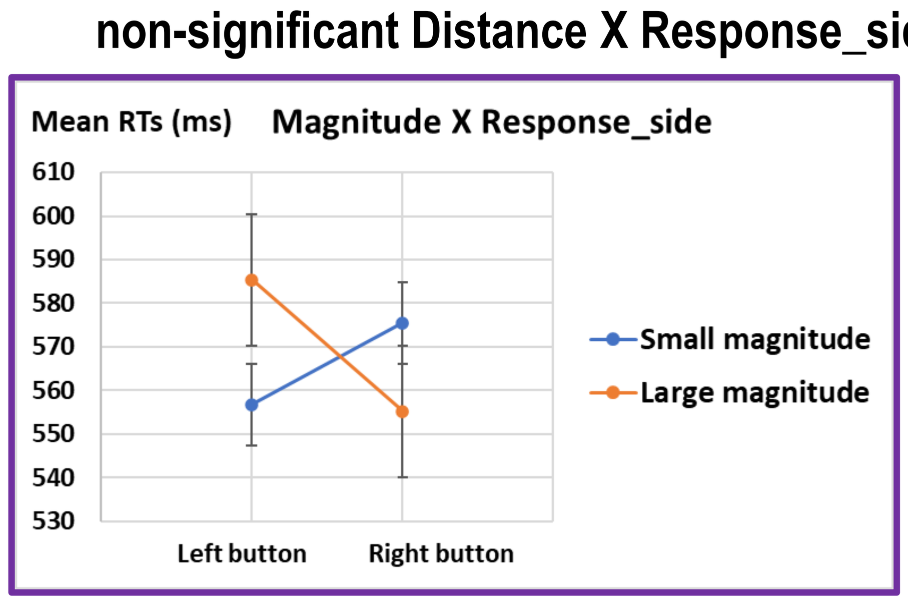
Analyses: Correct responses were considered. On trimmed Reaction Times (RTs; +/- 3 *standard deviations*), two repeated measures ANOVAs were computed: 2 (Task) X 2 (Magnitude) X 2 (Response_side) and 2 (Task) X 4 (Distance) X 2 (Response_side).

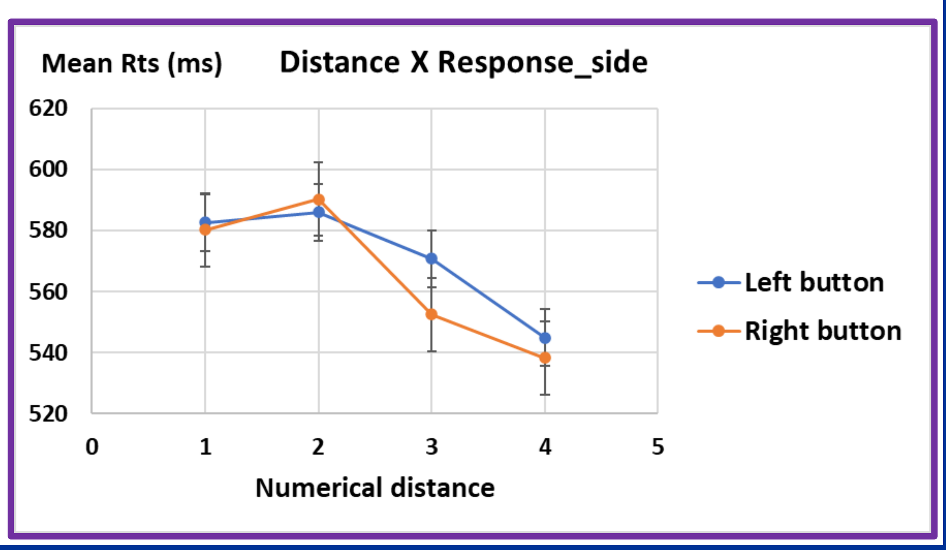
Results:

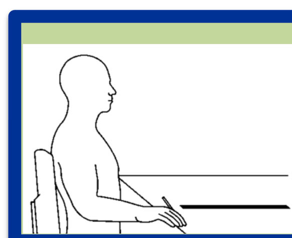
- Main effect of Distance (*p*<.001) and Distance X Task interaction (*p*<.001);



- Significant Magnitude X Response_side interaction, indicative of a Spatial-numerical magnitude associations of response codes, SNARC effect; *p*=.001); non-significant Distance X Response_side interaction (*p*=.6).







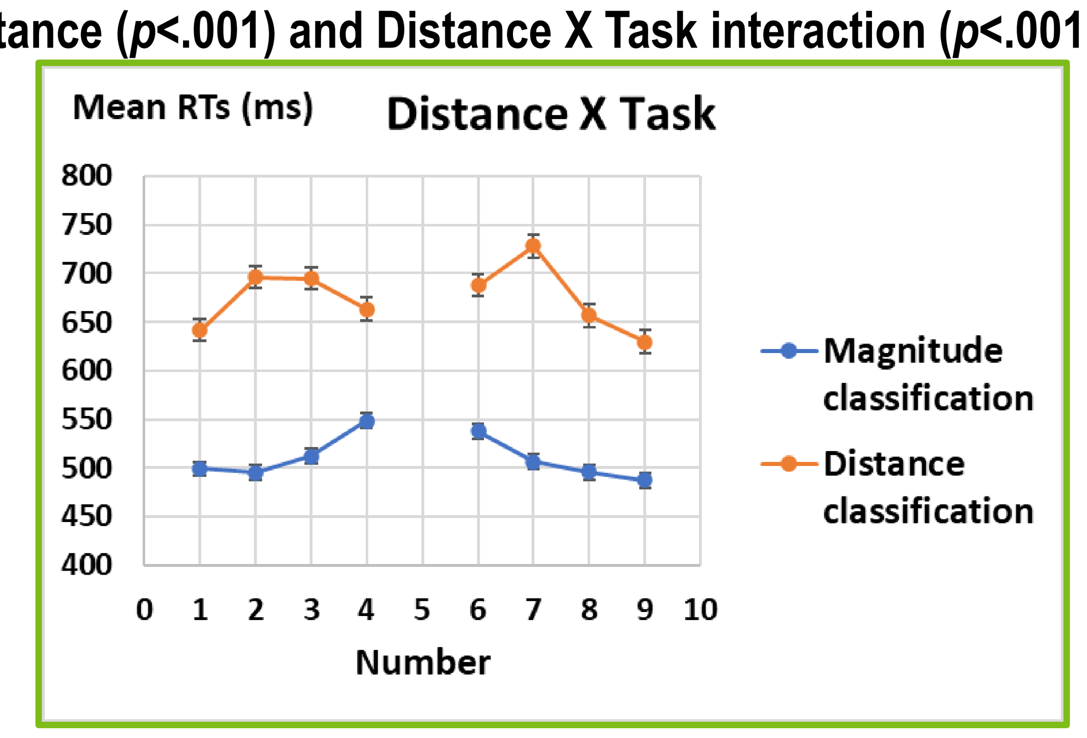
Experiment 2: Radial dimension (42/49 participants)

Method: Participants classified numbers 1-9 either by numerical magnitude (Magnitude classification task) or by numerical distance (Distance classification task) compared to the reference "5", by pressing the "*B*" and the "*T*" (20/25 participants) or the "*N*" and the "*I*" buttons on the keyboard (21/24 participants).

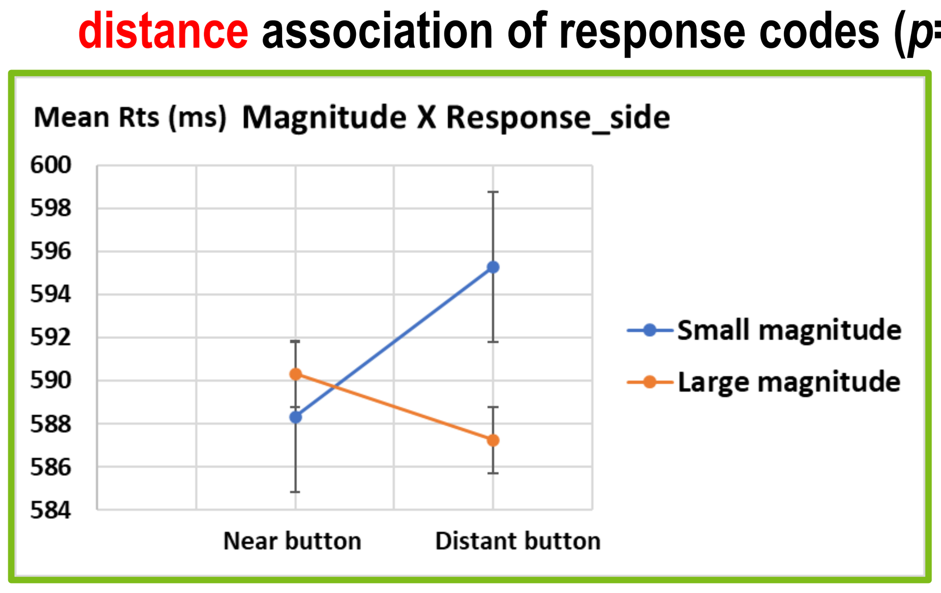
Analyses: Correct responses were considered. On trimmed Reaction Times (RTs; +/- 3 *standard deviations*), two repeated measures ANOVAs were computed: 2 (Task) X 2 (Magnitude) X 2 (Response_side) and 2 (Task) X 4 (Distance) X 2 (Response_side).

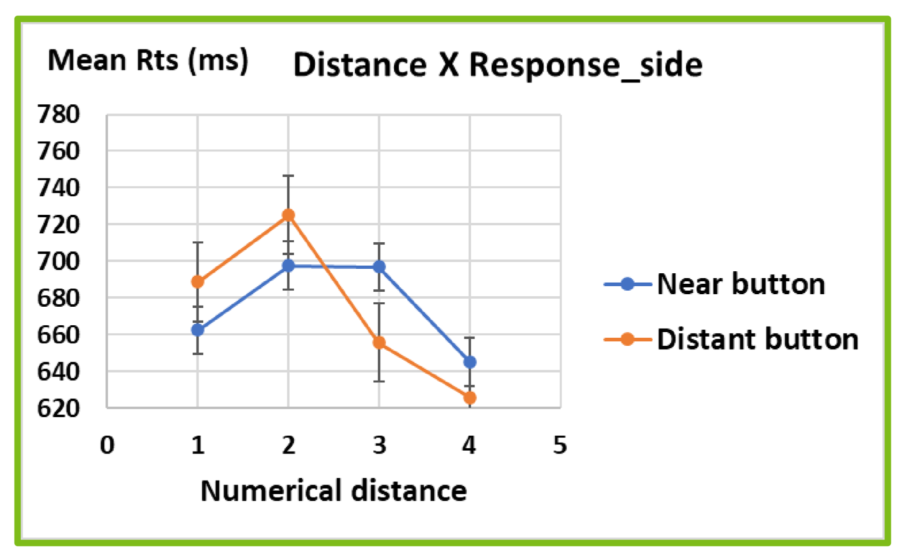
Results:

- Main effect of Distance (*p*<.001) and Distance X Task interaction (*p*<.001);



- Non-significant Magnitude X Response_side interaction, SNARC effect, *p*=.2); significant Distance X Response_side interaction, indicative of a Spatial-numerical distance association of response codes (*p*=.021).





Conclusions and Implications

- The introduction of the Distance classification allowed the comparison between implicit and explicit assessment of the DE and revealed differential activation of numerical representations as a function of the salience of the numerical distance;
- Newsworthy, in the Distance classification, the spatial layout of responses along the radial plane evoked a spatial congruency effect, suggesting correspondence between physical and representational distances [6].
- These findings point out the need to deeper explore the different facets of numerical distance, and they suggest to integrate the Distance classification task in future evaluations of numerical skills in populations with different ages, math and spatial abilities (e.g., dyscalculic children, professional mathematicians, neglect patients).

References

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