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The *N*-Effect: Beyond Probability Judgments

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The *N*-effect (Garcia & Tor, 2009) is a phenomenon in which the motivation to compete decreases as the number of competitors increases, even when controlling for overall expected payoffs. In their thoughtful Commentary, Mukherjee and Hogarth (2010) astutely argue that, given ability differences in the population, the greater sampling error (SE) in small-*N* settings increases weaker competitors' individual probability of winning, potentially increasing their motivation.[1] Although SE may sometimes contribute to the *N*-effect, we explain here why SE is a theoretically unlikely account of our 2009 findings,[2] and experimentally demonstrate the persistence of the *N*-effect under conditions in which an SE effect should not appear.

First, neither the absolute nor the relative individual-level competitiveness that the SE account implies agrees with our individual-level data. Mukherjee and Hogarth's own formula suggests that if the percentage of winners is small (e.g., 10%), as it was in our earlier article (Garcia & Tor, 2009), the SE account realistically applies only to a limited subset of competitors. For instance, Figure 1 in Mukherjee and Hogarth's Commentary shows that even with the benefits of SE, about half of the test population has no meaningful chance of winning even in the small-*N* competition.[3] Such competitors should therefore exhibit (a) no appreciable motivation and (b) comparable levels of motivation in small- and large-*N* competitions. Similarly, the majority of participating competitors (e.g., ~80% in Mukherjee & Hogarth's Fig. 1) should exhibit no SE-driven motivation in large-*N* samples, in which SE is highly diminished. Moreover, the SE account also suggests an upper bound to the *N*-effect: Individuals whose location in the population-wide distribution of ability is above the threshold for winning (p^*) benefit from the diminished SE in large-*N* competitions and should therefore exhibit a reverse *N*-effect. In contrast to this prediction, however, our individual-level data (Garcia & Tor, Studies 3–5) reveal above-minimum competitiveness for most participants, regardless of objective differences in ability, and virtually no individual-level motivation gains for large-*N* settings relative to small-*N* settings in within-subjects designs.

Second, for SE to have caused the *N*-effect in our studies, some unlikely prerequisites must have obtained. For example, individuals must have both accurately estimated their location in the relevant distribution and adapted their behavior to relatively small statistical effects, even in between-subjects designs. The literature casts doubt on whether these conditions will hold, however—particularly studies showing people's difficulty in accurately estimating their relative ability (e.g. Burson, Larrick, & Klayman, 2006; Kruger, 1999; Svenson, 1981; Windschitl, Conybeare, & Krizan, 2008) and studies providing evidence that individuals either ignore or overweight small probabilities (e.g., Kahneman & Tversky, 1979). Moreover, there is direct evidence that decision makers are commonly insensitive to sample size (e.g. Kahneman & Tversky, 1972). It is therefore implausible that most participants in our studies were able to correctly integrate into their decision processes the subtle effects of SE.

Putting theoretical implausibility aside, we next report a simple experiment that clarifies the limits of SE's potential contribution to our *N*-effect findings (Garcia & Tor, 2009).

Study: When Sampling Error Is Negligible

We tested for the *N*-effect under conditions in which SE variations would be so negligible that they should cause no appreciable differences in motivation between large-*N* and larger-*N* settings. We used a within-subjects design to enable participants to see both conditions (the large-*N* and larger-*N* settings), and give them an opportunity to compare the settings and realize the irrelevance of SE, thereby increasing the likelihood of finding a null effect of *N* on motivation. We predicted, however, a significant aggregate *N*-effect, even in this design.

Method

Eighty-two undergraduates (48 females and 34 males) participated in an online survey. They read the following scenario:

> Imagine you are one of several students from across the country raising money for charity by selling candy bars. You have been told at the start of the fundraising drive that all those who finish in the top 10% in candy sales will get a $1,000 scholarship.

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Participants then responded to two variations of the same question (presented in random order): "If 2,000 [20,000] students were participating in this fundraiser, to what extent would you be motivated to compete to place in the 10%? (1 = *not at all*, 7 = *extremely*)." We also asked, "Where do you estimate you stand in terms of the ability to sell candy bars for charity among students from across the country?" Participants then estimated their ability percentile in the population (0% = bottom of the distribution, 100% = top of the distribution).

Results and discussion

Participants indicated that they would feel significantly more motivated if they were competing among 2,000 students (M = 4.40, SD = 1.90) than if they were competing among 20,000 students (M = 3.09, SD = 1.78): N had a significant main effect, $F(1, 81) = 60.1$, $p < .001$. This manifestation of the N-effect cannot be explained by the SE account because the samples were both large and therefore differed only minimally in SE. Moreover, because this scenario required a top-10% placement to win, participants who believed themselves, for instance, to be below the 87th ability percentile should have exhibited little absolute motivation to compete, even in the smaller-N condition, given their exceedingly low probability (.0001 and less) of winning. However, this subset of participants was significantly more competitive (M = 4.26, SD = 1.95) than the "no motivation" score of 1, $t(67) = 13.8$, $p < .001$. In fact, only 5 participants (7.5%) indicated a motivation level of 1.

Furthermore, Mukherjee and Hogarth's SE account predicts that participants who believed they ranked outside the 87th to 92nd ability percentile range would have shown no appreciable difference in motivation between the two conditions: Even in the smaller-N condition, participants below this range had a .0001 (or less) probability of winning, and those above this range already had a .9999 probability of winning. However, participants both above and below this range demonstrated the N-effect, trying harder in the 2,000-competitors condition ($M_{below} = 4.26$, $SD_{below} = 1.95$; $M_{above} = 5.00$, $SD_{above} = 1.41$) than in the 20,000-competitors condition ($M_{below} = 3.01$, $SD_{below} = 1.71$; $M_{above} = 2.75$, $SD_{above} = 2.22$), $F_{below}(1, 67) = 42.2$, $p < .001$, and $F_{above}(1, 3) = 6.9$, $p = .078$. These results contradict the SE account.

Conclusion

In conclusion, SE cannot account for the N-effect we described in our previous report (Garcia & Tor, 2009), although it may have contributed to it. It is important to note, however, that our studies have only begun to identify the causes and boundaries of the N-effect. Further research is needed to identify conditions under which SE significantly contributes to the N-effect.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Notes

1. Our 2009 studies already addressed the SE argument in several ways by finding (Study 1a) that SAT scores fall as the number of test takers at a given venue increases, despite the fact that test takers partake in a single, national competition; by linking the N-effect to social comparison by showing it was moderated by social comparison orientation (SCO; Study 3) and showing it was predicted by social comparison after controlling for perceptions of the easiness of winning (Study 5); and by explicitly seeking to control for variations in individual ability (Studies 3 and 4), though without manipulation checks, as Mukherjee and Hogarth (2010) correctly note.
2. In Kareev and Avrahami's (2007) studies, SE also led both higher- and lower-ability participants in 2-person competitions (holding N constant) to exhibit greater motivation and effort. However, these findings obtained only when participants were aware that SE (a) is significant, (b) diminishes the relationship between competitive performance and compensation (rather than the relationship between effort and performance), and (c) may benefit weaker competitors of sufficiently similar ability. These findings therefore suggest that SE is of limited relevance in the circumstances of our 2009 studies (in which the first two conditions do not hold).
3. For example, the formula shows that the probability of winning is .002 for $p = .05$ and .0008 for $p = .45$.

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