Blueberries and Cognitive Ability: A Test of Publication Bias and Questionable Research
Practices

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Hein et al (1) published a systematic review of the effects of blueberries on cognitive performance, finding that benefits may be observed for delayed memory, executive functioning, and psychomotor functioning in healthy children, healthy older adults, and/or older adults suffering from mild cognitive impairment (MCI). The purpose of the following analyses was to examine the results of the studies included in the review for potential publication bias and/or questionable research practices (QRPs).

Method

The 22 p values listed in Tables 2-4 of Hein et al (1) were included in analyses, with the exception of a value of .043 in the healthy children studies, which indicated a significant difference but in the opposite direction than expected. Therefore, analyses were conducted both with and without this value. Separate analyses were conducted for the healthy children, healthy older adult, and MCI studies.

p -curve analyses (2) were conducted to test for evidential value of published research. These analyses test whether an observed distribution of p values is right-skewed (if there is evidential value in the conducted experiments, as expected), flat (if there is no true effect), or left-skewed (indicative of QRPs/ p -hacking). Three one-tailed Z-tests were conducted for each analysis. The first tests if the included studies contain evidential value; a significant result indicates a right-skewed p -curve. The second tests if the studies' evidential value, if any, is inadequate; a significant result indicates that the p -curve is flatter than expected if studies were powered at 33% (i.e., lacking evidential value). The third tests if studies lack evidential value and were intensely p -hacked through the use of QRPs; a significant result indicates a left-skewed p -curve, which suggests p -hacking/QRPs.

Additionally, the Test of Insufficient Variance (TIVA; 3) was conducted to test for publication bias and/or QRPs. TIVA tests for an insufficient variance of p values: If there is no publication bias or QRPs present, the variance of p values should be greater than 1. A value below 1 suggests that QRPs were used to avoid publishing non-significant results. This is analyzed with a χ^2 test.

Analyses were conducted on the p-checker Shiny app (4).

Results

Healthy Children

When excluding the extra .043 value, the p -curve analysis did not suggest that the studies contain evidential value ($Z=1.625$, $p=.948$), and that the studies' evidential value, if any, is inadequate ($Z=-2.979$, $p=.001$). There was no significant evidence that the studies were intensely p -hacked ($Z=-1.625$, $p=.052$). The variance of these p values = 0.016, so TIVA was significant ($\chi^2(7)=0.112$, $p<.001$).

The same results were found when the extra .043 value was included except for the third Z -test of the p -curve analysis, which was significant ($Z=-1.892$, $p=.029$).

Healthy older adults

The p -curve analysis did not suggest that the studies contain evidential value ($Z=0.501$, $p=.692$), and that the studies' evidential value, if any, is inadequate ($Z=-1.688$, $p=.046$). There was no significant evidence that the studies were intensely p -hacked ($Z=-0.501$, $p=.308$). The variance of these p values = 0.244, so TIVA was significant ($\chi^2(6)=1.464$, $p=.038$).

MCI

The p -curve analysis did not suggest that the studies contain evidential value ($Z=0.08$, $p=.532$), and that the studies' evidential value, if any, is not inadequate ($Z=-1.329$, $p=.092$).

There was no significant evidence that the studies were intensely p -hacked ($Z=-0.08$, $p=.468$).

The variance of these p values = 0.0808, so TIVA was significant ($\chi^2(5)=0.404$, $p=.005$).

Discussion

The p -curve and TIVA analyses suggest that publication bias and/or QRPs were evident in this sample of research examining the effects of blueberries on cognitive ability. These analyses do not suggest that Hein et al.'s (1) review is methodologically flawed, or that there is no relationship between blueberries and delayed memory, executive functioning, and psychomotor functioning. The magnitude of the effect of blueberries on cognitive ability - if an effect exists - is unclear. Better quality empirical research needs to be conducted to determine the existence/size of effect of blueberries on cognitive ability. Improved research practices, such as study pre-registration (5) and appropriate statistical power (6), are highly encouraged and would increase the probability of replications and strengthen the evidence of findings. As it stands, however, researchers should refrain from drawing any definitive conclusions regarding the effects of blueberries on cognitive abilities.

Figure 1. Distribution of observed p values for the healthy children studies (blue lines; Panel A), healthy older adult studies (Panel B), and MCI studies (Panel C). The red lines indicate the expected distribution if there is no effect. The green lines indicate if the alternate hypothesis is true but the studies were powered at 33%.

References

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