**Confidence judgements among older vs younger adults in Working Memory Tasks: Pre-registration**

### **Study Information**

1. **Title (required)**

Confidence judgements among older vs younger adults in Working Memory Tasks

1. **Authors (required)**

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1. **Description (optional)**

In this project, we address two key research questions.

**Research Question 1**: Gist Memory vs Verbatim memory interference

**Research Question 2:** Personality type vs confidence reporting

1. **Hypotheses (required)**

If distracting information impairs metacognitive awareness of the contents of working memory, then:

H1A: There should be a bigger difference between *k* (Working Memory capacity) and *meta-k* (the average estimated number of items held in mind) in the distractor, compared to the no-distractor (baseline condition). (Analyses 2 and 3)

H1B: The predictive accuracy of the meta-*k* judgements should be poorer in the distractor, compared to the no-distractor (baseline) condition. (Analysis 4)

H2: If higher WM capacity predicts better ability to accurately estimate the contents of one’s working memory, we should observe a correlation between *k* (WM capacity) at baseline, and *meta-memory accuracy* (i.e., the difference between actual *k* vs. self-reported meta-*k*). (Analysis 5)

H3: If higher WM capacity predicts better ability to ignore distraction, we should observe a correlation between *k* (WM capacity) at baseline, and a smaller *distractor cost* (i.e., the *difference* in *k* between the no-distractor and distractor conditions). (Analysis 6)

H4: If higher WM capacity predicts better awareness of the negative impact of distraction, we should observe a correlation between *k* (WM capacity) at baseline, and better *distraction awareness* (i.e., the differences between each participants’ meta-k inaccuracy in the distraction condition, from that in the no-distraction condition). (Analysis 7)

### **Design Plan**

1. **Study type (required)**
   1. Experiment
2. **Blinding (required)**
   1. No blinding
3. **Is there any additional blinding in this study?**
4. **Study design (required)**

We will use a within-subjects (paired) design with one factor (distraction) with two levels (No Distraction vs. Distraction). Participants will complete a WM task. In each trial, they will study six coloured squares for 1000 ms, presented in a circle. In half of the trials (distraction condition), a task-irrelevant unique black image (e.g., a fruit, animal, etc) will appear in the centre of the screen. Then, participants will rate how many of the coloured squares they think they remembered, by clicking on a number between 0 and 6. If they fail to give a rating within a 5000 ms timeframe, they will see a message saying “Please give a rating next time”. Finally, participants will see a two colored squares (presented in the centre of the screen), one of which was part of the original memory array, one that was not. The participants’ task is to click on the square that was presented in the original array.

Each participant will complete 136 trials, divided into 4 blocks containing 34 trials each, with breaks in between blocks.

1. **Randomization (optional)**

### **Sampling Plan**

1. **Data collection procedures (required)**

We will recruit all participants online, via prolific.com. Participants will be paid $5 for completing the study, which should take around 30 minutes. Participants will be pre-screened on Prolific to fit the following criteria:

* native speaker of English
* resident in the USA
* normal or corrected-to-normal vision
* no cognitive impairment or dementia
* no language-related disorders
* age must be between 18 and 30 years
* approval rating of at least 90% on prior submissions at Prolific

Also, the online consent form will state the following **ELIGIBILITY REQUIREMENTS:**

• Must be 18 – 30 years of age with normal or corrected-to-normal vision and hearing including normal color vision meaning the ability to distinguish shades and tint of color

• Must be fluent in the English language

• Must not have a diagnosis of photosensitive epilepsy in which seizures are triggered by flashing lights; bold, regular patterns; or regular moving patterns

We expect online data collection to be completed within two weeks of launching the study online.

1. **Sample size (required)**
2. participants.
3. **Sample size rationale (optional)**

Since the size of the effect is unknown, we assume that if there is an effect, it would be small to medium (Cohen’s *d* = 0.35). Bayes Factors design analysis simulations for our central planned analysis (see Analysis 3 above; using a Bayes Factor > 3 as a decision criteria) revealed that with 90 participants we could correctly detect an effect of that size in 83.9% of samples, whilst 14.5% were inconclusive, and 1.6% showed evidence for the null hypothesis. In contrast, assuming that there is no effect (Cohen’s *d* = 0.00), simulations correctly found evidence against an effect in 85.0% of samples, whilst 13.9% were inconclusive, and 1.2% showed evidence for an effect (i.e., a false positive). These simulated estimates indicate that 90 participants would provide sufficient statistical power for results to be convincing to others in the field.

### **Variables**

1. **Manipulated variables (optional)**
2. **Measured variables (required)**

*Outcome Variable 1.* Responses to WM probe items. Using this, we will estimate also *k* (the number of items held in WM; for details, see Transformations).

*Outcome Variable 2.* Meta-k ratings: The number of coloured squares participants thought they remembered on each trial (0 – 6).

Participants will also be asked to respond to the following demographics questions. These answers will not be included in our analyses.

* How old are you?
* What is your gender? (‘Female’, ‘Male’, ’Other’, ’Prefer not to report’).
* What is your racial group? (‘American Indian/Alaska Native’, ‘Asian’, ‘Black or African American’, ‘More Than One Race’, ‘Native Hawaiian or Other Pacific Islander’, ‘White or European’, ‘Other’, ‘Prefer not to report’).
* What is your ethnic group? (‘Hispanic or Latino/Latina’, ‘Not Hispanic or Latino/Latina’, ‘Other’, ‘Prefer not to report’).
* Which of these is the highest level of education you have completed? (‘No formal qualifications’, ‘Secondary education (e.g. GED/GCSE)’, ‘High school diploma/A-levels’, ‘Technical/community college’, ‘Undergraduate degree (BA/BSc/other)’, ‘Graduate degree (MA/MSc/MPhil/other)’, ‘Doctorate degree (PhD/other)’, ‘Don't know / not applicable’.
* How many years of college have you had? (‘0’, ‘1’, ‘2’, ‘3’, ‘4’, ‘more than 4’)

### **Analysis Plan**

1. **Statistical models (required)**

**Analysis 1:** The effect of distractor condition on memory accuracy

**Purpose** Explore the effect of distractor condition (distractor vs. no-distrator), on memory accuracy.

**Approach** Function ‘ttestBF’ (using package BayesFactor, in R).

**Dependent Variable:** Memory accuracy (proportion correct)

**Factors**

1. Distractor condition (No Distractors vs. Distractors)

**Analysis 2:**

**Purpose** Test whether distractors influenced working memory capacity (*k*) and meta-*k* to similar extents.

**Approach** 2 x 2 ANOVA approach, using the‘anovaBF’ function (R package BayesFactor).

**Dependent Variable** *k* (objective or subjective).

**Factors**

1. Distraction (No Distraction vs. Distraction condition)
2. The type of capacity measure (WM *k* or meta-*k*)
3. Participant ID will be included as a random effect

**Model specification** We will use the ‘anovaBF’ function’s default settings (R; the BayesFactor package). We will use the default setting priors, as recommended by Rouder, Morey, Speckman, and Province (2012) to obtain Bayes Factors, with the modification that the “whichModels” argument is set to “top”. We will run 50,000 MCMC iterations (setting iter = 50000), and an additional 10,000 iterations until the proportional error associated with each Bayes factor is less than 5%.

**Analysis 3:** The effect of distraction on *meta-memory inaccuracy* (memory capacity)

**Purpose** Explore the effect of distractor condition (No Distraction vs. Distraction), on meta-memory accuracy (i.e., the difference between actual *k* vs. self-reported meta-*k*).

**Approach** Function ‘ttestBF’ (using package BayesFactor, in R).

**Dependent Variable:** Meta-memory inaccuracy (see transformation below).

**Factors**

1. Distractor condition (no distractors vs. distractors)

**Analysis 4:** The effect of distraction on *meta-memory inaccuracy* (trial-level)

**Purpose** Explore the effect of distractor condition (No Distraction vs. Distraction), on meta-memory accuracy, on trial level data

**Approach** Bayesian Logistic Regression (brms package in R)

**Dependent Variable** Correct vs Incorrect answers (1 vs 0) on each trial

**Factors**

1. Participant identity will be included as a random intercept, to account for individual variation.
2. Trial number will be included as a random intercept, to estimate trial variability
3. Distractor condition (no distractors vs. distractors)
4. Meta-judgement (the number of items the participant thought they remembered in a given trial)

**Model specification**The Bayesian Logistic Regression model examining Working Memory performance using trial-level performance data will account for the binary distribution of our data (correct or incorrect). This model will estimate the effect on the parameter η (*eta*; memory performance) by set size-condition, using a Bernoulli distribution. Participant identity will be included as a random intercept, to account for individual variation, as well as the trial number, to estimate trial variability. We use a normally distributed prior for η(*eta;* memory performance).

**Reasons for using this analytical approach:** Multilevel models allow modeling of data measured on different levels at the same time, thus taking complex dependency structures into account. Advantages of using a Bayesian version of these models include that, in addition to predicting the mean of the response distribution, it allows a measure of the uncertainty of each parameter (the Bayesian Credible Interval). Also, this approach allows us to derive probability statements for every quantity of interest, and explicitly incorporate prior knowledge about parameters into the model. We are using Logistic Regression because the response data is binary (i.e., correct or incorrect).

**Analysis 5:** Correlation test: *k* and *meta-memory inaccuracy*

**Purpose** Test correlations between individual’s overall *k* (WM capacity, in the no-distractor condition) and meta-inaccuracy (in the no-distractor condition).

**Approach** Function ‘correlationBF’ in the R package BayesFactor

**Dependent Variable(s)** individual’s estimated k (WM task), and meta-inaccuracy.

**Factors** N/A.

**Model specification** We will use the ‘correlationBF’ function’s default settings and priors.

**Analysis 6:** Correlation test: *k* and *distractor cost*

**Purpose** Test correlations between individual’s overall *k* (WM capacity, in the no-distractor condition) and *distractor cost* (the difference in WM capacity in the no-distractor vs. the distractor condition).

**Approach** Function ‘correlationBF’ in the R package BayesFactor

**Dependent Variable(s)** individual’s estimated k (WM task), and *distractor cost.*

**Factors** N/A.

**Model specification** We will use the ‘correlationBF’ function’s default settings and priors.

**Analysis 7:** Correlation test: *k* and *distraction awareness*

**Purpose** Test correlations between individual’s overall *k* (WM capacity, in the no-distractor condition) and *distraction awareness* (the differences between each participants’ meta-k inaccuracy in the distraction condition, from that in the no-distraction condition).

**Approach** Function ‘correlationBF’ in the R package BayesFactor

**Dependent Variable(s)** individual’s estimated k (WM task), and *distraction awareness.*

**Factors** N/A.

**Model specification** We will use the ‘correlationBF’ function’s default settings and priors.

1. **Transformations (optional)**

***Working Memory Capacity (k)***

*K* (WM capacity) values from the WM task will be estimated for each participant. The probability of a correct response is k/N + (1-k/N)(.5). Based on this logic and formula, we can obtain *k* for each individual and distraction condition as follows:

*k* = *N*(2\**p(correct)* - 1), in which *p(correct*) is the proportion of correctly identified memory items.

***Distractor Cost***

The difference in *k* between the no-distractor and distractor conditions.

***Meta-Memory Capacity (meta-k)***

This is the average meta-memory rating of a specific participant, in a specific distraction condition.

***Meta-k inaccuracy***

To obtain this measure, use two approaches.

1. Absolute meta-k inaccuracy

First, we subtract each participants *k* (working memory capacity) from their meta-k (their ratings of their own memory capacity). 0 would indicate perfect meta-k accuracy, and a positive value would indicate that the participant overestimated their WM capacity, and a negative value would indicate underestimation. The absolute inaccuracy value is the difference between *k* and meta-*k* regardless of the direction of the error.

1. Proportional meta-k inaccuracy

Next, we obtain a *proportional meta-k inaccuracy* measure by dividing meta-*k* by k (*proportial meta-k inaccuracy* = meta-k/k). This measure will help capture proportional differences (e..g, thinking that you know remember 4 items when you actually only know 2 is a greater proportional overestimation than thinking that you remember 6 items when actually you only remember 4).

***Distraction awareness***

We obtain this measure by subtracting each participants’ meta-k inaccuracy in the distraction condition, from that in the no-distraction condition. We will use the absolute inaccuracy value for these analyses (i.e., ignoring whether the error was caused by under- or overestimation).

1. **Data exclusion (optional)**

We will exclude data from participants who:

1. Have one or more missing values (indicating a within-study ‘breaks’ longer than 10 minutes, because it might indicate that they were distracted whilst performing the task, or failure to complete the task/technical problems). Participants excluded for these reasons will be replaced by a new participant, such that final *N* = 90.
2. Perform close to floor level (<.55 accuracy) in the no-distraction WM condition; as an indication that such participants were not paying attention to the task (or did not understand the task). Participants excluded for these reasons will be replaced by a new participant, such that final N = 90.
3. Data from trials for which participants fail to provide a meta-memory rating, will be excluded from the analyses. If a participants fails to provide meta-memory ratings for more than 25% of trials, they will be excluded and replaced by a new participants.
4. **Missing data (optional)**

Only complete data files will be included in the analyses (see above).

1. **Exploratory analysis (optional)**