Registered Report: A Replication Examining Occupational Experience and Performance on the Water-Level task

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We have no known conflict of interest to disclose. We thank Matthew Aita, Zeynep Börek, Jacqueline M. Chen, Rebekka Daubert, Iara Delgado, Kyle Hudson Guttman, Alex Hall, Johannes Koopmann, Rebekah Obst, Johanna Röttsches, and Laura Schächtele for their insightful comments and research assistance, and we thank Heiko Hecht and Dennis Proffitt for sharing their wisdom and the data file from their original study. The Institutional Review Board at the University of Utah approved this study, and we obtained informed consent from all participants.

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Abstract

This is a registered report to directly replicate the primary finding in Hecht and Proffitt (1995). Hecht and Proffitt found that those with occupational experience handling liquid in containers performed worse at solving a water-level problem than those in occupations that did not require handling liquids. Shortly after, Vasta et al. (1997) found the opposite: experience was associated with superior performance on the task. The conflicting findings and the small sample sizes in each study leave the relationship between experience and water-level task performance uncertain. We address these concerns with a high-powered direct replication of Hecht and Proffitt (1995) with 407 adults in Germany. We fail to replicate Hecht and Proffitt's results, finding that their study had less than 33% power to detect the small, nonsignificant difference between groups that we observed.

Keywords: occupational experience, water-level task, registered report, replication, perception, expertise, intuitive physics, cognitive psychology

Research Transparency Statement

General Disclosures

Conflicts of interest: All authors declare no conflicts of interest. **Funding**: This research was financially supported by a grant from the Marriner S. Eccles Institute for Economics and Quantitative Analysis at the University of Utah awarded to the first author. **Artificial intelligence**: ChatGPT and Copilot were used as an intelligent thesaurus and copy-editing tool during the creation of this article. No other artificial intelligence assisted technologies were used in this research or the creation of this article. **Ethics**: This research received approval from the University of Utah ethics board (ID: IRB_00174435) and met the ethical guidelines and legal requirements of Ruhr-University Bochum, Germany. **Open Science Framework (OSF):** To ensure long-term preservation, we registered all OSF files at https://doi.org/10.17605/OSF.IO/YCV82.

Study Disclosures

Preregistration: The hypotheses, methods, and analysis plans were preregistered as a Stage 1 registered report (https://doi.org/10.17605/OSF.IO/ETQ5A) on Jul 16, 2024, prior to data collection which began on Sept 17, 2024. There were minor deviations from the preregistration (for details, see Table S1 in the Supplemental Material available online). **Materials**: All study materials are publicly available (https://osf.io/e6hps/). **Data**: All primary data are publicly available (https://osf.io/e6hps/). **Analysis scripts**: All analysis scripts are publicly available (https://osf.io/e6hps/). **Computational reproducibility:** The computational reproducibility of the results in the main article (but not the supplementary materials) has been independently confirmed by the journal’s STAR team.

Registered Report: A Replication Examining Occupational Experience and Performance on the Water-Level task

In 1995, Hecht and Proffitt documented evidence that experience can contribute to failure on certain intuitive physics tasks. Contrary to conventional wisdom that experience does not impair (and often improves) performance, individuals with professional experience handling liquid in containers (i.e., waitresses and bartenders) were more prone to errors than those without experience (i.e., bus drivers, students, and housewives) on a water level problem-solving task. For this task, participants indicate the angle or level of a liquid in a tilted glass (for an illustration, see Figure 1a; Piaget & Inhelder, 1948/1956). The laws of gravity dictate that the surface of a liquid stays level to the ground regardless of a container's tilt, whereas some people incorrectly anticipate that liquid levels correspond to the angle of its container.

In Hecht and Proffitt (1995), "experts" were bartenders and servers with over five years of experience at Munich's Oktoberfest, carrying 1L mugs of beer to customers a considerable distance away. The authors posited that repeatedly carrying liquid-filled glasses (with a focus on not spilling) leads workers to adopt an object-relative frame of reference. In this frame, people focus on the orientation of the water relative to its container. In contrast, when people adopt an environment-relative reference frame, the focus is on the orientation of the water relative to the ground (McAfee & Proffitt, 1991). Hecht and Proffitt (1995) argued that adopting an object-relative perspective creates a perceptual bias that is associated with greater errors on the water-level task. Their findings support this premise and offer a rare example of relevant task experience undermining task performance.

Two years later, Vasta et al. (1997) attempted a replication and produced findings in the other direction. In their study, workers with occupational experience handling liquid demonstrated *superior* performance on the water-level task. Vasta et al. (1997) attribute their divergent findings to their study being better controlled than Hecht and Proffitt (1995), with experimental and control groups better matched for age, education, and gender. Yet, in both studies, sample sizes were small by modern empirical standards and likely underpowered (*n* = 20 per cell), raising the possibility that both findings may have capitalized on chance variation. Additionally, although the high-experience participants in Vasta et al. (1997) had several years of experience, they may not exhibit the same depth of expertise as Munich's Oktoberfest servers or the event city's bartenders. Vasta et al.'s control group also differed from that of Hecht and Proffitt, recruiting salespeople and clerical employees rather than bus drivers, students, and housewives as in the original study. Finally, as noted by Vasta et al., the different results could also be influenced or explained by contextual discrepancies between the two studies (e.g., the studies were conducted in different countries). In sum, the role of occupational experience on performance in the water-level task is still uncertain.

Findings from Hecht and Proffitt (1995) and Vasta et al. (1997) have been cited over 230 times (according to Google Scholar as of June 13, 2024) and have been used to inform subsequent research in a range of scientific disciplines including cognitive psychology (Bilalić et al., 2008), marketing (Kilgour & Koslow, 2009), management (Dane, 2010) and education (Matthes et al., 2023). Often papers cite Hecht and Profitt to evoke the general idea that experience can impair performance, without recognizing the conflicting findings from Vasta et al. (e.g. Kilgour & Koslow, 2009; Dane, 2010; Dror et al., 2011; Matthes et al., 2023). Given the ambiguity created by the inconsistent findings in these two papers, attempting a high-powered "in-the-field" replication is a worthwhile endeavor, in line with recent propositions that ability to remove uncertainty should be a major consideration for replication targets (Hardwicke et al., 2018; Isager et al., 2021). We particularly highlight the value of registered reports and direct replications for verifying empirical findings with modern methodological standards (e.g., preregistration; Nosek et al., 2022; Zwaan et al., 2018). Unlike many in the scientific community who may prioritize ease of data accessibility (Pittelkow et al., 2023), we embrace the challenges presented by data collection in field settings to rigorously test the focal hypotheses in real-world conditions.

The Current Study

Our goal is to assess whether the primary finding in Hecht and Proffitt (1995) replicates. The literature points to different possibilities. According to Hecht and Proffitt, due to occupational demands, servers and bartenders are attuned to not spilling liquid and focus on the level of a liquid relative to the rim of the glass (an object-orientation) rather than the ground when solving the water level problem. Thus, occupational experience should impair performance on the water-level task. On the other hand, Vasta et al.'s (1997) replication found that occupational experience improved performance on the water-level task for both men and women and supports the commonly held belief that experts often outperform novices in tasks relevant to their area of expertise (for review, see Ericsson & Lehmann, 1996). It is also possible that occupational experience has no meaningful effect on whether a person adopts an object-relative or environment-relative reference system, and thus has no impact on performance on the water-level task. Holding a liquid in a glass is a common everyday experience, so additional occupational experience may not alter performance.

Extension: Occupational Experience and Falling Object Task Performance

We build on Hecht and Proffitt (1995) by including an additional intuitive physics task unrelated to fluid dynamics to further interrogate the mechanism proposed in the original paper.

Specifically, we also ask participants to anticipate the trajectory of a moving object as it falls (i.e., the “falling objects problem”; McCloskey, 1983; Riener et al., 2005). Illustrated in Figure 1b, when presented with this task, some participants expect the object to fall straight down or diagonally instead of in a forward parabolic motion. If occupational experience related to handling liquid is the primary cause of poor performance on the water-level task, as suggested by Hecht and Proffitt, then we should observe impaired performance only for intuitive physics tasks related to liquid dynamics and not for other intuitive physics tasks such as the falling object task (i.e., classical mechanics).

Method

Design

Similar to Hecht and Proffitt (1995), we compared participants with occupational experience in handling liquids (servers and bartenders) to participants inexperienced in handling liquids professionally (bus drivers and students).[1] As such, there was no randomization or counterbalancing. Researchers were not blind to groups, but to limit experimenter demand effects we followed a protocol for interacting with participants and handed participants paper materials without verbally explaining the task itself.[2]

[1] We chose not to recruit the “housewives” group (one of the subsamples that comprised the inexperienced group) used in Hecht and Proffitt for several reasons. First, the original group of housewives was a snowball sample from the mother of one of the authors (personal communication with Hecht, Feb 21, 2024). As such, it is unclear how to recruit a comparable sample of housewives to that of the original study. Second, we were concerned that the occupation of housewife/homemaker may not clearly represent low experience, as this role could include frequent liquid carrying tasks such as serving drinks and liquid foods within the home. Indeed, Hecht and Proffitt’s data show a considerably smaller difference in performance between experienced participants and housewives (for absolute error on the water-level task: d = 0.06) than between experienced participants and all other inexperienced participants (d = 1.01). Thus, focusing on the latter set of inexperienced participants (students and bus drivers) gives us the greatest chance of replicating Hecht and Proffitt’s primary result.

[2] To minimize collusion among participants, our research team sometimes asked participants not to speak to or discuss answers with others while completing the survey. Most participants were recruited directly from a researcher and the researcher was almost always nearby while the participant completed the survey, ready to discourage collusion. However, given the noisy environment for data collection, we cannot be certain that no collusion occurred.

Sample Size

Hecht and Proffitt (1995) combined servers and bartenders into an experienced group (*n* = 40) to compare to those in an inexperienced group (*n* = 80). We planned on obtaining a sample size 2.5 times that of the original paper (see Simonsohn, 2015). We aimed to balance sample size across groups, whereas Hecht and Proffitt had fewer experienced than inexperienced participants, and we obtained a sample size of 207 experienced and 200 inexperienced participants (i.e., 2.5 times that of the largest group in Hecht and Proffitt). Our sample consisted of 186 men, 207 women, 3 gender diverse, 5 who chose not to disclose, and 6 nonresponses. The average age in our sample was 27.3 years, with an age range of 17-65 years (7 participants did not respond to the question about age). See Table 1 for demographics of each group.

We had planned for even sample sizes across all four subsamples of participants, but due to unforeseen contingencies, we made changes during data collection that deviated from our stage 1 preregistration. We were unable to collect responses from 100 bartenders by the end of Oktoberfest, as it was harder to reach bartenders than servers, and instead increased the number of servers in our sample to reach our target of 200 experienced participants (i.e., 60 bartenders and 147 servers). We were also unable to collect responses from 100 bus drivers by the end of Oktoberfest, as the rest stop we had planned for recruitment was closed for renovation, and many bus drivers we approached declined to participate and/or did not speak German (the language of our survey). For this reason, we decided to continue recruiting bus drivers in another city in Germany after Oktoberfest ended, but this also proved difficult (i.e., we collected data from 6 bus drivers during Oktoberfest and 14 bus drivers after; see the preregistration-deviation information in Table S1 in the Supplemental Material available online). Consistent with our preregistration, after learning the total number of bus drivers reached, we collected additional responses from university students to reach our target of 200 inexperienced participants.[3] We stopped data collection when we reached our target sample size for each group (oversampling by seven because we noticed that several participants did not draw a line in the glass and would have to be omitted; see preregistration-deviation table).

Exclusions. We excluded 30 participants in the inexperienced group who reported some degree of beverage service experience (i.e., greater than 0 years of experience). We note that there were 117 missing responses to this question, primarily from university students (and all missing responses were participants in the inexperience group), presumably because they thought the question did not apply to them and so did not answer the question. We planned to exclude participants who drew a three-dimensional shape rather than a line on the water-level task, but no participants did so. Finally, we excluded 7 participants who failed to draw a line in the glass at all (one additional participant did this but was already excluded by the other criterion). These exclusions apply to all reported analyses, and left us with 170 inexperienced and 200 experienced participants.

Further, similar to exclusions used by Hecht and Proffitt (1995) and Vasta et al. (1997), we also analyzed our data after performing a second round of exclusions. We excluded participants who reported previous knowledge of the water-level task, as well as bartenders or servers who reported fewer than 5 years of experience. This second round of exclusions left us with 162 inexperienced participants and 123 experienced participants. Because we do not observe meaningful differences in results[4] when comparing the first and second set of exclusions

[3] We estimated that we could recruit 30 bus drivers total given our ongoing efforts, and therefore we collected data from 170 students while continuing to recruit bus drivers. However, reaching this target proved difficult, so we stopped at 20 bus drivers and collected data from 10 additional students.

[4] All results reported here above or below the significance threshold of $p < .05$ do not change when using our secondary set of exclusions, except for two findings. First, we examined group differences in performance across the two tasks

(i.e., similar effect sizes, and virtually all significant/nonsignificant results do not change when using the more restrictive exclusion set), we report results below only using the larger, more inclusive sample and report results using our second round of exclusions in the Supplemental Material.

Materials

One of the current authors (a bilingual German/English speaker) translated the original materials from Hecht and Proffitt (1995) into German. These materials were then revised in response to feedback from the original Hecht and Proffitt (1995) authorship team. Final materials were verified via back-translation by a different researcher not on the authorship team (Brislin, 1976). As in the original study, participants responded using paper-and-pencil surveys.

Measures

Water-level task (Piaget & Inhelder, 1948/1956). Participants were presented with a cross-section drawing of a glass, tilted 50 degrees clockwise from vertical. The glass is held above a bowl sitting on a table; the surface of the table is parallel to the ground. Participants were instructed to draw a single line representing the surface of the water that connects to a point marked on the right side of the glass. Figure 1a provides an illustration of the water-level task.

Performance on the water-level task was measured as how much the line angle drawn by participants deviated from horizontal. A protractor was placed parallel to the surface of the horizontal table to measure each participant's line angle. If participants did not draw a straight line, we extracted a line from the two endpoints of their drawing (as in Barhorst-Cates et al.,

(water-level versus falling-object) and report a negative interaction when adjusting for participant demographics (b = –0.17, SE = 0.06, z = –2.65, p = .008); this result fails to reach statistical significance when filtering on our secondary set of excluded participants (b = –0.16, SE = 0.08, z = –1.90, p = .058). Second, in the exploratory section, we report a nonsignificant correlation between age and absolute error on the water-level task (Pearson's r = .096, p = .07); this result becomes statistically significant when filtering out our additional set of excluded participants (Pearson's r = .142, p = .02).

2020). Data coders measuring line angles were blind to participant group. Two or three coders coded each response. If there were three coders and they were within a degree of each other, then the average was taken of the three measurements. If two of three coders produced the same number, then that number was chosen as the final number. Otherwise, discrepancies greater than 1 degree were resolved by discussion. After coding absolute angle of error, a team coded the direction of the error while still blind to participant occupation. See preregistration-deviation table (Table S1) for minor departures from our planned coding method.

Insert Figure 1 about here

Filler task. We used a similar "filler" task to that used by Hecht and Proffitt (1995). The task depicts two containers of different diameters, the first filled with water and the second empty. Participants were asked to draw the corresponding water level in the second container, after the contents of the first had been poured into the second. As reported by Hecht and Proffitt, this filler task was employed so that participants would not spend too much time mulling over the water-level task or wondering if the task was a trick question. Hecht and Proffitt also had a second filler task, which we replaced with the falling object task.

Falling object task (McCloskey, 1983). Participants were presented with an image of an airplane holding a canister moving in a horizontal direction across the page, and asked to draw the trajectory of the canister when dropped from the airplane (see Figure 1b for an illustration). We measured the falling object task categorically, as correct or incorrect (similar to Riener et al., 2005). Data coders who coded responses on this task were blind to participant occupation. We coded responses as correct if fall lines were drawn parabolically in the direction of the airplane's flight path, while all other responses (e.g., a straight line in the direction of the plane's flight path, a straight line directly down from the plane, or any trajectory in the opposite direction of the plane's flight path) were coded as incorrect (see supplementary materials for examples). Two or three coders coded each response, and discrepancies were resolved by discussion.

Gender. Participants reported their gender as male, female, gender diverse ("divers" in German), or "prefer not to answer."

Age. Participants reported their age in years.

General education. Participants reported their highest level of education on a 7-point ordinal scale (1 = *no degree*, 7 = *doctorate*), plus an "other" option with space to write-in a response.

Physics education. Participants reported the total number of years of physics education received.

Major. University students wrote-in their major and selected the type of program to which their major belonged (*natural sciences, engineering, medicine, social science, arts and humanities*, or *other/don't know*).

Previous task experience. Participants reported whether they had prior familiarity with each intuitive physics task by circling *yes* or *no* for each task.

Occupational experience. When collecting data, researchers recorded whether participants were bartenders, servers, bus drivers, or students. Participants also reported their current primary occupation, checking a box *for bartender, server, bus driver, student*, or *other* (with space to write-in a response). Participants then reported years of experience in their current occupation, as well as years worked in any beverage-service role.

See Table 1 for a summary of the descriptive statistics of the sample.

Insert Table 1 about here

Procedure

All participants were recruited in Germany and all data collection occurred in person (similar to Hecht and Proffitt, 1995). Like Hecht and Proffitt, participants were tested in their workplace or at their university, with as much time as needed to complete the task. Participants read the instructions in the questionnaire themselves and completed the paper-and-pencil water-level task, followed by a filler task, and finally, the falling object task. After each key task (i.e. the water-level task, the falling object task), participants reported whether they had prior experience with the task. Last, they answered questions about their gender, age, education, and occupation.

Researchers recruited servers during Oktoberfest in Munich, Germany. Servers were recruited before their shift began or during breaks, bartenders before their shift or when they were not busy, bus drivers at the end of bus lines or at rest stops, and students from a university in the western part of Germany. Non-student participants received financial compensation for completing the study (10 EUR Amazon.de gift card), and students received a chocolate bar as compensation (commensurate with norms for completing psychology studies at this university).

Here we summarize the procedural differences between our replication and Hecht and Proffitt (1995). First, we did not recruit housewives as one of the subpopulations comprising the inexperienced group. Second, we had a team of researchers administering the survey who did not automatically provide verbal instructions, whereas Hecht and Proffitt gave instructions verbally (in addition to identical written instructions). Third, we provided payment to participants who completed the study, whereas Hecht and Proffitt did not. Fourth, for our sample of university students, we administered surveys to graduate and undergraduate students from various programs of study, whereas Hecht and Proffitt recruited only graduate students (with half enrolled in social science programs and half in natural science programs). Finally, we did not recruit or select based on gender for any occupation (we do not know if Hecht and Proffitt actively selected based on gender, but they reported data from only female servers, male bartenders, and male bus drivers). This research was reviewed and received approval by the Institutional Review Board at the University of Utah (ID: IRB_00174435) and met the ethical guidelines and legal requirements of the Ruhr-University Bochum, Germany.

Results

Experience and Performance. We first examined whether participants with occupational experience performed differently on the water-level task compared to participants with no occupational experience. To examine this, we used absolute error (in degrees) as our dependent variable and conducted a two-tailed, two-sample *t*-test using robust standard errors (i.e., assuming unequal variances). Based on our final sample size of 370 participants (170 inexperienced and 200 experienced participants), we have 80% power to detect an effect of $d \geq 0.29$ using a two-tailed t-test and an alpha level of 0.05, and 90% power to detect an effect of $d \geq 0.34$. As a point of comparison, our sample size gives us more than 99% power to detect the original effect size of $d = 0.67$ observed by Hecht and Proffitt (calculated from data provided by Hecht; personal communication).

We failed to observe a significant difference in absolute error between experienced participants ($M = 9.19$, $SD = 12.62$) and inexperienced participants ($M = 9.46$, $SD = 11.40$), $t(366.62) = –0.22$, $p = .83$, $d = –0.02$. When using the same binary cutoff for performance used in Hecht and Proffitt (0 = more than five degrees error, 1 = five degrees or less of error), there was no significant difference in performance between experienced participants (59.0% correct) and inexperienced participants (51.2% correct), z = –1.51, *p* = .13. We also note that our results are directionally opposite to that found by Hecht and Proffitt.[5] See Figure 2.

Insert Figure 2 about here

We also tested for performance differences between groups after statistically adjusting for gender, age, and education. Using ordinary least squares, we regressed absolute error scores onto experience (0 = inexperienced, 1 = experienced) as well as gender (dummy-coded), age (in years), and education (dummy-coded). For this regression, as well as all others, we implemented robust standard errors. We again fail to find a statistically significant difference in absolute error between experienced participants (predicted *M* = 9.00) and inexperienced participants (predicted *M* = 10.0), *t*(344) = –0.64, *p* = .52. When using the same binary cutoff for performance as before,[6] we again failed to find a significant difference in correct responses between experienced participants (predicted probability = 59.5%) and inexperienced participants (predicted probability = 50.8%), *z* = –1.42, *p* = .16.

Replicability. We assess the replicability of Hecht and Proffitt (1995) using the "small telescopes" criterion, which asks whether our observed effect is large enough to have been detectable at 33% power based on the original sample size from Hecht and Proffitt (Simonsohn,

[5] For all analyses, test statistics and effect sizes are coded as negative when they are inconsistent with Hecht and Proffitt (1995).

[6] When statistically adjusting for demographics for binary outcomes, we conducted the same set of analyses as before but using logit regression rather than OLS regression. We report estimates, test statistics, and *p*-values based on the average marginal effects (i.e., difference in predicted probabilities), rather than based on the log-odds coefficient from the logit model (for a discussion on this issue, see McCabe et al., 2022). We note that in our data both approaches tend to return similar test statistics and *p*-values.

2015). Based on this criterion,[7,8] an effect size reliably smaller than $d = 0.30$ would be inconsistent with a true effect large enough to have been detectable by Hecht and Proffitt (and thus we consider a "failed" replication).[9] Using a one-sided t-test, the difference we observe between experienced and inexperienced participants was reliably smaller than a detectable effect, $t(368) = 3.11$, $p = .001$. We observed a similar result after statistically adjusting for participant gender, age, and education, $t(344) = 2.90$, $p = .002$. We fail to replicate the results of Hecht and Proffitt.

Extensions. On the falling object task, experienced participants were less likely to answer correctly (31.3%) than inexperienced participants (42.0%), $z = 2.13$, $p = .03$. This difference becomes statistically nonsignificant after adjusting for participant gender, age, and education (predicted probabilities were 31.7% versus 40.8%, respectively; $z = 1.57$, $p = .12$).

We next examined group differences in performance across the two tasks (water-level versus falling-object). First, we dichotomized performance on the water-level task similar to before (and similar to in Hecht & Proffitt, 1995) in order to compare performance across the two tasks. We then performed a logit regression in which we regressed task performance (0 = incorrect answer, 1 = correct answer) onto our predictors of experience (0 = inexperienced, 1 = experienced), task (0 = water level, 1 = falling object), and the interaction between experience

[7] We use Hecht and Profitt's (1995) total sample (including housewives) when performing our small telescopes calculation, even though our sample did not include housewives. Doing so creates a more stringent or conservative criteria for us to conclude a failed replication result.

[8] In our stage 1 preregistration, we had incorrectly reported this value as $d = 0.28$. Using either effect size does not change our results or conclusions.

[9] Another method for assessing replicability is the use of prediction intervals (Spence & Stanley, 2024). Given the observed effect and sample size found in Hecht and Proffitt (1995) and our replication sample size, any standardized effect falling outside the prediction interval [0.23, 1.11] would indicate a "failed" replication. Using this method, we again fail to replicate the results of Hecht and Proffitt—our observed effect size of $d = –0.02$ falls outside the replication interval.

and task. We implemented participant-clustered standard errors to account for potential nonindependence in performance across tasks. Per our stage 1 preregistration, our coefficient of interest is the interaction based on the difference in average marginal effects (rather than the interaction term from the logit model; see McCabe et al., 2022).

Based on Hecht and Proffitt's (1995) original hypothesis we should expect a positive interaction effect, which would imply a larger detrimental effect of beverage experience on the water-level task than on the falling object task. In fact, we observe a statistically significant *negative* interaction, $b = –0.19$, SE = 0.06, $z = –2.90$, $p = .004$. As discussed above, experienced participants (nonsignificantly) outperformed inexperienced participants on the water-level task, $z = –1.51$, $p = .131$, but performed worse than inexperienced participants on the falling object task, $z = 2.13$, $p = .034$. We observe a similar negative interaction when adjusting for participant demographics, $b = –0.17$, SE = 0.06, $z = –2.62$, $p = .009$.

Exploratory Analyses and Data Quality Checks. Hecht and Proffitt (1995) and Vasta et al. (1997) reported finding that men outperform women (also see Robert, 1990, and Tran & Formann, 2008; cf. Wu et al., 2017). Researchers have also found that participants who have more years of education, especially physics education, perform better on the water-level task (Riener et al., 2005). Hecht and Proffitt reported that younger participants performed best, but a well-powered study examining age found no decline in performance until around age 60 (Tran & Formann, 2008), which represents less than 1.5% of the participants in our sample. As an exploratory exercise and data-quality check, we examined whether younger participants, male participants, and more educated participants performed better on the water-level task than others (we also provide a correlation table between all variables in Supplemental Materials; see Table S2).

Absolute error on the water-level task was smaller for male participants (*M* = 8.51, *SD* = 12.28) than for female participants (*M* = 10.30, *SD* = 12.12), though the difference was not statistically significant, *t*(348.5) = 1.38, *p* = .17, *d* = 0.15. We observed a weak and nonsignificant positive correlation between age and absolute error (Pearson's *r* = .096, *p* = .07), and this relationship shrinks to virtually zero when examining the rank-order correlation between age and absolute error (Spearman's ρ = .004, *p* = .93). We observe a negative and nonsignificant rank-order correlation between educational level[10] and absolute error on the water-level task (Spearman's ρ = –.065, *p* = .22). Finally, we observe a negative and significant correlation between years of physics education and absolute error on the water-level task (Pearson's *r* = –.109, *p* = .04; Spearman's ρ = –.193, *p* < .001). In sum, the only demographic characteristic reliably related to superior performance on the water-level task was years of physics education.

Lastly, Hecht and Proffitt (1995) reported that only 3% of participants drew a line that was less than –5 degrees from horizontal. We found that 8.1% of participants in our sample made this type of error.

Discussion

We conducted a registered report to replicate Hecht and Proffitt (1995), examining the relationship between occupational experience and performance on an occupationally relevant intuitive physics task. We extended their study by adding an intuitive physics task unrelated to occupational experience as a further check of their theory. As in Hecht and Proffitt, we recruited participants with occupational experience handling liquids (servers and bartenders) and without this experience (students and bus drivers). We compared performance on the classic water-level

[10] For correlations with education, we exclude 1 additional respondent who reported "other" as their degree of educational attainment. This participant is not dropped from the prior regression analyses, because they were included as a fixed effect (i.e., dummy-coded), which does not assume a linear relationship across education levels and the outcome variable.

task (Piaget & Inhelder, 1956), and as an extension, on an intuitive physics task unrelated to handling liquid (the falling object task, McCloskey, 1983). Unlike Hecht and Proffitt, we did not find that participants with occupational experience performed worse on the water-level task. We observe a relatively precisely estimated null effect between groups.

Although we found no meaningful difference between the two groups on our target intuitive physics task (the water-level task), we did find that experienced participants performed relatively worse on an alternative intuitive physics task (the falling object task). One possibility is that experienced participants in our sample show a baseline performance deficit on intuitive physics tasks relative to inexperienced participants, and their occupational experience affords a performance boost on the water-level task specifically. This interpretation would be consistent with Vasta et al.'s (1997) finding that participants with occupational experience outperformed inexperienced participants on the water-level task. However, this explanation raises the question of why occupational experience with liquids would be associated with a performance deficit on non-liquid intuitive physics tasks. Higher education attainment in the inexperienced group, which was composed primarily of undergraduate and graduate students, is unlikely to account for this discrepancy, as education did not reliably predict performance on intuitive physics tasks in our study, and the two groups had similar levels of physics education. We also note that this interaction became nonsignificant when we filtered on our secondary set of excluded participants. Therefore, given the total available evidence, we believe that the most parsimonious explanation of these results is that there is likely no meaningful difference between experienced and inexperienced groups on the water-level task.

Strengths of our replication include a larger sample, and thus more statistical power, than that used by Hecht and Proffitt (1995). Our sample size allowed us to detect small-to-medium effects with a high degree of power and gave us over 99% power to detect effect sizes reported in the original paper by Hecht and Proffitt. Another strength of our design is the use of the registered report method, which provides readers with evidence of decisions we made before data collection (i.e., about the sample, analysis plans, etc.). We also collaborated with a member of the original authorship team to recreate their materials and closely follow their procedure, and a member of our authorship team had extensive prior experience coding the water-level task. Finally, we recruited participants in the same location and setting as the original study, unlike many replication studies (Hoffman et al., 2025).

Despite these strengths, there are several reasons why we may have failed to replicate the results of Hecht and Proffitt (1995). One possibility is that the original study was a false positive. Another possibility is that our replication is a false negative. Although our study had considerably higher power than that of Hecht and Proffitt, the true effect size may have been smaller than we had sufficient statistical power to detect. Other reasons that our findings were different from Hecht and Proffitt could be that, although we returned to the original location, perhaps participant characteristics have meaningfully changed over time (e.g., our servers had fewer years of work experience and were younger), or perhaps situational characteristics were meaningfully different (e.g., if our servers were less distracted when completing the survey). From our field observations, servers appeared more concerned with getting drinks to a table quickly (e.g., to put them down because they were heavy, and to get them to customers efficiently) than with spilling beverages. This tendency could be different from when Hecht and Proffitt studied servers, but nevertheless calls into question the hypothesis that occupational experience with liquids elicits an object-relative reference system.

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Figure Captions

Figure 1. Intuitive physics tasks: (a) water-level task and (b) falling-object task.

Figure 2. Performance on the water-level task for those with occupational experience handling liquid (servers at Oktoberfest and bartenders) and those without (students and bus drivers) in Hecht and Proffitt (1995) and the current replication. Horizontal lines represent means. Higher values indicate worse performance.

Table 1

Descriptive Statistics

	Inexperienced			Experienced		
Variable	Students	Bus Drivers	Total	Servers	Bartenders	Total
n[a]	153	17	170	146	54	200
Gender[b]						
Men	50	14	64	74	30	104
Women	92	3	95	69	24	93
Age[c]	21 (2.7)	47 (10.0)	24 (8.7)	31 (10.2)	30 (9.9)	31 (10.1)
Physics[c]	4.4 (2.7)	3.8 (3.1)	4.3 (2.8)	5.0 (2.6)	4.4 (3.5)	4.9 (2.9)
Beverage service[c]	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	9.5 (8.1)	7.7 (8.7)	9.0 (8.3)
Education[d]	5.1 (.39)	3.6 (1.3)	5.0 (.72)	4.6 (1.3)	4.4 (1.5)	4.5 (1.4)
WLT error[e]	8.8 (11)	15 (16)	9.5 (11)	6.4 (8.7)	17 (18)	9.2 (13)
WLT correct[f]	54%	29%	51%	65%	43%	59%
FOT correct[g]	42%	41%	42%	34%	23%	31%

Notes: Sample size per cell may vary because of missing values. WLT = water-level task; FOT = falling-object task.

a. 30 participants who reported some degree of beverage service experience in the inexperienced group and 8 participants who failed to draw a line in the glass were excluded (one person was excluded for both reasons, so 37 participants were excluded in total)

b. Other gender categories were excluded

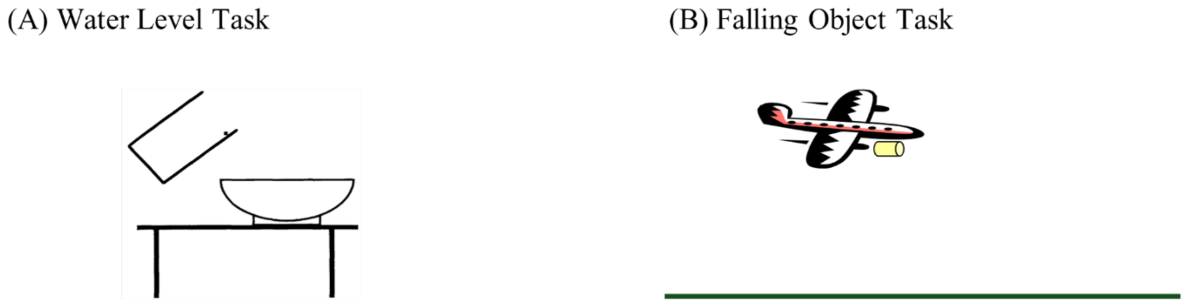
c. Mean years with standard deviation in parentheses

d. Scale from 1 to 7, excluding one additional participant who selected “other.” Standard deviations are in parentheses.

e. Mean absolute error in degrees on the water-level task with standard deviations in parentheses.

f. Correct on the water-level task

g. Correct on the falling-object task



(A) Water Level Task

Imagine the drawing is depicting a glass held perfectly still by an invisible hand so that the water rests within it. Draw a line that would represent the surface of the water if the surface touched the point on the right side of the glass. Note that the glass is held over the table you see in the drawing. The drawing is a side view of the container, so a single line is sufficient to indicate the water level.

(B) Falling Object Task

This airplane is carrying a canister of supplies as it flies over a field. The plane drops the canister. Draw the path that the canister will follow before it hits the ground.

Figure 1. Intuitive physics tasks: (a) water-level task and (b) falling-object task.

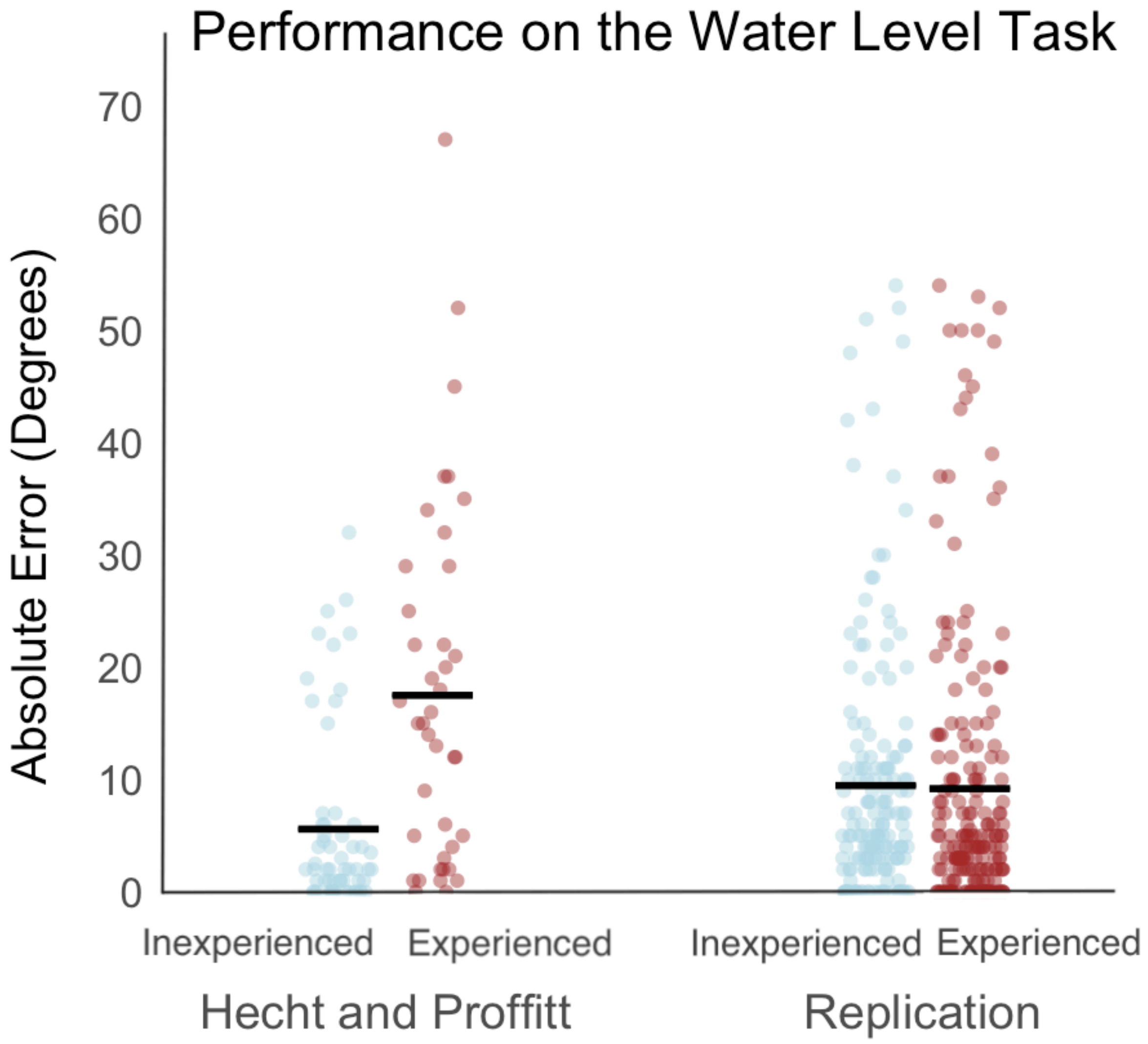


Figure 2. Performance on the water-level task for those with occupational experience handling liquid (servers at Oktoberfest and bartenders) and those without (students and bus drivers) in Hecht and Proffitt (1995) and the current replication. Horizontal lines represent means. Higher values indicate worse performance.