Power Analysis

for *Associative Memory, Beliefs and Investments: A Replication and Extension*

Companion document to the AEA RCT Registry pre-registration

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1. Overview

This document reports the power analysis for the five experiments of *Associative Memory, Beliefs and Investments: A Replication and Extension*. The target effect δ is the true effect size a test is powered to detect. For each replication hypothesis, we set δ equal to the original point estimate of the tested regression coefficient, together with its subject-clustered standard error, from Enke et al. (2024, henceforth the original paper), re-estimated on their public data (Mendeley 10.17632/545wb2gnd7.1). The two extension hypotheses (SimilarCue and investment) have no direct estimates in the original paper. The SimilarCue hypotheses are powered using the corresponding Cue values, under the assumption that a same-theme cue is as effective as an exactly repeated one. The investment target is derived by mapping the belief data of the original paper into investment shares, using power utility under our payoff structure; details are in Section 3. We calculate the required sample sizes and the minimum detectable effects at 80% power in Section 4.

2. Target effects for the replication hypotheses

We use the original paper's notation and its Table 1 variable labels (estimating Eqs. (6)–(7) of the original paper). s_{k+1} is the second-period signal (label "t=2 signal"). T is the *Cue* indicator ("1 if Cue"). z is the number of first-period signals congruent with s_{k+1}. $N_p - N_n$ is the net number of positive first-period signals.

- **Associative memory** (original Result 1): β_2, the coefficient on the $s_{k+1} \times T$ interaction ("t=2 signal $\times$ 1 if Cue"). Original Table 1, col. (1): 0.61, $SE = 0.15$. The treatment difference is concentrated at $z > 0$ (col. (3): 0.88) and absent at $z = 0$ (col. (2): not significant).
- **Number of cued signals** (original Result 2): β_6, the coefficient on the $s_{k+1} \times z$ interaction ("t=2 signal $\times$ # of congruent t=1 signals"). Original Table 1, col. (4): 0.32, $SE = 0.13$.
- **Cued-versus-non-cued weight** (beliefs-side evidence for original Result 3): the coefficient on the (sum of congruent t=1 signals)$\times T$ interaction ("Sum of congruent t=1 signals $\times$ 1 if Cue"). Original Table 1, col. (6): 0.50, $SE = 0.11$.
- **Asymmetric recall** (original Result 3): γ_3, the coefficient on the (Recall Cue)$\times$(congruent signal) interaction ("1 if Recall Cue $\times$ 1 if congruent signal"). Original Online Appendix Table C5, col. (3): 0.56, $SE = 0.09$.

3. Target effects for the extension hypotheses

3.1 SimilarCue hypotheses

Because SimilarCue is a new condition with no original estimate, we conservatively power it under the assumption that a same-theme cue is at least as effective as an exact repetition, and therefore use the corresponding Cue anchors: 0.61 ($SE = 0.15$) for beliefs and 0.56 ($SE = 0.09$) for recall.

3.2 Investment hypothesis

The investment associative-memory hypothesis has no counterpart in the original paper. We derive the target effect from the public data of the original paper's *Beliefs* experiment, which contain each subject's second-period belief b_2, the stated probability that the company is good after the second-period signal, for every company (100 subjects, 1,400 subject–company observations). The procedure has three steps.

1. **Convert each belief into an implied investment share.** We map each stated belief into the allocation a risk-averse expected-utility investor would choose under our payoff structure.

   In a good company the stock returns +20% with probability 0.65 and −10% otherwise; in a bad company the returns are mirrored. Let R be the stock's net return per unit of budget invested and $I \in [0, 1]$ the share of the budget put in the stock, the outcome of the Invest experiment. Given b_2, R takes the values $+0.20$, -0.10, -0.20, $+0.10$ with probabilities $0.65\, b_2$, $0.35\, b_2$, $0.65\,(1 - b_2)$, $0.35\,(1 - b_2)$, so $E[R \mid b_2] = 0.095\,(2b_2 - 1)$: the stock is attractive exactly when the subject is optimistic.

   Optimizing over I directly, with wealth $W = 1 + IR$, would put every belief below 0.5 at the corner $I^* = 0$, since cash then dominates, so the mapped shares would bunch at zero and stop responding to the signal. We therefore anchor the mapping at the even split, the neutral point of a two-asset allocation task and close to the average share of bet money on the good state in the original paper's Market data (0.51), and let the subject choose how far to move away from it: with $x = I - 0.5$, only the adjustment is exposed to the return, so the payoff that matters for the choice is $W = 1 + xR$.

   We use power utility,

   $$u(W) \;=\; \frac{W^{1-r}}{1-r},$$

   where r is the coefficient of relative risk aversion, the notation of Holt and Laury (2002), so that the optimal adjustment solves

   $$E\big[\, R\,(1 + xR)^{-r} \,\big|\, b_2 \,\big] \;=\; 0,$$

   whose left-hand side is strictly decreasing in x; the root is therefore unique and we compute it numerically at each b_2. The mapped share is $I = 0.5 + x^*(b_2)$, truncated to $[0, 1]$; the adjustment is positive for optimistic and negative for pessimistic subjects and symmetric around $b_2 = 0.5$.

   We take r from the laboratory literature and use $r = 0.48$ as the benchmark (Filippin & Crosetto, 2016).[1] Our own experiment elicits risk preferences for ex-post checks.

[1] Filippin and Crosetto (2016) pool 54 replications of the Holt–Laury task and estimate CRRA preferences by maximum likelihood on 4,899 subjects. Their estimates of relative risk aversion range from 0.19 to 0.48 across the three error specifications and across gender (Table 10); we take the largest as the benchmark and the smallest as the lower end of the sensitivity range below.

2. **Re-estimate the investment regression on the mapped shares.** We run the pre-registered investment specification on the mapped data:

$$I^{i,f} = \pi_1 s_{k+1}^{i,f} + \pi_2\, s_{k+1}^{i,f}\, T_{\text{Cue}}^{i,f} + \pi_3 T_{\text{Cue}}^{i,f} + \pi_4 (N_p^{i,f} - N_n^{i,f}) + \pi_0 + \varepsilon^{i,f},$$

where $I^{i,f}$ is the mapped share for subject i and company f, $T_{\text{Cue}}^{i,f}$ equals one if company f is in the Cue condition and zero in the NoCue baseline, and standard errors are clustered by subject; the remaining variables are defined in Section 2. The interaction coefficient π_2 captures the differential response of the investment share to the second-period signal in the Cue relative to the NoCue condition. It is the target effect: $\delta = \pi_2 = 0.056$ at $r = 0.48$.

Sensitivity to r. We repeat the mapping for r between 0.19, the smallest of the pooled Holt–Laury estimates (Filippin & Crosetto, 2016), and 1.37, the top of the classification range of Holt and Laury (2002, Table 3). The target effect stays between 0.052 and 0.067 and power at $N = 100$ above 0.89 (Table 1). At the lower values most mapped shares sit at the bounds, the familiar difficulty of transferring small-stakes risk-aversion estimates to a new allocation task.

Table 1: Sensitivity of the investment target effect to the coefficient of relative risk aversion r.

r	**Target effect** δ	**Mapped shares at a bound**	N_{80}	**Power at** $N = 100$
0.19	0.052	91%	77	0.89
0.48 (benchmark)	0.056	90%	67	0.93
0.70	0.058	86%	63	0.94
1.00	0.062	82%	54	0.97
1.37	0.067	72%	47	0.98

Notes. Each row re-runs the mapping of step 1 and the regression of step 2 at the stated r. N_{80} and the power at $N = 100$ use the pilot standard error of step 3.

3. **Take the reference standard error from our pilot.** In June 2026 we ran a two-session pilot of the Invest experiment ($N = 49$ student subjects), using our localized Chinese stimuli rather than the original materials, at the Experimental Economics Laboratory of Dongbei University of Finance and Economics. Each subject faced 14 companies, split 7–7 within subject between the Cue and NoCue conditions, giving 686 observations. Running the pre-registered investment specification on the pilot data gives a standard error of 0.0234, clustered by subject, for the same interaction $s_{k+1} \times T$. This is the reference standard error: $SE_{ref} = 0.0234$ at $N_{ref} = 49$ subjects. The pilot serves only to estimate the sampling variability of the design. We do not take the effect size from it, as $N_{ref} = 49$ is too small for precise effect-size estimates.

For the belief–investment consistency hypothesis we do not derive a target effect, so no power calculation is reported, for two reasons. First, the hypothesis is pre-registered as exploratory. Second, circularity: the mapped share is constructed from b_2, so regressing it on b_2 returns the slope built into the mapping, not a behavioral effect.

4. Analytical sample-size calculation

We fix power at the conventional 80% level and solve for the required sample size and the minimum detectable effect, using four standard formulas. The standard error at sample size N scales as

$$SE(N) \;=\; SE_{ref}\sqrt{N_{ref}/N},$$

where SE_{ref} is the reference standard error of the tested coefficient and N_{ref} is the number of subjects behind it. For the replication and SimilarCue hypotheses, SE_{ref} comes from the original data. For the investment hypothesis, it comes from our pilot.

Power at the target N is

$$\Phi(\delta/SE(N) - z_\alpha),$$

where Φ is the standard normal distribution function. The sample size required to detect δ with 80% power is

$$N_{80} \;=\; N_{ref}\left[(z_\alpha + z_\beta)\, SE_{ref}/\delta\right]^2.$$

The minimum detectable effect at the target N is

$$MDE_{80} \;=\; (z_\alpha + z_\beta)\, SE(N).$$

Throughout, $z_\alpha = 1.96$ (two-sided 5% test) and $z_\beta = 0.842$ (80% power). This matches the pre-registered decision rule. Table 2 reports the results.

Table 2: Analytical sample sizes and minimum detectable effects.

Hypothesis	**Effect** δ	SE_{ref}	**MDE**$_{80}$	N_{80}
Beliefs Cue+NoCue experiment, target $N = 127$				
Associative memory	0.61	0.150	0.37	47
Number of cued signals	0.32	0.128	0.32	127
Cued vs. non-cued weight	0.50	0.106	0.26	35
Beliefs SimilarCue+NoCue experiment, target $N = 127$				
Associative memory	0.61	0.150	0.37	47
Number of cued signals	0.32	0.128	0.32	127
Cued vs. non-cued weight	0.50	0.106	0.26	35
Recall Cue+NoCue experiment, target $N = 70$				
Asymmetric recall	0.56	0.090	0.25	15
Recall SimilarCue+NoCue experiment, target $N = 70$				
Asymmetric recall	0.56	0.090	0.25	15
Invest Cue+NoCue experiment, target $N = 100$				
Investment assoc. memory	0.056	0.0234	0.046	67

Notes. δ is the target effect of each hypothesis and SE_{ref} its reference standard error, estimated with N_{ref} subjects. MDE_{80} is the minimum detectable effect with 80% power at the target N; N_{80} is the number of subjects required to detect δ with 80% power. Standard errors are clustered by subject.

Each experiment's target N is the maximum of the computed N_{80} and the sample size of the corresponding experiment in the original paper. This gives 127 for the two beliefs experiments, 70 for the two recall experiments, and 100 for the investment experiment, 494 subjects in total. Every belief and recall test reaches at least 80% power at the planned sample sizes. The Result-2 interaction requires the largest sample, $N_{80} = 127$, which alone exceeds the original paper's $N = 100$. For investment, power reaches 0.93 at the benchmark $r = 0.48$ and does not fall below that across the range in Table 1; both investment hypotheses nevertheless remain exploratory, because the target rests on the assumed risk aversion and the neutral-allocation starting point. The subject is the unit of clustering in all regressions.

References

- Enke, B., Schwerter, F., & Zimmermann, F. (2024). *Associative memory, beliefs and market interactions*. Journal of Financial Economics, 157, 103853. doi:10.1016/j.jfineco.2024.103853.

- Filippin, A., & Crosetto, P. (2016). *A reconsideration of gender differences in risk attitudes.* Management Science, 62(11), 3138–3160.
- Holt, C. A., & Laury, S. K. (2002). *Risk aversion and incentive effects.* American Economic Review, 92(5), 1644–1655.