When Older Adults Outperform Young Adults: Effects of Prior-Task Success in Arithmetic

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Keywords
Older adults · Young adults · Prior-task success · Computational estimation task · Dot comparison task · Better strategy

Abstract
Background: Older adults improve their cognitive performance on a target task after succeeding in a prior task. We tested whether effects of prior-task success occur via changing older adults’ ability to select the better strategy and/or to execute strategies efficiently. Methods: Young and older participants (n = 162) accomplished a computational estimation task (i.e., providing the best estimates to arithmetic problems) after accomplishing a dot comparison task. Results: Both groups increased their performance on computational estimation following success on dot comparison. Older adults improved most and outperformed young adults following prior-task success. Prior-task success led older adults to select the better strategy more often and to repeat (or not) the same strategy more often when it was appropriate. Better strategy use mediated effects of prior-task success. Individual differences in baseline performance moderated individuals’ sensitivity to effects of prior-task success. Conclusion: Our findings further our understanding of mechanisms underlying effects of prior-task success and provide new perspectives on how social environment modulates age-related differences in cognitive performance.

Introduction
Among the most striking features of cognitive aging is that age-related decline in participants’ performance is modulated by a number of task parameters, such as stimulus or situational characteristics. One such characteristic that we investigated here is prior-task success. Several studies found that older adults improve cognitive performance on target tasks after successfully accomplishing a prior task. For example, Geraci and colleagues [1, 2] found that older adults correctly recalled more words in a free-recall task when they successfully accomplished a sentence scramble task (rearranging isolated words to form a sentence) immediately before the free-recall task relative to either when they failed on a prior task or had no prior task. Moreover, older adults obtained as good a recall performance as young adults under a prior-task success condition and poorer performance under no-prior-task or prior-task failure conditions.
Effects of prior-task success are not specific to one cognitive domain or task in which age-related differences in participants’ performance are large, like episodic memory. They have also been found in domains where negative effects of age on participants’ performance are much smaller or even nonexistent, like arithmetic problem solving [3]. However, the conditions of occurrence of effects of prior-task success, the underlying mechanisms, and how older individuals differ in their sensitivity to prior-task success are unclear. Also, as none of the previous studies found effects of prior-task success in younger adults, it is unknown whether young adults do not benefit from prior-task success or whether they can improve performance under some to-be-determined conditions. We address these issues in the present study.

Effects of prior-task success are interesting and important to understand for several reasons. First, they potentially inform the possibilities as well as the limitations of older adults’ cognitive plasticity, or under which conditions older adults’ cognitive performance can increase and be at least as good as that of young adults. Second, effects of prior-task success suggest that age-related declines in cognition may be buffered by psychosocial factors and may occur only under some circumstances even for most age-sensitive processes or domains like episodic memory. Third, effects of prior-task success may occur via mechanisms that may also be responsible for effects of other situational factors, like age-based stereotype threat [4, 5], stressful environment [6], framing [7–9], intergenerational interactions [10, 11], or induced younger subjective age [12, 13]. Understanding mechanisms responsible for effects of prior-task success may importantly advance our understanding of how situational factors modulate deleterious effects of age on human cognition and, more generally, our theories of cognitive aging.

The present experiment aimed at determining whether prior-task success changes the way older adults approach cognitive tasks. To achieve this end, we adopted a within-participants design never used in previous studies of prior-task success. Young and older adults were tested before and after experiencing task success in a prior-task success condition, and their performances were compared to participants who did not experience prior-task success. We also adopted a strategy approach [14]. Thus, we tested the hypothesis that effects of prior-task success improve older adults’ performance by leading them to select the more efficient strategy on each problem and to execute selected strategies more efficiently. We also aimed at determining if some older adults benefit more than others from prior-task success and, if yes, what characterizes these individuals. Young and older adults were asked to accomplish a computational estimation task (i.e., estimating products of two-digit multiplication problems like 48 × 72), either under a prior-task control or a prior-task success condition. We assessed which strategy was used and participants’ performance on each problem. We compared young and older adults’ strategy use and performance before and after they took a dot comparison task that participants accomplished either successfully or much less successfully. We tested the hypothesis that changes in strategic aspects of participants’ performance determine benefits of prior-task success. We predicted a boost in performance with respect to participants’ use of the better strategy, estimation latencies, and precision in the posttest session relative to pretest session in the success condition (i.e., only after experiencing success). Moreover, we predicted that strategy repetition across successive problems would decrease on unrepeated trials (prime and target problems to be estimated with different strategies) and increase on repeated trials (prime and target problems to be estimated with the same strategy). These effects were expected above and beyond mere test-retest effects found in the control condition.

**Method**

**Participants**

A total of 162 participants were tested: 80 young and 82 older adults (see Table 1 for participants’ characteristics). Half the participants were randomly assigned to the control condition and half to the success condition. Our target sample size was determined using an a-priori power analysis ($G^*$Power [15]). Previous results found that $\eta_p^2$ ranged from 0.05 [2] to 0.12 [1, 3]. Using a $\eta_p^2 = 0.05$, our study design of 2 between-participants factors (Age and Condition) and 1 repeated factor (Session) could achieve 80% power with 56 participants. In order to exceed this criterion and achieve greater than 80% power, we recruited 162 participants.

Prior to the experiment, all older adults accomplished the Mini-Mental State Examination (MMSE [16]). No older adults obtained scores lower than the usual cutoff score of 27; therefore, none were excluded.

Next, participants completed the French Kit [17] (a pencil-and-paper arithmetic fluency test). In this test, participants had to correctly solve 3 subsets of basic arithmetic problems (i.e., addition, subtraction, and multiplication) in a total of 6 min. Each subset of basic arithmetic problems was presented for 2 min, and participants were asked to solve as many problems as possible within the limited duration. Numbers of correct answers on each subset were summed to yield a total arithmetic fluency score.

Then, to assess individuals’ verbal fluency, participants completed the French version of the Mill Hill Vocabulary Scale (MHVS [18, 19]). MHVS consists of 33 items distributed across 2 pages. Each item was a target word followed by 6 proposed words, and
the task consisted of identifying which of the proposed words had the same meaning as the target word. The number of correct items represented the level of individuals’ verbal ability.

**Stimuli for the Prior Dot Comparison Task**

Stimuli were collections of black dots displayed on a white background. More specifically, in each trial, 2 collections of dots were presented side by side on a laptop and varied in number (i.e., one dot array always represented 24 dots, and the other 18, 20, 22, 26, 28, or 30).

Stimuli were selected on the basis of participants’ success rates in a previous study [Roquet and Lemaire, in press]. Thus, collections of dots for which more than 90% of the participants in Roquet and Lemaire’s study gave a correct response were tested in the success condition. Collections of dots for which only 50% of the participants gave a correct response were tested in the control condition. This led participants to have more chances to experience success in the success condition or to have no clue of success or failure in the control condition.

**Stimuli for the Target Computational Estimation Task**

Each of the 24 trials consisted of 3 consecutive two-digit multiplication problems. In other words, all participants solved 72 problems in each testing session. Each trial was followed by a letter judgment task. In this task, participants had to categorize whether the presented series of 4 letters was either uniquely composed of consonants (e.g., trlc) or vowels (e.g., aecio) or was composed of both consonants and vowels (e.g., ubqi). This task was important to avoid carry-over effects from one trial to the next (e.g., participants may repeat the same strategy on the last problem of a given trial and on the first problem of the next trial independently of which strategy is the best on each of these problems). Half the 4-letter series included either only consonants or only vowels, and half included both types of letters. The 3 two-digit multiplication problems were either homogeneous problems (i.e., prime problems) or heterogeneous problems (i.e., target problems). So-called homogeneous problems were problems with the unit digit of 1 of the operands smaller than 5 and the unit digit of the other operand larger than 5 (e.g., 43 × 69). They were selected as target problems as it is harder to select the better strategy on these problems for both young and older adults.

Following previous studies on strategy repetition [21–23], we tested whether participants have a tendency to repeat the same strategy on consecutive trials more often in the success than in the control condition. Although the better strategy was always the same across the first 2 (or prime) problems of a trial, the better strategy was either the same or different across the last 2 problems (i.e., prime followed by target problem) of a trial. Thus, trials where it was inappropriate to repeat the same strategy across prime and target problems were referred to as repeated trials, and trials where it was inappropriate to repeat the same strategy across prime and target problems were referred to as unRepeated trials (see Fig. 1). Half the trials were repeated trials, and half were unRepeated trials. All problems in a trial were better estimated with the rounding-down strategy in half of the repeated trials or with the rounding-up strategy in the other half of the repeated trials. Similarly, the first 2 prime problems were best estimated with the rounding-down strategy and the last target problems with the rounding-up strategy in half of the unRepeated trials (and the reverse in the other unRepeated trials).

Following previous findings in arithmetic [24, 25], problems were selected with the following constraints: (a) no operands had a 0 unit digit (e.g., 20 × 63) or a 5 unit digit (e.g., 25 × 63); (b) no digits were repeated within operands (e.g., 22 × 63); (c) no reverse orders of operands were used (e.g., 24 × 63 and 63 × 24); (d) the first operand was larger than the second operand in half the problems and vice versa; (e) no operand had its closest decade equal to 0, 10, or 100; and (f) rounded operands were never the same across 2 consecutive rounding problems in a given trial (e.g., if one problem in a trial was 32 × 64, the next problem could not be 31 × 62).

**Procedure**

The E-Prime software controlled stimulus display and latency collection for both the dot comparison and computational estimation tasks [26]. The experiment was conducted in 2 independent sessions, approximately 8 days apart (mean = 8.7 days, SD = 5.5, min. = 6, max. = 9). Each session lasted nearly 60–75 min.
In the first session, older adults first took the MMSE [16]. Then, both young and older adults took the MHVS [19] and the French Kit [17].

Next, young and older adults accomplished the computational estimation task. Two-digit multiplication problems were presented horizontally in 84-point Bold Courier font (black color) in the middle of a 15-inch white computer screen. Participants were asked to provide estimates to these problems using either a rounding-up or a rounding-down strategy. The rounding-down strategy was described as rounding both operands down to the nearest decades, for instance doing \( 50 \times 30 = 1,500 \) to estimate \( 54 \times 32 \), and the rounding-up strategy as rounding both operands up to the nearest decades, for instance doing \( 40 \times 20 = 800 \) to estimate \( 38 \times 19 \). All participants completed a short training session to familiarize themselves with the trial design and procedure, which included 3 arithmetic problems to be estimated followed by a letter judgement task.

Each trial started with a 300 ms blank screen before a 400 ms fixation cross displayed at the center of the screen, followed by the first problem, another 300 ms blank screen, a 400 ms fixation cross, and the second problem. A blank screen followed participants’ responses to the second problem for 300 ms. Then, the 400 ms fixation cross and the last problem of a trial were successively displayed. Following numerous previous works using this procedure [21], the timing of each response began when the problem appeared on the screen and ended when the experimenter pressed the right button of a 2-button mouse, the latter event occurring as soon as possible after participants’ responses. Participants were asked to calculate out loud to determine which strategy they used. On each problem, the experimenter recorded participants’ estimation responses and strategy choice.

After the last problem of each trial, a blank screen followed the participant’s response for 300 ms. Then, the warning signal appeared for 400 ms followed by 4 letters. Following previous experiments (Lemaire and Hinault [27]), this letter judgment task was used to prevent interference between the last item of a trial and the first item of the next trial. Letters were displayed until the participant responded, pressing on the “L” key of an AZERTY keyboard when the 4 letters were only consonants (e.g., trlc) or only vowels (e.g., acio) and on the “S” key when the 4 letters included both consonants and vowels (e.g., ubqi). A blank screen was finally displayed for 1,000 ms at the end of each trial and before the next trial started.

During the second session, participants first performed the prior or (i.e., dot comparison) task. On each trial, participants saw 2 arrays of dots for 1,500 ms and had to indicate, as quickly and accurately as possible, which collection was most numerous. In the success condition, participants received 3 feedbacks: (1) a feedback of success or failure (i.e., with a green square for success and red square for failure) after each trial; (2) a success rate was provided with the message “Excellent!! You correctly answer X% of trials” at the end of the task (X being equal to the participant’s success rate); and (3) finally, right after providing this success rate, the experimenter said “X%! Congratulations, you did really good at this task.” In the control condition, no feedbacks were provided. On average, young and older adults’ success rates were 92% and 91% in the success condition (corresponding rates were 54 and 56% in the control condition).

Next, all participants accomplished the same computational estimation task as in the first session with the following differences: (a) the order of operands for each problem was reversed (e.g., if \( 78 \times 27 \) was tested in Session 1, \( 27 \times 78 \) was tested in Session 2); (b) the order of trials was random (with the constraint that no more than 2 repeated or unrepeated trials occurred successively) but different from that of the order of trials in Session 1. In both Sessions 1 and 2, no feedbacks were provided on the computational estimation task performance. All participants had a short break in the middle of the computational estimation task (after 12 trials, each including 3 problems).

### Results

Results are reported in 4 main sections. We first analyzed participants’ performance to determine whether young and older adults improved their performance between pretest and posttest more in the success than in the control condition. Next, we analyzed strategy use to determine whether prior-task success leads participants to increase better strategy selection between pretest and posttest (see means in Table 2). Third, we tested whether strategy use mediated effects of prior-task success. Finally, we asked if some individuals benefit more from prior-task success than others. Estimation performance (i.e.,
Effects of Prior-Task Success on Estimation Performance

Percentages of Deviation

The Condition \times Session interaction ($F(1,158) = 7.52, MSe = 32, \eta^2_p = 0.05$) was significant. Further contrasts revealed that participants provided better estimates during posttest than during pretest in the success condition (13.6 vs. 12.6%; $F(1,158) = 8.03, \eta^2_p = 0.05$) and comparable estimates during both sessions in the control condition (13.0 vs. 13.3%; $F < 1.0, p = 0.32$). Moreover, the Age \times Session interaction was also significant ($F(1,158) = 4.0, MSe = 16, \eta^2_p = 0.02$). Older adults provided better estimates in the posttest than in the pretest session (12.7 vs. 13.5%; $F(1,158) = 5.69, \eta^2_p = 0.04$), while young adults had comparable performance in the 2 sessions (13.1 vs. 13.2%; $F < 1.0, p = 0.664$). Comparing young and older adults within each condition showed that young and older adults provided equally good estimates during pretest in both the success and control conditions ($Fs < 2.0$). During posttest, older adults provided better estimates than young adults in the success condition ($F(1,75) = 6.91, MSe = 1.78, \eta^2_p = 0.08$), and both groups provided equally good estimates in the control condition ($F < 1.0$).

Estimation Latencies

The only effect that came out significant was the main effect of session, as all participants were faster during posttest than during pretest (8,783 vs. 6,902 ms; $F(1,158) = 135.34, MSe = 285,618,597, \eta^2_p = 0.45$). Both young and older adults exhibited a larger increase in latencies between pretest and posttest in the success condition ($F(1,76) = 80.50, MSe = 2,064,624, \eta^2_p = 0.51$) than in the control condition ($F(1,84) = 55.25, MSe = 2,162,711, \eta^2_p = 0.40$). Comparing young and older adults within each condition showed that both age groups were equally fast during either pretest or posttest ($Fs < 1.0$). No other effects were found on participants’ performance.

In summary, clear effects of prior-task success were found on percentages of deviations in older adults only

Table 2. Mean estimation times, absolute percentages of deviations, and percentages of better strategy use during pretest and posttest in young and older adults tested under the control or success condition

<table>
<thead>
<tr>
<th>Session</th>
<th>Young adults</th>
<th>Older adults</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>control</td>
<td>success</td>
</tr>
<tr>
<td><strong>Estimation latencies, ms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>8,612</td>
<td>9,336</td>
</tr>
<tr>
<td>Posttest</td>
<td>6,695</td>
<td>6,986</td>
</tr>
<tr>
<td>Means</td>
<td>7,654</td>
<td>8,161</td>
</tr>
<tr>
<td>Differences</td>
<td><strong>–1,917</strong></td>
<td><strong>–2,350</strong></td>
</tr>
</tbody>
</table>

| Deviation, % |  |  |  |  |  |  |  |  |
| Pretest | 13.0 | 13.1 | 13.1 | 0.1 ns | 12.9 | 14.0 | 13.5 | 1.1 ns |
| Posttest | 13.4 | 13.0 | 13.2 | 0.4 ns | 13.2 | 12.2 | 12.7 | **–1.0** |
| Means | 13.2 | 13.1 | 13.2 | 0.1 ns | 13.1 | 13.1 | 13.1 | 0.1 ns |
| Differences | 0.4 ns | –0.1 ns | 0.1 ns | 0.3 ns | –1.8* | –0.8† |  |

| Better strategy selection, % |  |  |  |  |  |  |  |  |
| Pretest | 88.8 | 88.5 | 88.7 | –0.3 ns | 86.3 | 84.6 | 85.5 | –1.7 ns |
| Posttest | 89.7 | 89.0 | 89.4 | 0.7 ns | 85.8 | 91.7 | 88.8 | **5.9** |
| Means | 89.3 | 88.8 | 89.1 | 0.5 ns | 86.1 | 88.2 | 87.2 | 2.1 ns |
| Differences | 0.9 ns | 0.5 ns | 0.7 ns | –0.5 ns | 7.1** | 3.3** |  |

Differences: posttest – pretest. ns, nonsignificant. **p < 0.01; *p < 0.05; †p < 0.01.**
and on estimation latencies in both young and older adults. Only older adults provided better estimates, and both young and older adults were faster at posttest, after experiencing prior-task success. Note that these effects of prior-task success on estimation latencies and percentages of deviations occurred above and beyond test-retest effects as seen in larger differences between pretest and posttest under the success condition than under the control condition.

Effects of Prior-Task Success on Strategy Use

Better Strategy Selection

The significant Condition × Session ($F(1,158) = 8.02$, $MSe = 255, \eta^2_p = 0.05$) and Age × Session ($F(1,158) = 4.27$, $MSe = 136, \eta^2_p = 0.03$) interactions were qualified by a significant Age × Condition × Session interaction ($F(1,158) = 9.90, MSe = 315, \eta^2_p = 0.06$). Separate analyses in each age group revealed that the Condition × Session interaction was significant in older adults ($F(1,80) = 13.52, MSe = 42.82, \eta^2_p = 0.14$) but not in young adults ($F < 1.0$). As can be seen from Table 2, further contrasts revealed that older adults increased their use of better strategy by 7.1% during posttest relative to pretest in the success condition ($F(1,158) = 31.13, \eta^2_p = 0.17$) but not in the control condition ($F < 1.0, p = 0.70$). Young adults selected the better strategy equally often during pretest and posttest both under the success and the control conditions ($F < 1.0$). In other words, young and older adults’ use of the better strategy was comparable during pretest in both the success and control conditions ($F < 1.0$). However, only older adults’ better strategy selection improved in the success condition ($F(1,158) = 11.77, MSe = 704, \eta^2_p = 0.07$). 1

Strategy Repetitions on Target Problems

To analyze participants’ tendency to repeat the same strategy across the first 2 problems and the last problem in a given trial, strategy repetition was coded 1, if participants used the same strategy on both the first 2 problems and the last problems of a trial, and 0 otherwise. An ANOVA was performed on mean percentages of strategy repetitions (Table 3) with a mixed design: 2 (Age: young, older adults) × 2 (Condition: control, success) × 2 (Session: pretest, posttest) × 2 (Trial: repeated, unrepeated), with repeated measures on the last 2 factors. Recall that all 3 problems in a trial were better estimated with the same strategy for repeated trials and that the better strategy was different on the first 2 problems, on the one hand, and on the last problems of a trial for unrepeated trials, on the other.

The following main and interaction effects came out significant: Trial ($F(1,158) = 470, MSe = 661.03, \eta^2_p =$

### Table 3. Mean percentages of strategy repetitions during pre- and posttests in young and older adults tested under the control and success conditions for each repeated and unrepeated trial

<table>
<thead>
<tr>
<th>Trials</th>
<th>Young adults (n = 80)</th>
<th></th>
<th></th>
<th>Older adults (n = 82)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>control (n = 43)</td>
<td>success (n = 37)</td>
<td>means</td>
<td>differences</td>
<td>control (n = 42)</td>
<td>success (n = 40)</td>
</tr>
<tr>
<td><strong>Repeated</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>72.7</td>
<td>70.9</td>
<td>71.8</td>
<td>-1.8 ns</td>
<td>71.8</td>
<td>71.9</td>
</tr>
<tr>
<td>Posttest</td>
<td>71.3</td>
<td>72.5</td>
<td>71.9</td>
<td>1.2 ns</td>
<td>68.4</td>
<td>76.9</td>
</tr>
<tr>
<td>Means</td>
<td>72.0</td>
<td>71.7</td>
<td>71.9</td>
<td>-0.3 ns</td>
<td>70.1</td>
<td>74.4</td>
</tr>
<tr>
<td>Difference</td>
<td>-1.4 ns</td>
<td>1.6 ns</td>
<td>0.1 ns</td>
<td></td>
<td>-3.4 ns</td>
<td>5.0 ns</td>
</tr>
<tr>
<td><strong>Unrepeated</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>24.8</td>
<td>28.4</td>
<td>26.6</td>
<td>3.6 ns</td>
<td>34.7</td>
<td>33.1</td>
</tr>
<tr>
<td>Posttest</td>
<td>23.3</td>
<td>27.5</td>
<td>25.4</td>
<td>4.2 ns</td>
<td>31.2</td>
<td>22.7</td>
</tr>
<tr>
<td>Means</td>
<td>24.1</td>
<td>28.0</td>
<td>26.1</td>
<td>3.9 ns</td>
<td>33.0</td>
<td>27.9</td>
</tr>
<tr>
<td>Difference</td>
<td>-1.5 ns</td>
<td>-0.9 ns</td>
<td>-1.2 ns</td>
<td></td>
<td>-3.5 ns</td>
<td>-10.4**</td>
</tr>
</tbody>
</table>

Differences: posttest – pretest. ns, nonsignificant. ** $p < 0.01$; * $p < 0.05$.

1 To determine whether effects of prior-task success were observed in the entire age range of older adults (and not only in oldest older adults), we conducted correlational analyses between age and effects of prior-task success (i.e., differences between posttest and pretest) on all dependent variables in the success condition. No significant correlations were found between age and prior-task success effects in strategy selection ($p = 0.442$), percentages of deviations ($p = 0.829$), and estimation latencies ($p = 0.496$).
Effects of Prior-Task Success in Arithmetic

0.75), Session × Trial ($F(1, 158) = 5.42$, $MSe = 155.68, \eta_p^2 = 0.03$), and Condition × Session × Trial ($F(1, 158) = 4.96$, $MSe = 155.68, \eta_p^2 = 0.03$). We ran breakdown analyses in each age group and pairwise comparisons to analyze changes in strategy repetitions between pretest and posttest. Only older adults tested under the success condition repeated the same strategy on unrepeated trials less often during posttest than during pretest ($F(1, 39) = 8.66$, $MSe = 25,063, \eta_p^2 = 0.18$). No other effects came out significant on participants’ mean percentages of strategy repetitions ($Fs < 3.0$).

In summary, prior-task success influenced strategy use in older adults only. Indeed, following success, older participants selected the better strategy more often and repeated strategies across problems less often when it was inappropriate (unrepeated trials) and more often when it was appropriate (repeated trials). Prior-task success did not change young adults’ better strategy use or strategy repetitions.

Mediation Analyses

To determine whether strategy use mediated effects of prior-task success in older adults, simple mediation analyses were conducted on percentages of deviations. Mediation analyses were not conducted for young adults as differences in strategy use from pretest to posttest were not significant.

Using the PROCESS macro for IBM SPSS (10,000 bootstrapped resamples; Model 4) [28], we regressed the differences in deviations from pretest to posttest on Group (dummy coded: 0 = Control and 1 = PTS [prior-task success]) and entered differences in mean percentages of use of the better strategy from pretest to posttest as the mediator. As can be seen in Figure 2, participants in the success group used the better strategy more often than those in the control group ($a = 7.5$), and the more often participants selected the better strategy, the smaller the deviation ($b = 0.27$). The mediation effects ($ab = 2.07$ [1.02], 95% CI $-4.71$ to $-0.59$) through differences in percentages of use of the better strategy between pretest and posttest were significant (Sobel test, $p = 0.0006$). In other words, there was no evidence that prior-task success influenced percent deviations independent of its effect on percentages of use of the better strategy (direct effect, $c' = 0.05$, $p = 0.92$). Strategy use was thus a significant mediator of prior-task success on percentages of deviations.

Individual Differences in Prior-Task Success Effects on Older Adults

Close examination of older individuals’ data revealed that some older individuals showed larger pretest-posttest differences in percentages of deviation than others. Interestingly, the correlation between differences between pretest and posttest in percentages of deviation and percentages of deviation during pretest was highly significant and larger in the success ($r = -0.98$) than in the control ($r = -0.13$) condition. In other words, effects of success benefitted those older individuals who scored the lowest during pretest. This was independent of participants’ arithmetic fluency, as revealed by nonsignificant correlations between individuals’ performance in the pencil-and-paper arithmetic fluency test and differences between pretest and posttest in percent deviations ($r = 0.24$, ns). Thus, those who benefitted more from prior-task success were not those older individuals with poorer basic arithmetic skills, but those with poorer performance at pretest.

Discussion

We found that participants improved their performance in a target computational estimation task after experiencing success in a prior dot comparison task. These findings replicate previously reported effects of prior-task success [1–3]. In addition, prior-task success led older adults to outperform young adults and to use the better strategy on each problem more often. By examining...
directly which strategy participants selected among 2 available strategies and their performance on each problem in a pretest-posttest design, our findings unambiguously establish the role of strategic variations in effects of prior-task success and revealed that older adults who benefit the most from prior-task success are those who initially perform more poorly. Such findings have important implications for further understanding and studying effects of prior-task success as well as how social environment modulates age-related differences in human cognition.

Interestingly, effects of prior-task success did not influence the same strategy dimensions in young and older adults. Older adults changed their strategy use and how quickly and accurately they executed strategies after experiencing success, whereas young adults only increased speed at executing strategies. Note that this is the first study to find that prior-task success improves young adults’ performance. In addition to our pretest-posttest design, 2 features of the present study may have contributed to reveal effects of prior-task success in young adults. One concerns the type of prior task and the other the feedbacks received by participants on prior-task performance. Previous works used scramble sentence and target detection [1, 2] or the pencil-and-paper version of the Stroop task [3] as prior tasks. Here, our prior dot comparison task is cognitively related to the target task (both tasks are from the numerical cognition domain). Overlap between prior and target tasks may be crucial. Consistent with this, Geraci and colleagues [1, 2] found effects of prior-task success when both prior and target tasks were cognitive tasks (i.e., participants accomplished verbal or visual cognitive prior tasks and episodic memory target tasks) but not when the prior task was a motor task (i.e., throwing a bean bag into a bucket) and the target task a cognitive task (i.e., episodic memory). Another important difference between the present and previous studies are the feedbacks participants received. Here, participants were told how successful they were on each trial and over all trials at the end of the prior task. No feedbacks were provided in previous studies.

One important result of the present study is that prior-task success changed young adults’ speed but not their percentage of deviations or percentage of better strategy use. Decreased percentages of deviations may have occurred if young adults had increased their better strategy use following success. The lack of changes in better strategy selection suggests that they did not accomplish the computational estimation task with different mechanisms after success. It may be premature to conclude that success does not change young adults’ mechanisms while accomplishing cognitive tasks. Indeed, it is possible that in different task environments (e.g., harder target tasks), prior-task success may lead young adults to improve strategy selection, a prediction that could be tested in future studies.

Older adults improved both strategy selection and strategy execution after success, as seen in increased rates of better strategy selection, decreased rates of inappropriate strategy repetitions, increased speed, and decreased percentages of deviations at posttest. We also found important individual differences in effects of success on older adults’ performance, with those older individuals performing poorer at pretest benefitting more from success. Further, our mediation analyses found that prior-task success influence on percentages of deviation occurred via changes in strategies. Following success, older adults used the better strategy more often on each problem, which led them to provide better estimates. This suggests that when age-related differences in cognitive performance are investigated, it may be important to keep in mind that (a) older adults’ cognitive performance may not be the best it could be and (b) as a consequence, age-related differences may be overestimated.

Interestingly, prior-task success led older adults to provide better estimates than young adults. This did not occur at the expense of estimation latencies, as there were no age differences in estimation latencies both in the control and success conditions and both during pretest and posttest. Better performance in older adults than in young adults after prior-task success occurred here in arithmetic, a domain known to undergo either no or less age-related decline [29–31]. In episodic memory, known to undergo much more pronounced age-related decline, Geraci and colleagues [1, 2] found that prior-task success led older adults to recall as many words as young adults. At a general level, this suggests that benefits of prior-task success may interact with cognitive domains. Prior-task success may lead older adults to perform as good as young adults in most age-sensitive domains, like memory, and to perform better than young adults in domains where negative effects of age are either inexistent or much smaller, like arithmetic.

There were 2 limitations of the present study that future studies may examine. First, empirically, future studies may test how long effects of prior-task success last. Do they occur only during the beginning of the target task or throughout the target task? With more problems, future
studies may determine whether effects of prior-task success last throughout the target tasks or only on initial trials. Also, future studies may investigate whether prior-task success influences only the target task immediately following the prior task or whether it lasts longer and performance on several successive target tasks is improved following prior-task success.

The second limitation of our study is theoretical. After establishing that prior-task success increases performance via better strategy use in older adults and via improved strategy execution in young adults, it is important to determine how prior-task success impacts strategy selection and execution. Several types of mechanisms can be responsible, and different mechanisms may intervene in young and older adults. First, cognitive mechanisms include factors that past research showed to be crucial in strategy selection and strategy execution, like executive control [27, 32–36] or metacognition [37–39]. Second, psycho-social mechanisms include factors like reduced stress and anxiety, increased positive mood, or reduced stereotype threat activation [5, 40] in older adults. Speculatively, it could be envisaged that prior-task success may lead participants to be more confident in their cognitive performance. Such increased self-confidence may result in participants deploying more cognitive resources (e.g., higher processing speed, better executive control, larger amount of attention, and/or more efficient monitoring of task performance) in the target task. This would lead them to be faster and more accurate via executing strategies more quickly and accurately and/or via using the better strategy more often under the success condition.

The present findings that age-related differences in cognitive performance and strategies are modulated by prior-task success have important implications for understanding and studying cognitive aging. Effects of prior-task success suggest that the influence of aging on cognitive processes does not occur independently of the situation in which these processes are executed. As a consequence, different conclusions can be drawn if effects of aging on a given set of processes are assessed without taking into account the context in which these processes are executed. For example, effects of prior-task success may have important consequences in clinical research where order of task administration may lead to over- or underestimate patients’ true cognitive capacities. Future studies must further explore the benefits of prior-task success effects in specific aging populations (e.g., Alzheimer’s patients). Note that prior-task success is one type of situational factor that modulates effects of aging on human cognition. A number of other features of social environment has been found to influence older adults’ cognitive performance, like stressful environment [6], framing [7–9], intergenerational interactions [10, 11], subjective age [12, 13], or age-based stereotype threat [4, 5]. To provide a mechanistic account of how these features of the social environment exert their modulating effects on older adults’ cognitive performance, future research could fruitfully adopt the present strategy approach.

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Statement of Ethics

Participants have given their written informed consent. The authors have no ethical conflicts to disclose.

Disclosure Statement

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Authors Contributions

P.L. devised the study and analyses of the data and wrote the paper. J.G. and P.N. ran data analyses.

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