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Technology, Social Impact

Numerical Magnitude Affects Accuracy but Not Precision of Temporal Judgments

Motivation and objective

- The processing of space, time, and the number has been fundamental to human cognition.
- One of the prominent theories of magnitude processing, a *theory of magnitude* (ATOM), suggests that space, time, and quantities are processed through a generalized magnitude system; thereby, the task-irrelevant magnitude dimensions could potentially interact with task-relevant magnitude dimensions.
- Previous studies have found support for the generalized magnitude system. However, it is largely unknown whether such cross-domain magnitude interaction arises from a change in the accuracy of the magnitude judgments or results from changes in precision of the processing of magnitude.
- Therefore, we aim to examine whether large numerical magnitude affects temporal accuracy or temporal precision, or both. In other words, whether numerical magnitudes change our temporal experience or simply bias duration judgments.

Temporal Comparison Task

Twenty-seven participants (15 males; age range 20–27 years) performed a *Temporal Comparison Task.*

FIGURE 1 | Illustration of the Task: each trial starts with the fixation cross followed by a standard stimulus with a fixed duration and subsequently a comparison stimulus with variable durations and numbers. Participants were required to compare whether the comparison stimulus lasted longer as compared to the standard stimulus.

Standard Duration: 550ms
Test Durations: 250-850ms with in steps of 100ms.
Numerical Magnitude: 1, 5 and 9

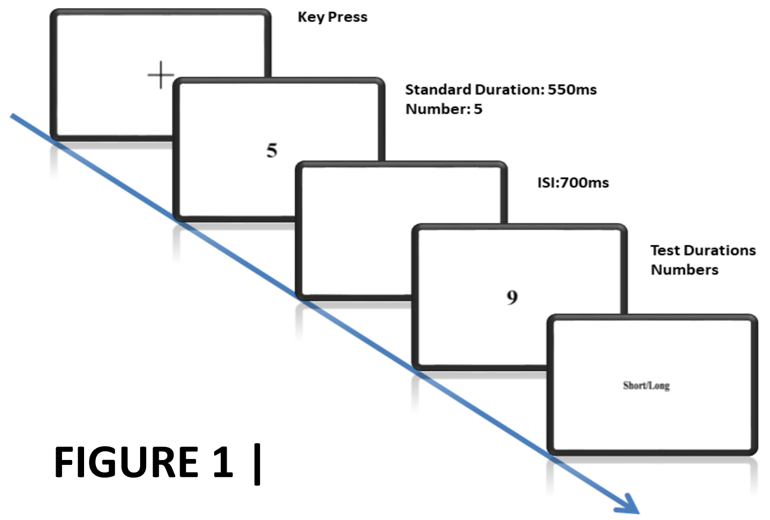

FIGURE 1 |

Results

1. DOES NUMERICAL MAGNITUDE ACTUALLY ELICIT MORE "LONG"/"SHORT" RESPONSES?

- An ANOVA-type analysis indicated the p(long) responses systematically increased with increased duration ($F(1.88,\infty) = 320.57$, $p < 0.05$). The post hoc analysis suggested that *Short* (0.118 ±0.10), *Same* (0.516 ± 0.25), and *Long* (0.851 ± 0.12) durations were perceived different from one another ($p<0.05$). The results also suggested differences in p(long) responses across different magnitude ($F(1.99,\infty) = 12.94$, $p < 0.05$).
- However, we did not observe Magnitude × Duration interactions ($F(2.38,\infty) = 0.071$, $p > 0.05$). The insignificant interaction suggests that the p(long) responses for the magnitude were not different across durations.

2. Does Numerical Magnitude Affect Temporal Perception?

- We estimated a *point of subject equality (PSE)* by fitting a *Logistic function* to p(long) response across test durations (i.e., 250-850 ms).
- PSE is the point on the psychometric fit where the frequencies of long and short responses are found to be the same (i.e., 50%). PSE is considered as the *accuracy of temporal judgments*. Lower the PSE, higher the overestimation of duration and vice-versa.
- A one-way repeated measures ANOVA analysis pointed that the PSE values differed significantly across the numerical magnitudes ($F(2,46) = 10.23$, $p < 0.001$). The post hoc test suggested that duration judgments associated with large numerical magnitude were significantly overestimated than those with small and identical magnitudes ($p < 0.05$).
- Further, we show that each numerical magnitude's PSE is not significantly different from the standard duration (i.e., 550ms). This indicates the numerical magnitude affected temporal perception in relative terms but may not have altered temporal processing concerning the objective duration. **[See Fig-2]**

3. Does Numerical Magnitude Affect Duration Discrimination?

- We calculated the *Weber ratio* (temporal sensitivity index) for each numerical magnitude. Lower the Weber ratio, the steeper the curve, and the higher the temporal sensitivity.
- We used Friedman ANOVA to check whether the numerical magnitude affected the temporal sensitivity of temporal judgments. The result suggests that the numerical magnitudes did not help discriminate the duration to be longer or shorter; instead, they might have biased the temporal perception $\chi^2(2) = 2.33$, $p > 0.05$). **[See Fig-3]**

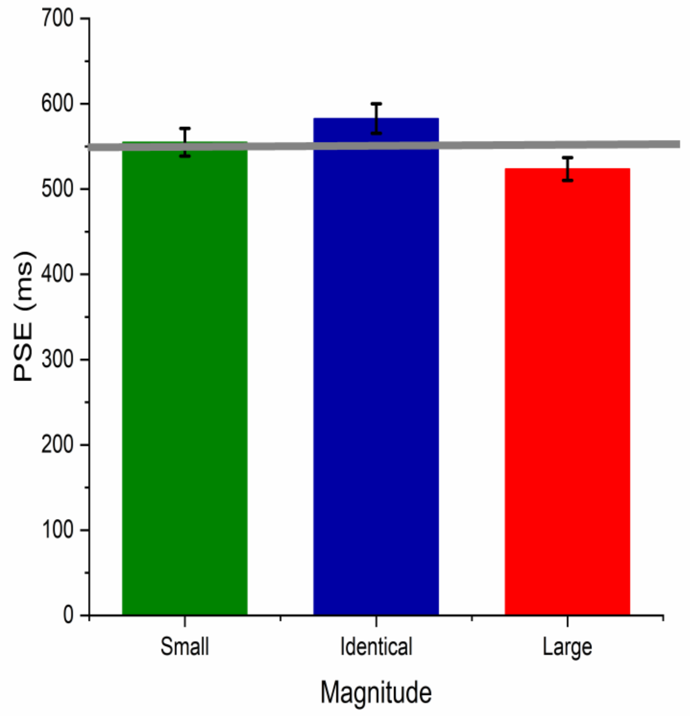

FIGURE-2: PSE Plot

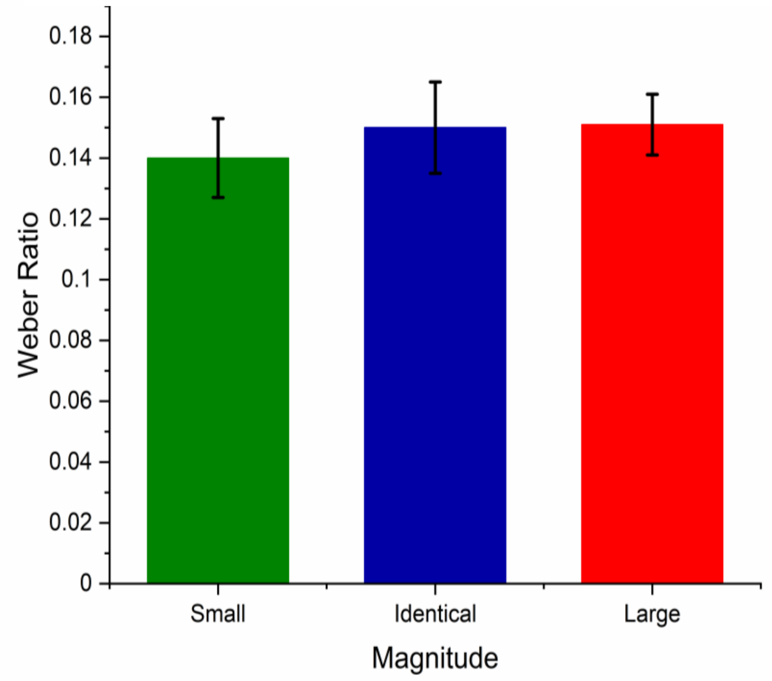

FIGURE-3: Weber Ratio

Conclusion

- Our findings suggest that the temporal accuracy (judgment) is biased by the presence of numerical magnitude but did not modulate temporal precision (discrimination) itself.
- We suggest that such biases can occur from the attentional mechanism and may not be contingent on the existence of a common magnitude processing system proposed under the ATOM framework.

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