# Figure 1

## Caption

Summary statistic fits of the baseline CMR model to PEERS data. **Left**: probability of recall initiation by serial position. **Middle**: conditional response probability as a function of lag. **Right**: recall probability by serial position.

## Alt Text

Three side-by-side plots comparing human free-recall data to the CMR model. Left: Recall-initiation probabilities by study position show a strong recency peak (last item) and a smaller primacy peak (first item); model follows the same U-shape. Middle: Lag-CRP curve is forward-skewed, with the highest transition at +1; model tracks this asymmetry. Right: Overall recall accuracy by study position forms a shallow U across the 16 positions; model slightly underestimates primacy and final-item recall but captures the general trend.

# Figure 2

## Caption

Summary statistic fits of baseline CRU (**Top**), CRU with free start context integration rate (**Middle**), and CRU freeing both start context integration rate () and primacy gradient ( and ) parameters (**Bottom**) to PEERS free recall data. **Left**: probability of recall initiation by serial position. **Middle**: conditional response probability as a function of lag. **Right**: recall probability by serial position.

## Alt Text

A comparison of three CRU variants against empirical free-recall patterns. Rows index by model variants: Top: baseline CRU; middle: CRU with a free start-context integration rate (); bottom: CRU with both and an associative primacy gradient ( and ). Columns index summary measures. First-recall curve (left column): probability that recall begins with each serial position. A steep rise at the end marks the recency effect (late items recalled first); a smaller peak at the start marks the primacy effect (early items sometimes recalled first). Lag-CRP (center column): probability of transitioning between recalled items separated by a given study lag. Tall bars at +1 show the forward short-lag preference; smaller bars at –1 show a smaller preference for backward short-lag transitions. Serial-position curve (right column): overall recall probability for each position—high at the start (primacy) and end (recency). Take-away: Freeing lets the model capture the strong recency start, while adding the primacy gradient boosts early-item recall and heightens ±1 lag peaks, bringing all three panels much closer to the data.

# Figure 3

## Caption

Simulation of the impact of shifting the start context integration rate parameter on the probability of starting recall by serial position (**Left**) and the recall probability by serial position (**Right**) for CMR. Using parameters fit to PEERS free recall data, is shifted from 0 to 1 in increments of 0.1, with the color of the lines indicating the value of the parameter.

## Alt Text

Two side-by-side line charts (using a shared color legend with values 0.0 – 0.9) illustrate how gradually increasing the start-of-list context-integration parameter reshapes simulated recall behavior in CMR. Left panel – “Probability of N-th Recall”: For 16 study positions on the x-axis, each colored line shows the chance that the first item recalled (i.e., recall initiation) comes from that position. Lower values (light gray) yield a steep recency peak at the final position, whereas higher values (dark gray/black) progressively shift initiation toward the first item, producing a strong primacy peak. Right panel – “Recall Rate”: The same color-coded lines plot overall recall probability for every serial position. As increases, the recency advantage at the end of the list diminishes while recall of early positions improves, creating the classic U-shaped primacy–recency curve. Together the panels show that governs how strongly the end-of-list context is blended back toward the start: small values favor recency-driven cueing, large values favor primacy-driven cueing, and intermediate values balance the two.

# Figure 4

## Caption

Summary statistic fits of models to the PEERS free recall dataset [@healey2014memory]. **Top**: CRU with free pre-experimental context-to-feature memory (, ), primacy gradient (, ), and start context integration rate () parameters. **Middle**: CRU with free item-to-context learning rate (), primacy gradient (, ), and start context integration rate () parameters. **Bottom**: CRU with free item-to-context learning rate (), pre-experimental context-to-feature memory (, ), primacy gradient (, ), and start context integration rate () parameters – equivalent to CMR. **Left**: Probability of starting recall by serial position. **Left**: Probability of starting recall by serial position. **Middle**: Conditional response probability as a function of lag. **Right**: Recall probability by serial position.

## Alt Text

Nine mini-plots arranged in a 3 × 3 grid compare *model* (black) to *human data* (gray) for three increasingly complex CRU/CMR variants. Rows (top -> bottom) show, respectively: (1) CRU + pre-experimental support + primacy gradient, (2) CRU + feature-to-context learning + primacy gradient, (3) Full CMR (all mechanisms enabled). Columns (left -> right) display three benchmark statistics for 16-word free-recall lists. Left column: Recall-initiation curve. Y: probability the first recall comes from each study position. High right-end values illustrate the recency effect (participants often start with the last-studied word), whereas smaller left-end bumps reflect primacy (some start with the first word). Middle column: Lag-conditional response probability (lag-CRP). X: positional lag between successive recalls; Y: conditional probability. The sharp forward spike at +1 and the gentler backward spike at -1 indicate a short-lag contiguity bias; people tend to move to temporally adjacent items, more so forward than backward. Right column: Serial-position curve (SPC). Y: overall recall rate for each study position. The U-shape reprises primacy (higher accuracy for early items) and recency (late-item advantage after a dip in the middle). Error bars show ±1 SE. Progressing down the rows shows that adding each CMR mechanism successively narrows the gap between model curves and gray data points: the forward and backward peaks in the lag-CRP grow taller, and the SPC’s early-item accuracy rises, demonstrating better fits to primacy, recency, and short-lag phenomena.

# Figure 5

## Caption

Simulation of the impact of shifting CMR’s (**Left**) and (**Right**) parameters on the conditional response probability as a function of lag for CMR. Using parameters fit to @healey2014memory, the learning rate parameter is shifted from 0 to 1 in increments of 0.1, and the item support parameter is shifted from 0 to 10 in increments of 1, with the color of the lines indicating the value of the parameter.

## Alt Text

Two side-by-side line plots show how changing two CMR parameters alters the lag-conditional response probability (lag-CRP). The left plot varies the learning-rate parameter from 0.0 (light gray) to 0.9 (dark gray / black) in 0.1 steps: larger sharply boosts the probability of a +1 backward transition (lag –1) while slightly reducing the –3 to –5 lags. The right plot varies the self-support parameter from 0.0 (light gray) to 8.9 (dark gray / black) in unit steps: higher steepens both the forward +1 and backward –1 peaks while depressing longer-lag transitions. Each coloured line therefore traces how strengthening either parameter concentrates recall transitions around neighbouring items, with the legend listing the parameter values.

# Figure 6

## Caption

Summary statistic fits of CMR with CRU’s context-based recall termination mechanism to @healey2014memory. **Left**: probability of starting recall by serial position. **Middle**: conditional response probability as a function of lag. **Right**: recall probability by serial position.

## Alt Text

Three side-by-side line plots compare a CMR model that uses CRU’s context-based stopping rule (black) with empirical free-recall data from @healey2014memory (gray). Left panel: probability that each study position is produced as the N-th recall; both model and data rise steeply at the end of the list, though the model sits slightly higher at the final positions. Middle panel: lag-conditional response probability, showing a forward-skewed peak at +1; the model captures the overall shape but undershoots the sharpness of the +1 jump. Right panel: overall recall rate by study position; both traces form a shallow “U”, but the model overestimates mid-list recall and underestimates the depth of the primacy dip.

# Figure 7

## Caption

Serial recall accuracy (SRAC) fits to @logan2021serial serial recall data for list lengths of 5 (**Left Column**), 6 (**Middle Column**), 7 (**Right Column**) of baseline CRU (**Top**), the best performing CRU variant with free pre-experimental context-to-feature memory (, ) and CMR-specific primacy gradient (, ) parameters (**Middle**), and CMR with its default position-based recall termination mechanism and CRU’s item identification confusability mechanism (**Bottom**).

## Alt Text

Nine‐panel line chart comparing observed versus model-predicted *serial recall accuracy* (SRAC). Columns correspond to list lengths 5 (left), 6 (middle), and 7 (right). Rows show, top to bottom: (1) baseline CRU; (2) best-performing CRU variant that adds CMR’s associative primacy gradient plus pre-experimental context–feature support; (3) CMR with its native position-based stop rule but augmented with CRU’s item-confusability mechanism. In every panel, study position (x-axis) runs from first to last list item; SRAC (y-axis) runs from 0.3–1.0. Greay lines with error bars plot human data; black lines plot model fits. All models capture the overall primacy gradient (higher accuracy for early study positions) but diverge in later positions: baseline CRU underestimates late-list accuracy, the hybrid CRU variant closes that gap, and the CMR-based model slightly overestimates mid-list accuracy for longer lists.

# Figure 8

## Caption

Intrusion, order, and omission error rates (top, middle, and bottom rows respectively) by serial position for list lengths 5, 6, and 7 (left, center, and right columns), in @logan2021serial serial recall data. Lines compare observed error rates with predicted error rates from best performing CRU variant with free pre-experimental context-to-feature memory (, ) and CMR-specific primacy gradient (, ) parameters.

## Alt Text

Nine mini-plots arranged in a 3 by 3 grid. Rows represent error type during serial recall of letters. Top row – Intrusion errors: recalling a letter that was not on the study list. Middle row – Order errors: recalling a studied letter but in the wrong serial position. Bottom row – Omission errors: failing to supply any letter for a position. Columns represent list length: 5-item lists (left), 6-item lists (centre), 7-item lists (right). Within each panel, grey points/lines plot observed error rates by study position; black points/lines plot predicted rates from the best-fitting CRU + CMR hybrid model (which adds pre-experimental context-to-item associations and a primacy gradient). Error bars show ±1 SE. The model tracks the upward error trend across later positions and captures the different magnitudes for intrusion, order and omission errors across list lengths.

# Figure 9

## Caption

Lag-conditional response probability (lag-CRP) fits of baseline CRU (**Top**); best performing CRU variant with free pre-experimental context-to-feature memory (, ) and CMR-specific primacy gradient (, ) parameters (**Middle**); and CMR with its default position-based recall termination mechanism and CRU’s item identification confusability mechanism (**Bottom**) to @logan2021serial serial recall data. Lines compare observed lag-CRP with predicted lag-CRP for the applicable model variant.

## Alt Text

Lag-conditional response probability (lag-CRP) curves for serial-recall lists of length 5, 6, and 7 (columns). Within each column, three rows show: (1) baseline CRU; (2) the hybrid CRU that adds primacy and pre-experimental support; (3) CMR with position-based stopping. Observed data (grey lines ± SE) and model predictions (black lines) are plotted for lags −4 to +5. All variants fit the dominant +1 forward transition, but only the hybrid CRU (row 2) closely tracks the small yet reliable −1 “fill-in” backward transition, while baseline CRU underestimates and CMR overestimates backward-lag probabilities beyond −1.