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The Grid Learning Task: Examining the Effects of Overlap Type on New Learning Within Healthy Adult Participants

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Abstract

In everyday life, people often need to remember the locations of objects, such as where a car was parked on a given day. A key question is whether a similar prior experience (e.g., parking in the same lot the previous day) facilitates or interferes with memory for a new event. The Grid Learning Task (GLT) was developed to address this question. In this task, participants study a set of objects arranged on a grid and are then asked to place them in their correct locations on an empty version of the grid. Two overlap conditions are of primary interest: the Location overlap condition and the Object overlap condition. In the Location overlap condition, different objects are presented in the same spatial configuration as the previous grid. In the Object overlap condition, the same objects are presented in a different spatial configuration. The current protocol modifies the original task to a within-subjects design in which participants experience all overlap types. By comparing learning attempts across the Location overlap and Object overlap conditions, the GLT provides insight into how different forms of overlap with prior experiences influence new learning. Findings from this task generally show that overlapping object identities increase the number of attempts required to learn a subsequent grid, reflecting memory interference. In contrast, overlapping object locations reduce the number of attempts required to learn a subsequent grid, reflecting memory facilitation. Overall, the GLT provides a framework for examining how prior experiences influence new learning by revealing both interfering and facilitatory effects.

Introduction

Our everyday experiences often contain overlapping information. Prior knowledge can sometimes support new learning by providing a scaffold, but it can also interfere with learning, creating confusion and hindering performance^{1,2,3,4}. For example, when visiting a new grocery store, people can readily locate carts or checkout counters by relying on knowledge acquired from previous grocery store layouts. However, remembering the exact location of a specific item may be more difficult when its placement differs from that in a familiar store. This illustrates a broader question: under what

conditions does prior experience facilitate new learning, and when does it interfere with it?

Researchers have long investigated how prior knowledge affects learning, but evidence for its facilitatory and interfering effects has often emerged from distinct experimental paradigms^{1,2,3,4}. Consequently, developing a coherent account of how prior knowledge influences the acquisition of new information remains challenging. Interference effects are typically examined using word-pair learning tasks^{1,2,5,6,7}. In these tasks, participants first learn a set of word pairs (e.g., A-B), then learn a second list in which some pairs share an item with the first list (e.g., A-C), along with

control pairs without overlap (e.g., D-E). When the shared item (A) is used as a retrieval cue, recall of the second-list pair (C) is often impaired, a phenomenon known as proactive interference⁶. This effect is commonly attributed to competition between the previously learned association (A-B) and the newer association (A-C), reducing the likelihood of retrieving the latter⁵.

In contrast, facilitation effects have been observed in object-location learning tasks^{3,8}. In these tasks, participants learn the positions of multiple objects on a grid, and learning is enhanced when a new set of objects is presented within a previously learned spatial layout rather than a novel one. This beneficial effect of overlapping spatial structure has been demonstrated in both humans and rodents^{3,8}, highlighting how prior knowledge can support new learning. Importantly, prior spatial knowledge represents only one form of schematic knowledge that can influence behavior⁹. Schemas may also include semantic knowledge (e.g., grocery stores sell food but may also carry household items), which can facilitate the acquisition of new information and guide behavior more broadly⁹. For example, if someone wishes to purchase an apple, they may rely on an existing schema that it is more likely to be found in a grocery store than in a hardware store.

The Grid Learning Task (GLT)¹⁰ was developed to provide a unified framework for examining how prior knowledge influences new learning by incorporating both facilitation and interference within a single task. In the GLT, participants learn multiple object-location grids, repeating the learning process until all object locations are remembered. Crucially, the type of overlap between consecutive grids is manipulated. In the Location overlap condition, different objects are presented within the same spatial layout. In the Object overlap condition, the same objects are presented in different locations. Previous findings showed that learning is facilitated when spatial layouts overlap but impaired when object identities overlap¹⁰. However, initial applications of the GLT compared overlap conditions across participants¹⁰, raising the possibility that these opposing effects reflected individual differences rather than overlap type itself.

The present protocol describes a modified within-subjects version of the GLT in which each participant experiences all overlap conditions. This methodological modification reduces between-subject variability and allows facilitation and interference to be measured within the same individual. As a result, the design more directly tests whether different forms of prior knowledge exert distinct influences on new learning. Collectively, these findings suggest that the type of prior knowledge may determine whether prior experience facilitates or hinders subsequent learning.

The objective of the GLT is to quantify how prior experience influences new learning in human participants by measuring learning attempts within a within-subject grid-learning paradigm

that systematically manipulates overlap types, thereby assessing facilitation and interference effects on learning performance. By enabling the measurement of both facilitation and interference within a single paradigm, the GLT provides a unified framework for studying how prior experience shapes new learning. Unlike existing paradigms that typically examine facilitation or interference in isolation^{1,2,3,5,6,7,8}, the GLT systematically manipulates overlap while maintaining a consistent task structure. This approach allows direct comparison of how different forms of prior information influence learning within individuals. One potential limitation is that facilitation and interference effects may vary with the order in which overlap conditions are presented, leading to under- or overestimation. Nevertheless, the GLT remains a versatile tool for investigating the mechanisms underlying memory, learning, generalization, and interference, as well as individual differences in susceptibility to prior-knowledge effects across learning contexts.

Protocol

All procedures involving human participants were approved by the University of California, Riverside Institutional Review Board (Protocol #30014). Written informed consent was obtained from all participants prior to participation. All methods were performed in accordance with relevant institutional guidelines and regulations.

1. Consent and instructions

1. Give participants a consent form that explains participant rights and provides a general overview of the study. Obtain written informed consent from all participants before participation.
2. After participants sign the consent form, verbally explain that the task involves memorizing object locations and placing objects on the correct tiles during the test phase across four different grids, with a math distractor task presented between grids.
3. Briefly describe the overall task structure, including the practice and studied grid phases. Ask participants to repeat the task instructions back to the researcher and provide clarification as needed.

2. Grid learning task

1. Open the Grid Learning Task program (**Supplementary File 1** and **Supplementary Figure 1**) using PsychoPy¹¹. Click the "Run" button, ensuring the program is not in pilot testing mode.
2. A prompt requesting a participant identification number will appear. The participant identification number is used to maintain participant anonymity. Instruct participants to

enter their pre-assigned participant identification number and continue by **clicking** the "OK" button.

3. Start the program. The screen prompts participants to use the space bar to advance through the instructions.
4. Instruct participants to adjust the screen size by simultaneously pressing the Command (Mac) or Control (Windows) key and the "+" or "-" key until all four corners of the grid are visible on the screen.

NOTE: Ensure that all four corners of the grid are visible before beginning the task. Improper screen scaling may affect stimulus presentation and participant performance.

5. Practice Phase

1. Begin the practice phase. **Figure 1** illustrates the "Study – Fixation – Test – Feedback" cycle. For the first practice phase, present a small 3 × 3 grid containing one object.
2. Display the study screen for 4 s. Present a 3 s retention interval immediately afterward, during which the grid disappears, and a fixation cross is displayed before the test screen appears.
3. Display an empty grid with the object positioned below the grid. Prompt participants to drag and drop the object to its original location.

1. Use colored everyday object images with white backgrounds from the Bank of Standardized Stimuli (BOSS)^{12,13}. Across the four studied grids, use three object sets and three location sets to create nine unique 8 × 8 grids.
2. Randomly select each object set from a fixed pool of 24 objects spanning 12 categories (e.g., outdoor activities and sports, stationery, kitchen utensils, decorations, musical instruments, games, household tools, furniture, and clothing) (**Supplementary Figure 2**).

4. After participants submit their response by pressing the space bar, display a feedback screen indicating whether the placement was correct. Allow participants to press "y" to repeat the trial or "n" to proceed. Participants may repeat this first practice phase up to 10 times.

NOTE: Use this practice phase to familiarize participants with dragging and dropping objects onto the grid.

5. Begin the second practice phase. Present a full-sized 8 × 8 grid containing two objects.

1. Use the same "Study – Fixation – Test – Feedback" cycle and timing as in the first practice phase, except that the study screen is displayed for 8 s.

2. After participants submit their response, display a feedback screen indicating whether all object locations were placed correctly. If at least one object is incorrect, inform participants that one or more placements were incorrect without identifying specific objects.
3. If the response is incorrect, prompt participants to press the space bar to try again. If all placements are correct, prompt participants to proceed to the next stage of the task.
4. Prompt participants to press "y" to repeat the practice phase or "n" to continue. Participants may repeat this second practice grid up to 10 times.

NOTE: Use this practice phase to familiarize participants with the full-sized 8 × 8 grid. Objects and locations used during practice do not appear during the studied grid phase.

6. Studied grid phase

1. Display the instruction screen indicating the start of the studied grid phase. Have participants begin the studied grid phase by pressing the space bar and following the on-screen instructions.
2. Present screens using the same "Study – Fixation – Test – Feedback" cycle and timing as in the second practice phase. Unlike the practice phase, participants learn four different grids, each containing eight objects.

NOTE: Ensure that participants understand that each grid must be learned to criterion before advancing. Failure to learn one grid may affect performance on subsequent grids.

3. Present a study screen containing eight different objects arranged on an 8 × 8 grid. Display the study screen for 8 s, then instruct participants to memorize the locations of the objects.
 1. Use everyday objects displayed on a white background.
 2. Arrange objects according to one of the predefined object-location sets.
 3. Create three location sets by pseudorandomly assigning object locations such that objects are not placed along grid edges and do not occupy adjacent cells. Corner-sharing tiles are permitted.
4. Present a retention interval screen displaying a fixation cross for 3 s.
5. Present a test screen prompting participants to place each object in its remembered location. Display an

empty 8×8 grid with object images randomly arranged below the grid.

6. Have participants drag and drop each object onto the grid to indicate its remembered location. Automatically center each object within the selected grid tile. Allow participants to reposition objects an unlimited number of times before submitting a response.
 7. Once participants are satisfied with their placements, instruct them to press the space bar to submit their response. The test phase is self-paced and has no time limit.
 8. Display a feedback screen indicating the number of correctly placed objects. Do not identify which objects were placed correctly.
 9. Repeat the "Study – Fixation – Test – Feedback" cycle until all eight objects are placed correctly or until 10 study-test cycles have been completed, whichever occurs first. The program then automatically advances to the math distractor task.
7. Math distractor task
1. Begin the math distractor task. Instruct participants to read the on-screen instructions and complete simple arithmetic problems before proceeding to the next grid.
 2. Present simple arithmetic problems involving addition or subtraction one at a time on the screen. Instruct participants to indicate whether each equation is correct or incorrect by pressing "T" for true or "F" for false.
 1. For example, when presented with the equation $2 + 4 = 6$, instruct participants to press "T". When presented with the equation $2 + 5 = 10$, instruct participants to **press "F"**.
 3. Display a feedback screen after each response.
 1. Indicate whether the response was correct or incorrect. If no response is made within 4 s, automatically advance to the feedback screen and display a message prompting participants to respond more quickly.
 2. Allow the feedback screen to remain visible for 2 s. After 2 s, the program automatically advances to the next trial.
 4. Require participants to complete 20 arithmetic questions before proceeding to the next grid. Completion of the distractor task typically requires approximately 1 min.

NOTE: Use this task to prevent active rehearsal of the previous grid and to maintain participant engagement. Although overall accuracy is not provided as feedback during the experiment, exclude participants from analysis if accuracy is below 75%¹⁰.

8. Overlap manipulation

1. After completion of the math distractor task, display on-screen instructions indicating that the next grid will begin. Instruct participants to press the space bar to start the next trial. Repeat the "Study – Fixation – Test – Feedback" cycle for the subsequent grid. Across the task, participants learn four different grids separated by math distractor tasks.
2. Configure the four grids such that two consecutive grids share the same object images but different locations, whereas another pair of consecutive grids shares the same spatial layout but different object images (**Figure 2**).
 1. Construct the four studied grids from the predefined object and location sets described in Steps 2.5.3.1–2.5.3.2 and 2.6.3.3. Grids will be randomly selected such that one transition represents the Object overlap condition, one transition represents the Location overlap condition, and one transition represents the No overlap condition.
 2. For the Object overlap condition, use the same object set across two consecutive grids while assigning different location sets. For the Location overlap condition, use the same location set across two consecutive grids while assigning different object sets. For the No overlap condition, use different object sets and different location sets across consecutive grids.
3. Randomly assign and fully counterbalance overlap-condition order across participants, resulting in six possible overlap orders.

NOTE: Fully counterbalance the overlap-condition order across participants to minimize order effects and ensure valid estimates of facilitation and interference.
4. Present a different set of 20 arithmetic questions during each distractor phase, resulting in three unique question sets across the experiment.
9. After completion of the fourth grid, display an end-of-task screen. Instruct participants to press the space bar to exit the program.

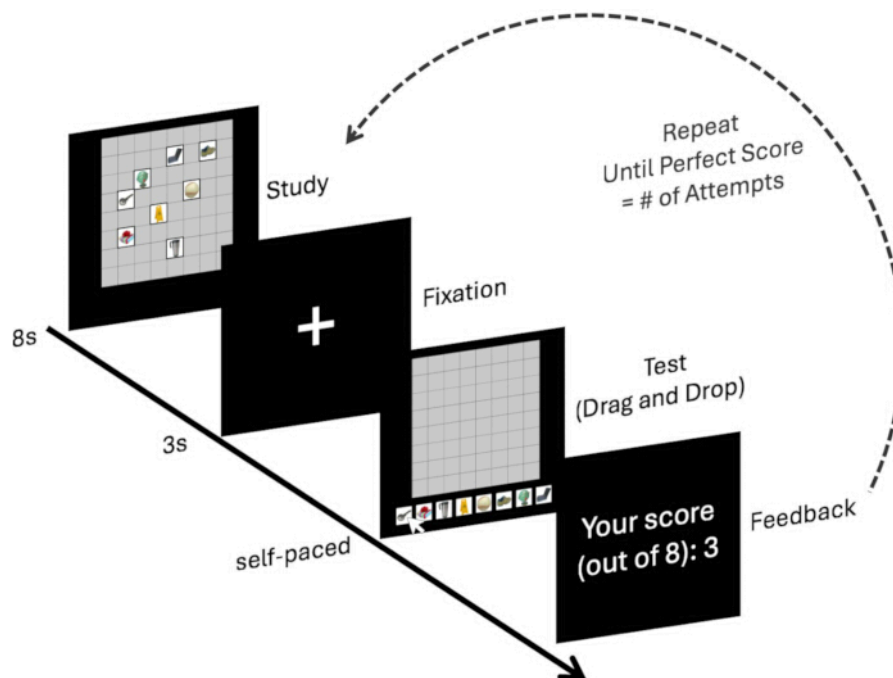


Figure 1: Order and timing of screens in the Grid Learning Task. Each learning trial consists of a repeating “Study – Fixation – Test – Feedback” cycle. During the Study phase, participants view eight objects arranged on an 8×8 grid and memorize their locations. The 8s Study phase is followed by a 3s fixation screen and a self-paced Test phase, during which participants drag and drop objects onto an empty grid to indicate remembered locations. After participants submit their response, a Feedback screen displays the number of correctly placed objects. This cycle repeats until all objects are placed correctly or until a maximum of 10 learning attempts has been completed, whichever occurs first. [Please click here to view a larger version of this figure.](#)

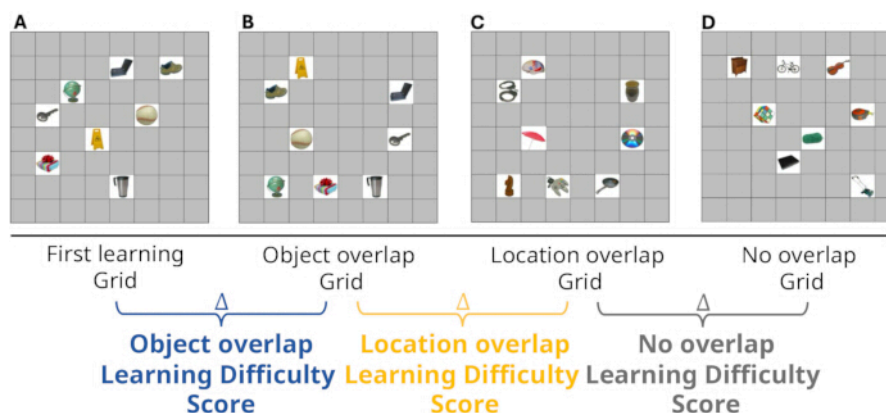


Figure 2: Overlap conditions in the Grid Learning Task. Participants learn four different grids. (A) The first grid serves as a baseline for calculating the Learning Difficulty Score between consecutive grids. Beginning with the second grid, participants experience either (B) the Object overlap condition, (C) the Location overlap condition, or (D) the No overlap condition across consecutive grids. The example shown illustrates the overlap order Object overlap → Location overlap → No overlap. Overlap-condition order is counterbalanced across participants. Images shown are unaltered stimuli from the Bank of Standardized Stimuli (BOSS) set^{12,13} and are used under the Creative Commons Attribution License (<http://creativecommons.org/licenses/by-sa/3.0/>). [Please click here to view a larger version of this figure.](#)

3. Optional forms

1. Administer the feedback form. Ask participants what they believe the experiment investigated and which strategies they used during the task. Invite additional feedback and suggestions for improvement.

2. Administer the demographic form. Collect demographic information, including age and ethnicity. Inform participants that all information will be reported in aggregate form to maintain anonymity.

3. Provide participants with a paper copy of the debriefing form. The debriefing form explains the study's purpose and the rationale for the task.

Results

Participants were excluded based on the following criteria: (a) failure to learn any grid within 10 attempts or (b) accuracy below 75% on the math distractor task. These criteria were adopted from a previous study using the Grid Learning Task (GLT)¹⁰. Of the 46 participants who completed the GLT, 1 was excluded under the first criterion, and none were excluded under the second. All statistical tests were evaluated using a two-tailed α level of .05.

Across the four grids, participants learned each grid in approximately 4 attempts ($M = 3.81$, $SD = 0.93$). The number of learning attempts decreased numerically across grids, from Grid 1 ($M = 4.69$, $SD = 1.53$) to Grid 2 ($M = 3.62$, $SD = 1.59$), Grid 3 ($M = 3.51$, $SD = 1.50$), and Grid 4 ($M = 3.40$, $SD = 1.21$) (**Table 1**). A repeated-measures Analysis of Variance (ANOVA) conducted on data from 45 participants revealed a significant effect of Grid Number on learning attempts ($F(3, 132) = 9.32$, $p < .001$, $\eta^2 = .18$). Post hoc pairwise t-tests with Benjamini-Hochberg (BH) correction ($N = 45$) indicated that learning attempts for Grid 1 were significantly greater than those for all subsequent grids (all BH-adjusted p values $< .001$). No other pairwise comparisons remained significant after correction (all BH-adjusted p values $> .678$).

	Grid 1	Grid 2	Grid 3	Grid 4
<i>M</i>	4.69	3.62	3.51	3.4
<i>SD</i>	1.53	1.59	1.50	1.21

Table 1: Descriptive statistics for learning attempts across grids, collapsed across overlap conditions in the Grid Learning Task. Values represent the mean and standard deviation (SD). $N = 45$ participants.

To quantify facilitation and interference effects, a Learning Difficulty Score was calculated for each overlap condition by subtracting the number of learning attempts required for the previous grid ($[n - 1]$) from the number required for the current grid ($[n]$). Negative scores indicate facilitated learning of the current grid relative to the previous grid ($[n] - [n - 1] < 0$), whereas positive scores indicate hindered learning ($[n] - [n - 1] > 0$).

The no-overlap condition was included to account for individual differences in learning unrelated to overlap. Therefore, Learning Difficulty Scores in the Object overlap and Location overlap conditions were compared with the No overlap condition rather than with zero.

Among the 45 participants included in the analysis, a repeated-measures ANOVA revealed a significant effect of Overlap Type on Learning Difficulty Score ($F(2, 88) = 10.80$, $p < .001$, η^2

$= .20$; **Figure 3**). Pairwise t-tests ($N = 45$) indicated that Learning Difficulty Scores were higher in the Object overlap condition ($M = 0.58$, $SD = 1.53$) than in the No overlap condition ($M = -0.53$, $SD = 1.31$; $t(44) = 3.19$, $p = .003$, Cohen's $d_z = .48$), indicating hindered learning. In contrast, Learning Difficulty Scores in the Location overlap condition ($M = -1.33$, $SD = 2.15$) were numerically lower than those in the No overlap condition ($t(44) = -1.90$, $p = .064$, Cohen's $d_z = .28$), consistent with a marginal facilitation effect. Overall, these findings indicate that overlap type influenced learning performance, with object overlap associated with impaired learning and location overlap associated with numerically facilitated learning relative to the No overlap condition. An exploratory analysis of response time difference scores revealed no significant effect of overlap type (**Supplementary Figure 3**).

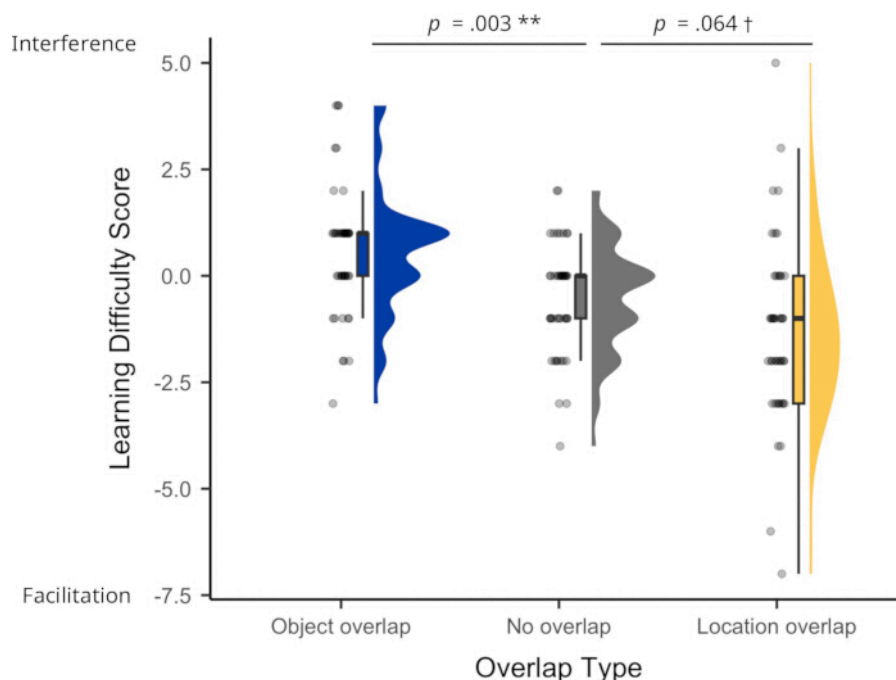


Figure 3: Learning difficulty score as a function of overlap type in the Grid Learning Task. Learning Difficulty Score was calculated as the number of learning attempts required for the current grid ($[n]$) minus the number required for the previous grid ($[n - 1]$). A repeated-measures ANOVA ($N = 45$) revealed a significant effect of Overlap Type ($F(2, 88) = 10.80, p < .001, \eta^2 = .20$). Pairwise t-tests ($N = 45$) indicated that Learning Difficulty Scores were higher in the Object overlap condition ($M = 0.58, SD = 1.53$) than in the No overlap condition ($M = -0.53, SD = 1.31; t(44) = 3.19, p = .003$, Cohen's $d_z = .48$), whereas Learning Difficulty Scores in the Location overlap condition ($M = -1.33, SD = 2.15$) were numerically lower than those in the No overlap condition ($t(44) = -1.90, p = .064$, Cohen's $d_z = .28$). The center line of each box represents the median, the box indicates the interquartile range, and the whiskers extend to $1.5 \times$ the interquartile range. Each point represents an individual participant. Horizontal lines indicate pairwise comparisons of Object overlap versus No overlap conditions and Location overlap versus No overlap conditions based on pairwise t-tests. All statistical tests were two-tailed with $\alpha = .05$. ** indicates $p < .01$ and † indicates $p < .10$. [Please click here to view a larger version of this figure.](#)

Supplementary File 1: The Grid Learning Task (GLT) program.

The script implements and runs the Grid Learning Task program, from stimulus presentation to data recording. [Please click here to download this file.](#)

Supplementary Figure 1: Grid Learning Task (GLT) data from a large ($N = 228$), online replication sample.

The general structure of the protocol was similar to that outlined in the body of the text, except that verbal instructions were replaced by additional on-screen instructions, since the task took place fully online with no direct or virtual contact between the experimenter and the participant. The figure uses color to denote Overlap type: blue indicates the Object overlap condition, gray indicates the No overlap condition, and yellow indicates the Location overlap condition. As in the in-person experiment, a repeated-measure ANOVA showed that there was a significant effect of Overlap type ($F(2, 454) = 31.80, p < .001, \eta^2 = .11$). Pairwise t-tests showed that the Learning Difficulty Score of Object overlap condition was higher than that of No overlap condition ($t(227) = 2.69, p = .008$, Cohen's $d_z = .29$), indicating interference, whereas Location overlap was lower than No overlap condition ($t(227) = -5.28, p < .001$, Cohen's $d_z = .56$), indicating facilitation. Each small, colored dot represents an individual participant. Error bars represent 95% confidence

intervals, and the black dots within the error bars indicate the mean Learning Difficulty Score for each condition. All statistical tests were two-tailed with $\alpha = .05$. *** indicates $p < .001$ and ** indicates $p < .01$. [Please click here to download this file.](#)

Supplementary Figure 2: Effect of object set on Learning Difficulty Score.

Mean Learning Difficulty Scores for each object set are shown across overlap conditions. Error bars represent 95% confidence intervals. A linear mixed-effects model was used to analyze whether object set influenced Learning Difficulty Scores across overlap conditions. Importantly, regardless of which object set was used, the direction of the Overlap type effects remain the same (object set1 $\times$ Location overlap: $\beta = 0.06, SE = 0.90, p = .94$; object set3 $\times$ Location overlap: $\beta = -0.04, SE = 0.91, p = .97$; object set1 $\times$ Object overlap: $\beta = 0.30, SE = 0.97, p = .76$; object set3 $\times$ Object overlap: $\beta = 0.16, SE = 0.85, p = .85$; where object set 2 and No overlap were references). This indicates that differences in object set did not account for the observed overlap effects. [Please click here to download this file.](#)

Supplementary Figure 3: Response time difference scores across overlap conditions. Response time difference scores (difference in mean response time between consecutive grids, $[n] - [n -$

1)) are shown for the Location overlap, No overlap, and Object overlap conditions. Colored dots represent individual participants, black circles indicate group means, and error bars represent 95% confidence intervals. A repeated-measures ANOVA revealed no significant effect of overlap type ($F(2, 88) = 0.17, p = .847$), indicating that response time differences did not vary across overlap conditions. All statistical tests were two-tailed with $\alpha = .05$. [Please click here to download this file.](#)

Discussion

The Grid Learning Task (GLT)¹⁰ provides a flexible behavioral protocol for examining how overlap between prior knowledge and new information shapes learning. In this task, participants repeatedly study object-location associations on a grid until all object locations are learned, and learning effects are quantified using the Learning Difficulty Score, which measures the difference in the number of attempts required to learn two consecutive grids. A critical feature of the protocol is the manipulation of overlap type between consecutive grids, allowing either object identity or spatial layout to overlap. Although the GLT was originally developed as a between-subjects design in which participants experienced only a single overlap condition¹⁰, the present protocol adapts the task to a within-subject design in which each participant experiences all overlap types across multiple grids. This modification reduces between-subject variability and enables direct comparison of facilitation and interference effects within individuals. Using this approach, hindered learning was replicated in the Object overlap condition, and a numerical, although statistically marginal, facilitation effect was observed in the Location overlap condition. In a large-scale online replication ($N = 228$; **Supplementary Figure 1**), statistically significant evidence was observed for both Object-overlap-induced interference and Location-overlap-induced facilitation, suggesting that both effects can be detected in the within-subject version of the task but may be sensitive to sample size.

Despite the advantages of the within-subject design, several methodological and practical considerations should be considered when implementing the GLT. Early in the task, the largest decrease in learning attempts occurred between Grid 1 and Grid 2, which may reflect practice effects or a shift in learning strategy. Although a practice phase was included, this pattern may indicate an additional practice benefit or a change in learning strategy after successful acquisition of the first grid. However, this pattern is unlikely to alter the overall conclusions because the overlap-condition order was counterbalanced across participants. Specifically, the overlap type occurring in Grid 2 (Location, Object, or None) varied across participants. Nevertheless, if Learning Difficulty Scores are used as within-person measures, consideration of overlap order may be warranted. In addition,

participants may fail to learn a grid within the maximum number of attempts, which can reflect either task difficulty or reduced engagement. While the participants who did not meet this criterion were excluded, and this criterion was introduced by the extensive pilot tests in the previous study¹⁰, this issue can be mitigated through clearer instructions and pre-task comprehension checks. Because the task relies on repeated learning to criterion, it may be less suitable for populations with severe learning impairments or limited task endurance. Furthermore, misunderstandings of the drag-and-drop interface may introduce noise, which can be addressed through mandatory practice trials with feedback prior to experimental trials. Finally, although the Learning Difficulty Score places facilitation and interference on a single numerical scale, the cognitive mechanisms underlying these opposing effects may differ^{14,15,16}.

The validity and reproducibility of GLT-based findings depend on several critical implementation steps. Accurate screen calibration and standardized display settings are essential to ensure consistent exposure to the object-location associations on the grids. Equally important is verification of participant understanding through structured comprehension checks and practice trials. The counterbalancing of overlap conditions across grid positions is a key design feature that allows separation of condition-specific effects from general practice or fatigue effects. Careful construction and randomization of object and location sets in the experimental program are also necessary to avoid systematic semantic or perceptual confounds. Finally, strict enforcement of exclusion (e.g., failure to learn any grid within the maximum number of attempts or insufficient engagement during practice) is essential for maintaining data quality and interpretability.

Some prior-knowledge research has emphasized semantic content rather than the spatial overlap examined in the GLT¹⁷. In the present design, item identities overlapped only in the Object overlap condition. However, because objects were assigned randomly to study sets, semantic relationships among items were not systematically manipulated. Consequently, the influence of prior knowledge in the present task was likely more constrained to the spatial domain. Future studies could systematically manipulate additional forms of overlap to determine which aspects of prior knowledge most strongly influence learning.

An additional consideration concerns the relationship between the present findings and the broader literature on schemas, which are often acquired gradually through repeated, spaced experiences¹⁷. Theoretical work suggests that knowledge can also be acquired rapidly¹⁸, in some cases following a single exposure¹⁹. Other studies have proposed that schema-related influences depend on the strength of the underlying memory representation²⁰. In the present task, each grid was acquired through multiple learning repetitions, but all learning occurred within a single session. Consequently, the findings are interpreted

as reflecting the influence of prior knowledge acquired within a single learning episode. Future work could examine whether prior knowledge acquired gradually over time or consolidated across separate learning sessions differentially affects the acquisition of new information.

Relative to traditional behavioral approaches used to study overlap effects on learning, the GLT offers a unified framework for examining facilitation and interference within a single paradigm. Classic approaches have typically investigated interference using word-pair learning tasks and facilitation using object-location learning paradigms, often in separate groups of participants^{1,2,3,5,6,7,8}. In contrast, the GLT systematically manipulates overlap type across consecutive learning episodes while maintaining a constant task structure, enabling direct comparison of how different forms of prior knowledge—object identity *versus* spatial layout—influence learning. By using a consistent behavioral metric across conditions, the GLT reduces methodological heterogeneity and enables clearer inferences about the mechanisms by which prior knowledge shapes new learning. The GLT is well-suited to addressing research questions on memory facilitation, interference resolution, and representational overlap. Its flexibility makes it a useful tool for studying individual differences, aging, and populations in which learning from prior experience may be altered. For example, the task could be used to investigate how older adults, who typically possess greater semantic knowledge than younger adults²¹, differentially benefit from or are hindered by overlapping information. More broadly, by identifying conditions under which overlap facilitates or impairs learning, the GLT provides a useful framework for understanding memory in situations where experiences share common elements. The task may also be extended to examine additional forms of overlap, including perceptual and conceptual similarity among stimuli. Such manipulations would introduce additional sources of interference beyond identity- or location-based overlap and would enable investigation of how semantic structure and contextual relatedness shape learning. Finally, the GLT can be readily adapted for functional magnetic resonance imaging (fMRI) studies to examine the neural systems supporting these effects^{22,23} and to investigate how brain regions involved in representation respond to overlap-driven facilitation and interference.

In summary, the Grid Learning Task provides a flexible and efficient method for examining how prior experiences influence new learning. By manipulating overlap type within a single paradigm, the task enables direct measurement of both interference and facilitation effects while maintaining a consistent learning structure. The within-subject implementation described here offers a useful framework for investigating memory, learning, and individual differences in the influence of prior knowledge across a range of experimental settings.

Disclosures

The authors declare no competing interests.

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None.

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