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The role of culture and semantic organization in working memory updating

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ABSTRACT

Westerners tend to relate items in a categorical manner, whereas Easterners focus more on functional relationships. The present study extended research on semantic organization in long-term memory to working memory. First, Americans' and Turks' preferences for categorical versus functional relationships were tested. Second, working memory interference was assessed using a 2-back working memory paradigm in which lure items were categorically and functionally related to targets. Next, a mediation model tested direct effects of culture and semantic organization on working memory task behaviour, and the indirect effect, whether semantic organization mediated the relationship between culture and working memory interference. Whereas Americans had slower response times to correctly rejecting functional lures compared to categorical lures, conditions did not differ for Turks. However, semantic organization did not mediate cultural difference in working memory interference. Across cultures, there was evidence that semantic organization affected working memory errors, with individuals who endorsed categorical more than functional pairings committing more categorical than functional errors on the 2-back task. Results align with prior research suggesting individual differences in use of different types of semantic relationships, and further that literature by indicating effects on interference in working memory. However, these individual differences may not be culture-dependent.

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Culture; cognition; working memory; semantic organization; individual differences

Prior work has demonstrated that Westerners tend to relate items in a categorical manner, whereas Easterners focus more on functional relationships (Chiu, 1972; Ji et al., 2004; Unsworth et al., 2005a). A commonly used example of this concept is whether one considers "cow" to be more related to "chicken" or "grass". Both being farm animals, the cow/chicken dyad represents a categorical relationship, which Westerners are more prone to endorse. Because a cow eats grass, the cow/grass relationship is a functional one; Easterners are more prone to endorse these types of relationships. The root of this difference in semantic organization has been attributed to analytic vs. holistic cognitive styles which are preferred by Westerners and Easterners, respectively (Masuda & Nisbett, 2001; Nisbett et al., 2001). Analytic cognitive style is characterised by a tendency to distinguish focal objects from their context and classify items taxonomically according to specific, tangible features. Contrarily, holistic thinkers are more likely to rely on contextual and experience-based knowledge and classify objects accordingly. Long-term memory studies have demonstrated that cultural differences in semantic organization also are apparent in retrieval strategies (Gutchess et al., 2006) and in memory errors (Gutchess & Boduroglu, 2019; Schwartz et al., 2014).

The mechanism underlying how semantic memory influences working memory is still a matter of debate among researchers. Some researchers attribute these influences to attentional refreshing, a working memory maintenance mechanism that works by briefly recalling recently active items (Camos, 2015, 2017). There is some evidence that the refreshed information is retrieved from long-term memory and that this is true for both episodic (Loaiza & McCabe, 2012, 2013) and semantic (Loaiza et al., 2015; Zhang & Verhaeghen, 2009) information. According to this account, long term semantic memory influences working memory through the intermediate maintenance process of refreshing.

However, some researchers argue that there is no need to dissociate at all between long term and working memory, and in fact short term retrieval (what we know as working memory) relies on the same cue-based mechanisms as long-term memory (Crowder, 1982; Melton, 1963; Nairne, 1990, 2002). Research supporting this theory demonstrates that the effects of cue-based retrieval from long-term memory on working memory performance are independent of refreshing (Camos et al., 2019; Loaiza & Camos, 2018). According to this unitary view of memory,

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semantic effects on working memory are simply the result of the same factors that influence long-term memory (e.g., semantically related cues facilitate retrieval). Another position, taking a middle ground position between unified memory theories and fully independent memory systems theories, argues that working memory is embedded in long-term memory by representing the activated parts of long-term memory (Oberauer, 2013; see also Cowan, 1999). Activation of information in long-term memory can provide a mechanism whereby semantic information can support the maintenance of information in working memory, including by freeing up resources (Kowialiewski et al., 2021; Popov & Reder, 2020).

Each of these models of working memory would predict that cross-cultural patterns seen in long-term memory studies (e.g., Westerners are more prone to categorical interference and Easterners are more prone to functional interference) will also manifest in working memory, either through refreshing or activating information in long-term memory. Thus, prior research and models gives us reason to believe cultural differences in semantic organization will extend to working memory.

The present study investigates semantic organization biases in Easterners and Westerners, directly testing the extent to which these biases influence information processing during a working memory task. This study consists of two main components. First, to assess semantic organization, we measured Americans' and Turks' preferences for categorical and functional relationships. The second component of this study tested working memory interference using a 2-back working memory paradigm in which lure items were categorically and functionally related to targets. The n-back task is sensitive to different sources of interference, such as whether the distracting content is from the same domain (e.g., verbal versus spatial) as the information to be maintained (e.g., Postle et al., 2005) as well as the semantic relatedness of items (Szmalec et al., 2011). The current paradigm probes whether the *type* of semantic relatedness of the distractors – whether they are categorically or functionally related to the target – affects the impact of interference in working memory. Specifically, it may be more difficult to reject items 2-back in working memory that are categorically or functionally related to the target item if a participant or cultural group is more attuned to a particular type of information. A mediation model was used to analyze the relationships amongst culture, semantic organization, and behaviour on working memory task behaviour. We tested whether culture and/or semantic organization (i.e., preference for categorical or functional pairings) were directly associated with performance on an n-back working memory task, in addition to testing whether the indirect effect of semantic organization mediated the relationship between culture and working memory interference (i.e., do culture effects on working memory operate through the preference for categorical or functional pairings?).

We predicted that, in line with prior work, Westerners would demonstrate a greater tendency to organise categorically, endorsing more categorical than functional word pairs. Easterners, in turn, would demonstrate a greater tendency to organise functionally, endorsing more functional than categorical word pairs. For both cultural groups, their semantic organization tendencies would lead them to make more errors and have slower reaction time for correct rejections of lures related to their preferred type of semantic organization: categorical for Westerners, functional for Easterners. We also predicted that independent of culture, organizational tendencies would relate to the different types of errors and response times made during the working memory task such that preferences for a particular organization type (functional or categorical) would result in higher levels of incorrect endorsement of those type of lures as well as slower correct response times. Finally, we predicted there would be a significant indirect effect such that culture influences semantic organization, which in turn influences working memory errors and response times. This predicted indirect effect is the most critical analysis as a significant result would implicate semantic organization as a mechanism by which culture influences working memory updating. The present study compared Americans and Turks as Westerners and Easterners, respectively. Past research conceptualises of Turkish culture as having both Western and Eastern influences; studies investigating self-construal and social processes, as well as holistic versus analytic processing, indicated greater Eastern influences (Imamoğlu & Karakitapoğlu-Aygün, 2007; Kâğitçibaşi, 1994; Kashima & Hardie, 2000; Uskul et al., 2008). In addition, some past research found cultural differences for Americans and Turks in the use of categories in long-term memory (Schwartz et al., 2014; Gutchess & Boduroglu, 2019).

Method

Preregistration

Hypotheses and data analysis plans for this study were preregistered on the Open Science Framework: https://osf.io/utr43.

Participants

Data from 50 American young adults (23 male, 22 female, 2 gender nonbinary, 3 preferred not to say) recruited from undergraduate students at Brandeis University in Waltham, MA, USA, and 52 Turkish young adults (15 male, 37 female) recruited from undergraduate students at Boğaziçi University and Koç University in Istanbul, Turkey were analyzed for the main experimental tasks: the categorical/functional word endorsement and 2-back working memory tasks. Participants provided written informed consent to protocols approved by Institutional Review Boards (Brandeis University #19034R; Boğaziçi University #2022-018, approval E-84391427-050.01.04-57418). Participants in both cultural groups had not lived outside

their native country for more than two years. These data were derived from an original sample of 72 Americans and 58 Turks, but due to technical errors related to online data collection, only a subset of participants completed the non-semantic working memory tasks that were administered to assess working memory across the samples and, if needed, control for possible general working memory ability differences across groups. In order to have approximately equal culture group sample sizes for primary analyses, only American participants who completed the main experiment tasks and at least one non-semantic working memory control task and had behavioural performance in line with the inclusion criterion set in pre-registration (i.e., above chance 2-back target accuracy) were included in analyses. One Turkish participant was excluded due to below chance 2-back target accuracy, and five others' data did not save properly due to failure to follow online task instructions. Data were screened for average reaction times < 300 msec, which would indicate inattention to the task, but no participants were eliminated from analyses for this reason.

Sample size targets for the primary analyses were determined using a Monte Carlo power analysis simulation based on methods and software by Schoeman and colleagues (Schoemann et al., 2017). The simulation parameters were as follows: target power = .80, confidence levels = .95, number of replications = 1000, draws per replication = 20,000. For a power analysis of the simple mediation model, the standardised coefficient for direct effect of culture group on working memory performance was set at .50, based on a previous study examining cross-cultural effects of categorical memory errors showing a moderate effect size (Schwartz et al., 2014). The other components of the model (culture group on semantic organization, semantic organization on memory performance) were both set at .30, anticipating a low to moderate effect size. This power analysis indicated a total sample size of 100, with 50 in each cultural group.

Categorically and functionally related words

A list of 108 unique words was used for the main experiment tasks. Both English and Turkish language versions of the list were generated. The word list was comprised of 36 triads: a primary word, a word categorically related to the primary word, and a word functionally related to the primary word (e.g., apple-orange-tree). Words were taken from lists of English association words (Altarriba et al., 1999; McEvoy & Nelson, 1982) and had been developed for use in a previous study of Americans and Turks (Paige, 2014). In that study, an initial pool of 55 triads were first checked across sites to ensure consistent translations and meaning (bilingual assistants led by A.B.); 12 triads were eliminated. For the remaining 43 triads, participants rated how categorically- and functionally-related the word pairs were on a scale of 1 (very unlikely to be related) to 5 (very likely to be related). Based on ratings from 22 Americans and 21 Turks, separate samples than those who completed the tasks reported in this manuscript, means and standard deviations for every pair in each culture were calculated and only pairs rated 4 and above were included in the final stimulus list, which consisted of 36 triads. Participants completed all study tasks using these words in their native language.

Categorical/functional 2-back working memory task

We use a 2-back working memory task to measure the relative amounts of categorical and functional interference experienced by participants. This task was created using PsychoPy v2021 and was run online using Pavlovia.

Instructions and task words were presented in the participant's native language (English or Turkish). During the task, participants were presented with a word in the center of the screen and had to indicate with a keyboard press whether the present word is "same" or "different" from the word presented two trials back. There were 216 total trials presented in pseudorandom order, and each word was viewed a total of two times across the entire task. To limit participant fatigue, the task was broken into four blocks. Participants were not required to respond to the first two trials of each block (since there was no trial 2-back), which meant 8 trials were not included for analyses. Words were presented on screen for 3000 ms with a 500 ms inter-stimulus interval between trials. Once the stimulus appeared, participants had until the onset of the next stimulus to make their response.

There were four experimental conditions for this task: Target (32 trials), Unrelated (104 trials), Categorical (36 trials), and Functional (36 trials). During Target trials, the 2-back word was the same word as the present word (e.g., apple), and during Unrelated trials, the 2-back word (e.g., car) was unrelated to the present word. For Categorical (e.g., orange) and Functional (e.g., tree) trials, the 2-back word was related to the present word according to the condition. The conditions are illustrated in Figure 1.

Categorical/functional word endorsement task

After completing the 2-back categorical/functional working memory task, participants completed a task measuring their tendency to endorse categorical or functional relationships between words. As with the 2-back categorical/functional task, this task was created using PsychoPy v2021 and was run online using Pavlovia. This task was composed of 36 trials, one for each of the triads that make up the word lists used in the previous 2-back working memory task. During each trial, participants were presented with the triad's primary word in the center of the screen. Below the primary word, the associated categorical and functional counterparts were displayed. Participants were instructed to select which of

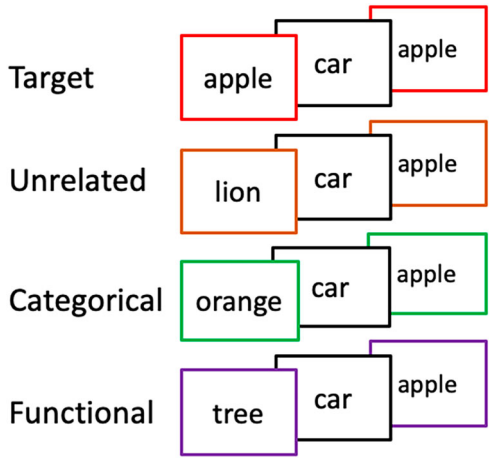


Figure 1. Illustration of the different conditions. For each trial, the item 2-back (first in the sequence of trials, appearing on the left) is manipulated to be either a Target (same as the current trial), Unrelated, Categorically-related or Functionally-related to the trial for which the decision is made (appearing on the right).

the two bottom words was more strongly related to the center word. Trials were self-paced, and the next triad would appear immediately after they made their response. Triads were presented in random order, and categorical and functional words were presented on the left and right sides of the screen an equal number of times.

Non-semantic working memory tasks to characterise samples

After completing the main experimental tasks, participants completed additional cognitive tasks intended to measure working memory capacity. These tasks were used to verify that cross-cultural samples were well-matched on cognitive ability and to confirm that any significant results found in our main tasks are the result of our variable of interest (i.e., categorical or functional relationship of words), and not confounded with a general working memory difference between groups. These tasks were run online using EPrime GO and participants were instructed to complete these tasks in the same session immediately following the main tasks. All task instructions and stimuli were in the participants' native language (English or Turkish).

The non-semantic working memory task was a spatial (nonverbal) 2-back task (Friedman et al., 2016). Participants completed this task immediately after the main experiment tasks. For this task, participants were shown an arrangement of squares on the screen, and during each trial, one square would be "activated" (filled in with black). Participants were instructed to indicate whether the presently activated square is the same or different from the one activated two trials back. There were three conditions in this task: Target (activated square is same as two trials back), Lure (activated square is the same as three trials back), and Foil (activated square is not the same as two trials back or any recent trials). To limit participant fatigue, the task was split into 6 runs with 24 trials each for a total of 144 trials. Across the entire task were 36 Target trials (6 per run), 30 Lure trials (5 per run), and 78 Foil trials (13 per run). Each trial lasted 500 milliseconds. Like the main experimental 2-back task, the spatial 2-back task required participants to continually update and make judgements based on working memory. However, unlike the main task, stimuli in this task did not have any semantic manipulations, so we were able to test for the existence of general working memory differences across cultures, which would inform our interpretations of the categorical/functional 2-back results.

The second non-semantic working memory task was the Operation Span (OSPAN) task (Unsworth et al., 2005a). This task was completed by participants after the spatial 2-back task. In this task, participants were required to solve a series of simple arithmetic problems while also remembering short sequences of letters. Participants completed a simple arithmetic problem followed by the presentation of a letter. After 3–7 instances of these arithmetic-letter sequences, participants were asked to recall the letters in presented order. There were a total of 15 letter recall trials. This task measured working memory capacity and the ability to resist interfering information, allowing us to test for any group differences in these abilities that would influence our main results. Data are scored such that all to-be-remembered items recalled in the correct serial position are counted, regardless of whether the entire sequence is recalled perfectly, and all trials are weighted the same across different loads. This method is referred to as partial-unit scoring in OSPAN literature; we also examined math accuracy scores to ensure that cultures did not emphasise different components of the task.

Correlations between study variables for both the main categorical/functional tasks and the non-semantic working memory tasks are available in Supplementary Materials. Correlations were conducted collapsing across culture groups (Supplementary Table 1) and separately for Americans (Supplementary Table 2) and Turks (Supplementary Table 3).

Results

Non-semantic working memory tasks

We used the spatial 2-back and the OSPAN tasks to assess working memory capacity in both culture groups. Mean performance for both tasks is displayed in Table 1. We note that, due to technical errors related to online data collection (e.g., primarily due to participants' disregard of instructions that they needed to complete the tasks on a computer with Windows operating system), only a subset of the sample included in the main analyses completed the non-semantic working memory tasks (spatial 2-back American $n = 46$, Turkish $n = 35$; OSPAN American

Table 1. Performance on non-semantic working memory tasks across cultures

	Americans		Turks			
	M	SD	M	SD	*t*	*p*
Spatial 2-back						
Proportion correct						
Target	.82	.13	.81	.12	.57	.57
Lure	.61	.28	.63	.20	.42	.68
Foil	.89	.12	.86	.11	1.10	.28
Reaction time (ms)						
Target	729.29	183.96	744.74	175.77	.38	.70
Lure	767.87	174.09	769.30	171.82	.04	.97
Foil	727.52	156.92	741.64	146.49	.42	.68
OSPAN						
Partial Unit	.79	.20	.82	.14	.49	.63
Math Accuracy	.91	.08	.93	.09	1.22	.23

$n = 50$, Turkish $n = 29$). There were no significant differences between groups for any of the measures.

Categorical/functional word endorsement

To test for cultural differences in the tendency to endorse categorical relationships versus functional relationships, we analyzed responses in the categorical/functional word endorsement task. For each participant, we computed a difference score by subtracting the proportion of trials in which they endorsed the functionally related word from the proportion of trials in which they endorsed the categorically related word. A positive difference score reflected a greater tendency to endorse categorical relationships whereas a negative score reflected a greater tendency to endorse functional relationships. An independent samples t-test revealed that cultures did not significantly differ in the tendency to endorse categorical versus functional relationships ($t(102) = .71$, $p = .47$, Cohen's d = .14; Figure 2).

Categorical/functional working memory interference: proportion correct and reaction times

We analyzed the proportion of errors and reaction times for the categorical/functional 2-back task in order to assess the extent to which American and Turkish participants experienced categorical and functional interference. A 2 (culture: American, Turkish) x 4 (2-back condition: target, unrelated, categorical, functional) ANOVA on proportion of errors revealed a main effect of culture such that Americans had a higher proportion of errors across all conditions compared to Turks ($F(1, 100) = 14.42$, $p < .001$, $\eta p^2 = .13$). There was also a main effect of 2-back condition ($F(1, 100) = 22.52$, $p < .001$, $\eta p^2 = .18$), such that across culture groups participants made significantly fewer errors in the Unrelated condition compared to the Target condition ($t(101) = 7.00$, $p < .001$, Cohen's $d = .69$), the Categorical condition ($t(101) = 9.30$, $p < .001$, Cohen's $d = .92$), and the Functional condition ($t(101) = 7.46$, $p < .001$, Cohen's $d = .74$). There was a significant interaction between culture and condition ($F(1, 100) = 4.16$, $p = .01$, $\eta p^2 = .04$): Americans and Turks did not have significantly different error rates for Target trials ($t(100) = 1.29$, $p = .20$, Cohen's $d = .26$), but Americans made significantly more errors than Turks on Unrelated trials ($t(100) = 3.51$, $p < .001$, Cohen's $d = .70$), Categorical trials ($t(100) = 3.32$, $p < .001$, Cohen's $d = .66$), and Functional trials ($t(100) = 3.84$, $p < .001$, Cohen's $d = .76$). Both cultures' proportion of errors for all conditions are plotted in Figure 3.

Because we were most interested in errors as a result of interference from categorical and functional relationships, we also conducted a 2 (culture: American, Turkish) x 2 (2-back condition: categorical, functional) ANOVA for proportion of errors. This analysis revealed a main effect of culture such that, collapsing across conditions, Americans had a higher proportion of errors than Turks ($F(1, 100) = 14.18$, $p < .001$, $\eta p^2 = .12$). There was no significant main effect of condition ($F(1, 100) = 3.97$, $p = .05$, $\eta p^2 = .04$) nor an interaction between condition and culture ($F(1, 100) = .54$, $p = .56$, $\eta p^2 = .005$).

In addition to working memory errors, we also analyzed response times of correct responses, as this measure may capture subtle effects of interference even when accuracy is high. A 2 (culture: American, Turkish) x 4 (2-back condition: target, unrelated, categorical, functional) ANOVA for correct response reaction times found no significant main effect of culture ($F(1, 100) = .23$, $p = .63$, $\eta p^2 = .002$), nor a significant interaction between culture and condition ($F(1, 100) = 2.00$, $p = .11$, $\eta p^2 = .02$). There was a main effect of condition ($F(1, 100) = 3.44$, $p = .02$, $\eta p^2 = .03$), driven by the fact that reaction times for correct Target responses were significantly slower than for correct Unrelated responses ($t(101) = 2.87$, $p = .01$, Cohen's $d = .28$). There was a no significant difference between Target and Categorical response times ($t(101) = 1.80$, $p = .08$, Cohen's $d = .18$,) nor between Target and Functional response times ($t(101) = .67$, $p = .51$, Cohen's $d = .07$). Correct response times for both culture groups are plotted in Figure 4.

As for the proportion of errors analyses, we were primarily interested in how interference during the Categorical and Functional trials would influence reaction time. A 2 (culture: American, Turkish) x 2 (2-back condition: categorical, functional) ANOVA for reaction times for correct rejections showed no main effect of culture ($F(1, 100) = .55$, $p = .46$, $\eta p^2 = .01$), nor a main effect of condition ($F(1, 100) = 2.66$, $p = .11$, $\eta p^2 = .03$). There was a significant interaction between culture and condition, ($F(1, 100) = 5.02$, $p = .03$, $\eta p^2 = .05$), such that Americans had slower reaction times in the Functional condition compared to the Categorical condition ($t(49) = 2.25$, $p = .03$, Cohen's $d = .32$), but Turks had no significant difference between conditions ($t(51) = .58$, $p = .56$, Cohen's $d = .08$).

Mediation analyses

Mediation models were used to investigate the relationships between culture (X), categorical/functional

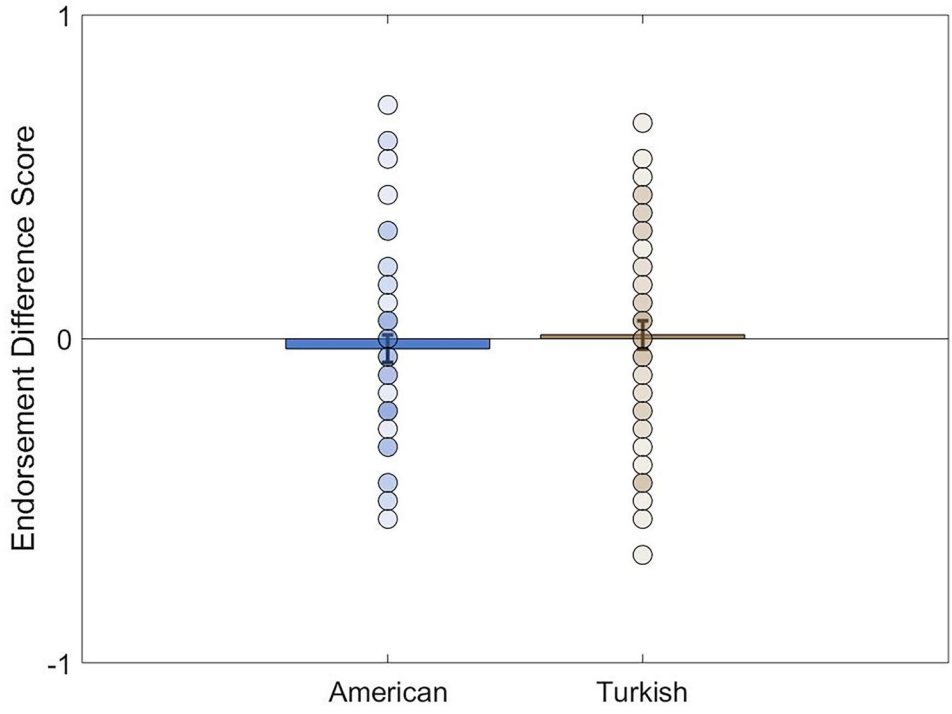


Figure 2. Proportion of categorical and functional relationships endorsed by cultures groups. Individual participants are represented by transparent dots layered such that the appearance of darker dots indicate a higher number of participants with that score (maximum number: American = 6; Turkish = 5); positive scores indicate a greater tendency to endorse categorical relationships and negative scores indicate a greater tendency to endorse functional relationships. Error bars represent between-subjects standard error of the mean. There were no significant differences between cultures in tendency to endorse categorical versus functional words.

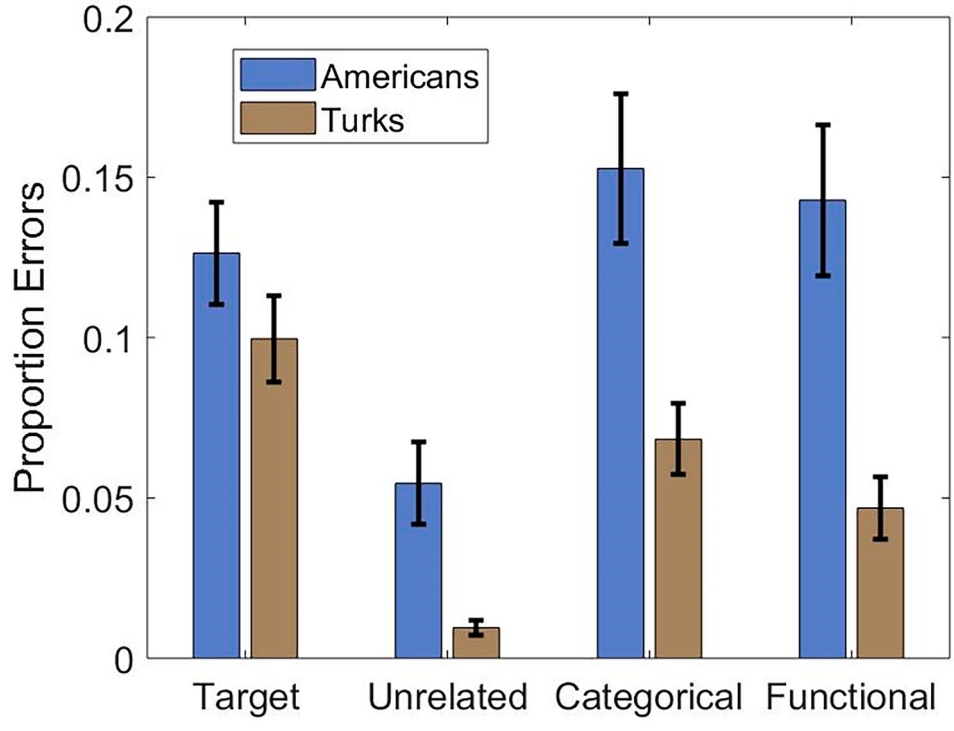


Figure 3. Proportion of working memory errors made across 2-back conditions. Across all conditions, Americans had a higher proportion of incorrect responses compared to Turks. Error bars represent between-subjects standard error of the mean.

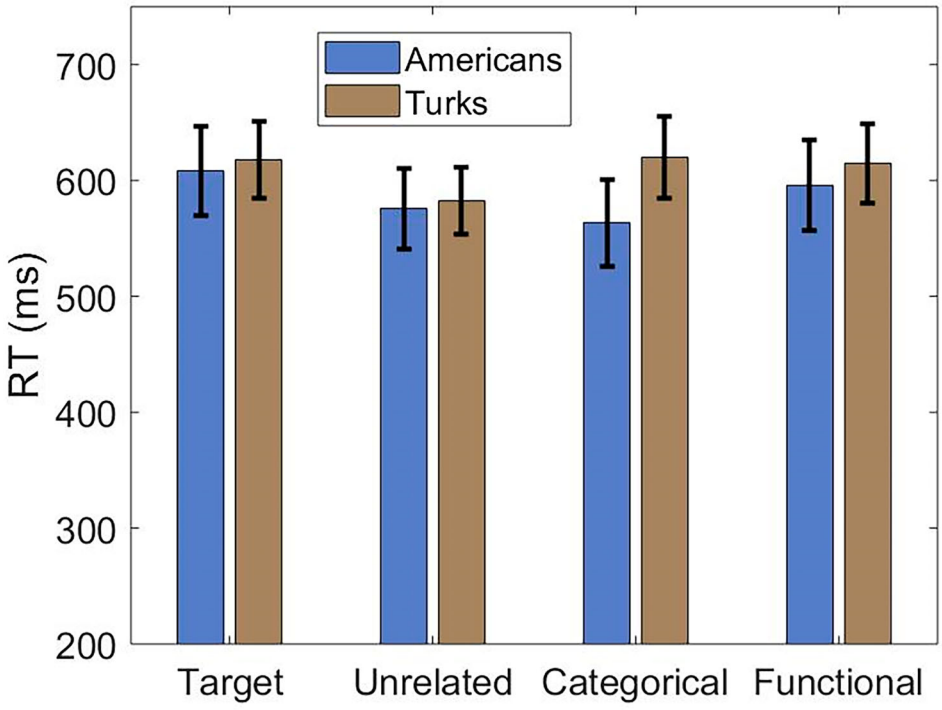


Figure 4. Reaction times for correct responses in all 2-back conditions. Error bars represent between-subjects standard error of the mean.

endorsements (M), and categorical/functional working memory interference (Y: 2-back errors or response times). A significant indirect effect would implicate semantic organization as a mechanism by which culture influences working memory updating. Culture was a binary categorical variable (American or Turkish), and categorical/functional endorsement was operationalized as the difference between proportion of categorical and functional word selections in the endorsement task. We conducted two separate mediation analyses which were identical except for the Y variable: one used the difference between categorical and functional 2-back errors, and another used the difference between categorical and functional correct rejection response times. Results from both models are summarised in Figure 5.

The total effect model testing the relationship between culture and 2-back errors showed no significant association (c: $\beta = 0.07$, $p = .50$). Culture also was not significantly associated with categorical/functional endorsement (a: $\beta = 0.07$, $p = .47$). There was a significant relationship between categorical/functional endorsement and 2-back errors such that a greater difference between categorical

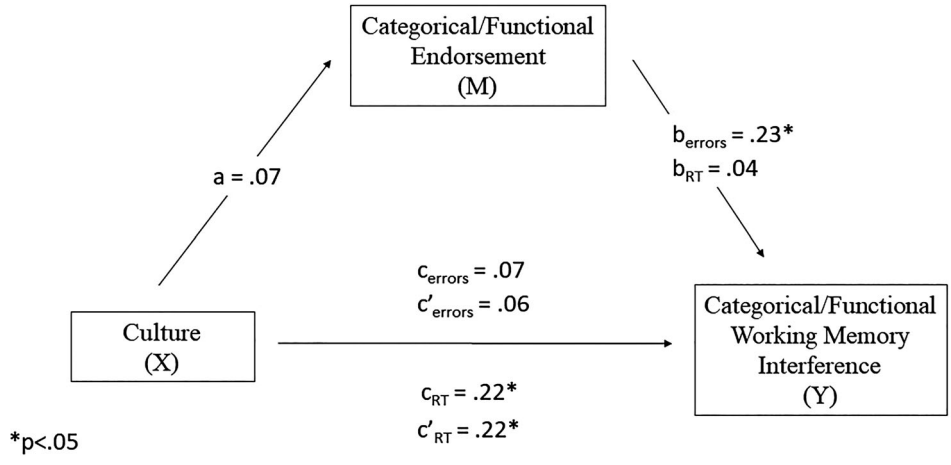


Figure 5. Mediation model results for relationships between culture, categorical/functional endorsement, and working memory interference. For reaction times, culture was significantly associated with reaction time differences such that compared to Turks, Americans had slower response times to functional trials compared to categorical trials. For 2-back errors, there was a significant relationship between differences in proportion of categorical/functional endorsements and difference in categorical/functional 2-back errors. Categorical/functional endorsement was not a significant mediator in either model.

and functional endorsement predicted a larger difference between proportion of categorical and functional 2-back errors (b: β = 0.23, p = .01) (e.g., participants who endorsed categorical pairings more than functional ones committed more categorical errors on the 2-back task). This significant relationship between categorical/functional endorsement and 2-back errors is illustrated in Figure 6. The effects of culture on 2-back errors were not significantly mediated by categorical/functional endorsement (Indirect effect: β = −0.02, p = .55, 95% bias-correct bootstrapped confidence interval − 0.09–0.03), and the direct effect of culture on 2-back errors remained non-significant (c': β = 0.06, p = .59).

When testing the relationship between culture and categorical/functional correct response times, the total effect model indicated that compared to Turks, Americans had slower response times when correctly rejecting functional compared to categorical trials (c: β = 0.22, p = .002). There was no significant relationship between categorical/functional endorsement and response times (b: β = 0.04, p = .62). The effects of culture on response times were not significantly mediated by categorical/functional endorsement (Indirect effect: β = 0.003, p = .80, 95% bias-correct bootstrapped confidence interval − 0.008–0.04), and the direct effect of culture on response times remained significant (c': β = 0.22, p = .002).

Discussion

The aim of this study was to examine the relationship between culture, semantic organization, and working memory. We predicted that, in a working memory task, Americans would be more susceptible to interference from categorical lures while Turks would be more susceptible to interference from functional lures; this would extend prior findings of cultural differences in errors in long-term memory (Gutchess et al., 2006; Gutchess & Boduroglu, 2019; Schwartz et al., 2014) into working memory. Critically, we hypothesised that this relationship would be mediated by semantic organization such that Americans would more frequently endorse categorically-related word pairs whereas Turks would more frequently endorse functionally related word pairs.

Although we predicted semantic organization would mediate the relationship between culture and working memory interference, this pathway was not significant. Instead, we found evidence for a significant relationship between the endorsement of categorically-related word pairs and working memory interference. That is, regardless of culture, those individuals who tended to endorse categorical pairings more than functional pairings also committed more working memory errors for categorical than functional lures. This finding extends research on

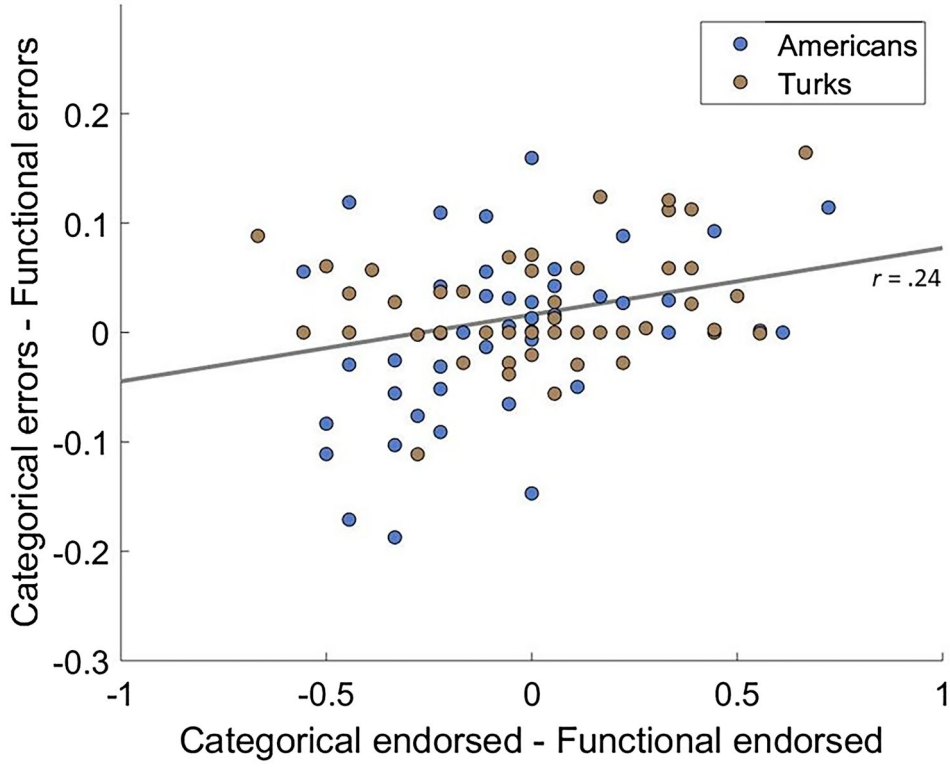


Figure 6. Scatter plot displaying the correlation between categorical vs. functional word endorsement and categorical/functional errors in the 2-back task. Dots represent individual subjects and Americans and Turks are shown in blue and brown, respectively. Scores are presented as difference scores. Positive scores reflect more categorical than functional errors (y-axis) and endorsements (x-axis) and negative scores reflect more functional than categorical errors (y-axis) and endorsements (x-axis).

individual differences in the structure of semantic systems, including the strength of taxonomic and thematic relationships (related to the distinction in the present study between categorical and functional) (for a review, see Mirman et al., 2017). Specifically, our results indicate that relative differences in preference, or strength, of categorical versus functional relationships in long-term memory could contribute to one's vulnerability to certain types of semantic interference in working memory. This evidence indicates that the task developed in the present study captures some component of semantic organization that influences working memory behaviour. However, it may not be a component that is culturally-influenced.

The lack of cultural differences in endorsement of functional vs. categorical information or the proneness to interference from different types of information in working memory contrasts our predictions. The present study differed in a number of ways from previous research that demonstrated these effects. In the initial studies investigating the endorsement of categorical vs. functional information, Westerners were compared with Chinese, rather than Turkish, participants (Chiu, 1972; Ji et al., 2004; Unsworth et al., 2005b; using a variant of the task and a heterogeneous East Asian sample, Gutchess et al., 2010 found neural differences but not behavioral differences across cultures). However, a recent study found that Turkish participants made more thematic (vs. taxonomic, or categorical) classifications than did Anglo-Western or even East Asian participants (Uskul et al., 2023). In terms of memory, previous studies investigating cultural differences in the use of and interference from categorical information exclusively focused on *long-term memory* (Schwartz et al., 2014; Gutchess & Boduroglu, 2019). These effects that could depend on substantially different cognitive processes, or the ways in which long-term memory is prone to additional sources of interference, than what we have assessed in these tasks. The present study is the only one to focus on cross-cultural differences in interference in *working memory*. In addition, the process used to select stimuli may have differed across studies. The present study only included items for which both the functional and categorical lure were endorsed by both cultures as highly related (ratings of at least a 4 on a 5-point scale) during pilot testing. By removing more ambiguously related items or those for which one type of relationship is much stronger than the other, this may have restricted our ability to detect cultural differences.

Interestingly, a recent study comparing North American and Japanese participants across several social orientation and cognitive style measures (including a triads task similar to that used in the present study), also found no difference between groups in categorical vs. functional endorsements (Na et al., 2020). One might expect cognitive style differences to be starker when comparing North Americans and Japanese (a more traditionally "Eastern" group than Turks), so it is notable they also found no significant differences for this measure. In this same study, Na and colleagues noted high levels of inter-individual variability across measures, despite group differences found for many of the measures, and they call for reform in how cross-cultural differences in social orientation and cognitive style are conceptualised, pointing out that many paradigms that are ostensibly measuring the same concept (e.g., cognitive style) do not correlate with one another. Our results are in alignment with this position. We did not find coherence between measures that we expected would have cultural alignment (categorical/functional word endorsement and categorical/functional 2-back), suggesting the observed cross-cultural differences in working memory are the result of processes that were not captured in this study and may be outside of traditional conceptualizations of cultural differences in cognitive style.

In terms of cultural differences that emerged in the study, there was some evidence for an unexpected relationship between culture and working memory interference in reaction times. Americans were slower to make correct responses to functional trials compared to categorical trials, but for Turkish participants there was no significant difference between conditions. It is possible that at a general level, this could serve as evidence for a larger distinction between categorical and functional relationships for Americans, which could lead to more competition or interference between the two types of information. In contrast, both types of relationships are more equal for Turks and are not seen as in competition (see a similar pattern in long-term memory in Gutchess & Boduroglu, 2019). Although we had predicted that cultural differences would emerge as an effect of more interference producing longer response times, in line with longer reaction times in *n*-back tasks reflecting proactive interference (Szmalec et al., 2011), it is also possible to think about the task in terms of stronger relationships facilitating responses. For example, Szmalec and colleagues (2011) argued that recollection processes could be engaged that would facilitate mismatch responses, consistent with spreading activation models (Collins & Loftus, 1975) and the role of competition in categorical priming (Voss et al., 2013). Before entertaining alternate interpretations of the pattern of data, it would be necessary to replicate the pattern of response time data from the present study to ensure that it is not a spurious finding. Should the pattern replicate, future studies could more precisely titrate the level of interference or manipulate response time windows to better distinguish the processes that differ across cultures. In addition, the n-back task includes far more mismatch ("no") than match ("yes") trials. Although this is typical in many n-back studies, the numbers in the present study (~15% match trials) may be more extreme given the inclusion of multiple types of lures and the predictions focused on them. This distribution may have made the "no" response strongly prepotent, making it easier to reject the interference trials.

Cultural groups also could be differently sensitive to the response distributions; for example, Americans could commit more errors if they have a lower threshold to respond "yes" than Turks. Extending research to tasks with more balanced response distributions would be beneficial for investigating cultural differences in interference.

Overall, our results suggest that the differing preferences for categorical vs. functional relationships observed in prior cross-cultural work are not apparent for Americans vs. Turks, at least when assessed with an explicit preference task, and do not mediate cultural differences in working memory. Though our data did not show a significant mediating relationship of semantic organization between culture and working memory, we did find a significant relationship between culture and response time to categorical vs. functional interference, but in the opposite direction as predicted, with Americans slower to reject functional lures. We also found evidence that, for both Americans and Turks, semantic organization was related to the types of working memory errors made. By using a mediation analysis approach, we were able to test the effects of a candidate mechanism (i.e., semantic organization) on cultural differences in working memory. We advocate that future work take this approach as it allows for insight on how different facets of cognition, such as long and short term memory, interface with each other and how culture can influence such dynamics.

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References

Altarriba, J., Bauer, L. M., & Benvenuto, C. (1999). Concreteness, context availability, and imageability ratings and word associations for abstract, concrete, and emotion words. *Behavior Research Methods, Instruments, & Computers*, *31*(4), 578–602. https://doi.org/10.3758/BF03200738

Camos, V. (2015). Storing verbal information in working memory. *Current Directions in Psychological Science*, *24*(6), 440–445. https://doi.org/10.1177/0963721415606630

Camos, V. (2017). Psychology of learning and motivation. *Psychology of Learning and Motivation*, *67*, 135–171. https://doi.org/10.1016/bs.plm.2017.03.005

Camos, V., Mora, G., Oftinger, A.-L., Mariz Elsig, S., Schneider, P., & Vergauwe, E. (2019). Does semantic long-term memory impact refreshing in verbal working memory? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *45*(9), 1664. https://doi.org/10.1037/xlm0000657

Chiu, L.-H. (1972). A cross-cultural comparison of cognitive styles in Chinese and American children. *International Journal of Psychology*, *7*(4), 235–242. https://doi.org/10.1080/00207597208246604

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review*, *82*(6), 407–428. https://doi.org/10.1037/0033-295X.82.6.407

Cowan, N. (1999). An embedded-processes model of working memory. In A. Miyake, & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 62–101). Cambridge University Press. https://doi.org/10.1017/CBO9781139174909.006

Crowder, R. G. (1982). The demise of short-term memory. *Acta Psychologica*, *50*(3), 291–323. https://doi.org/10.1016/0001-6918(82)90044-0

Friedman, N. P., Miyake, A., Altamirano, L. J., Corley, R. P., Young, S. E., Rhea, S. A., & Hewitt, J. K. (2016). Stability and change in executive function abilities from late adolescence to early adulthood: A longitudinal twin study. *Developmental Psychology*, *52*(2), 326. https://doi.org/10.1037/dev0000075

Gutchess, A., & Boduroglu, A. (2019). Cultural differences in categorical memory errors persist with age. *Aging & Mental Health*, *23*(7), 851–854. https://doi.org/10.1080/13607863.2017.1421616

Gutchess, A. H., Hedden, T., Ketay, S., Aron, A., & Gabrieli, J. D. E. (2010). Neural differences in the processing of semantic relationships across cultures. *Social Cognitive and Affective Neuroscience*, *5*(2-3), 254–263. https://doi.org/10.1093/scan/nsp059

Gutchess, A. H., Yoon, C., Luo, T., Feinberg, F., Hedden, T., Jing, Q., Nisbett, R. E., & Park, D. C. (2006). Categorical organization in free recall across culture and age. *Gerontology*, *52*(5), 314–323. https://doi.org/10.1159/000094613

Imamoğlu, E. O., & Karakitapoğlu-Aygün, Z. (2007). Relatedness of identities and emotional closeness with parents across and within cultures. *Asian Journal of Social Psychology*, *10*(3), 145–161. https://doi.org/10.1111/j.1467-839X.2007.00221.x

Ji, L.-J., Zhang, Z., & Nisbett, R. E. (2004). Is it culture or is it language? Examination of language effects in cross-cultural research on categorization. *Journal of Personality and Social Psychology*, *87*(1), 57. https://doi.org/10.1037/0022-3514.87.1.57

Kâğitçibaşi, Ç. (1994). A critical appraisal of individualism and collectivism: Toward a new formulation. In *Individualism and collectivism: Theory, method, and applications* (pp. 52–65). Sage Publications, Inc.

Kashima, E. S., & Hardie, E. A. (2000). The development and validation of the relational, individual, and collective self-aspects (RIC) scale. *Asian Journal of Social Psychology*, *3*(1), 19–48. https://doi.org/10.1111/1467-839X.00053

Kowialiewski, B., Lemaire, B., & Portrat, S. (2021). How does semantic knowledge impact working memory maintenance? Computational and behavioral investigations. *Journal of Memory and Language*, *117*, 104208. https://doi.org/10.1016/j.jml.2020.104208

Loaiza, V. M., & Camos, V. (2018). The role of semantic representations in verbal working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *44*(6), 863. https://doi.org/10.1037/xlm0000475

Loaiza, V. M., & McCabe, D. P. (2012). Temporal–contextual processing in working memory: Evidence from delayed cued recall and delayed free recall tests. *Memory & Cognition*, *40*(2), 191–203. https://doi.org/10.3758/s13421-011-0148-2

Loaiza, V. M., & McCabe, D. P. (2013). The influence of aging on attentional refreshing and articulatory rehearsal during working

memory on later episodic memory performance. *Aging, Neuropsychology, and Cognition*, *20*(4), 471–493. https://doi.org/10.1080/13825585.2012.738289

Loaiza, V. M., Rhodes, M. G., & Anglin, J. (2015). The influence of age-related differences in prior knowledge and attentional refreshing opportunities on episodic memory. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *70*(5), 729–736. https://doi.org/10.1093/geronb/gbt119

Masuda, T., & Nisbett, R. E. (2001). Attending holistically versus analytically: Comparing the context sensitivity of Japanese and Americans. *Journal of Personality and Social Psychology*, *81*(5), 922. https://doi.org/10.1037/0022-3514.81.5.922

McEvoy, C. L., & Nelson, D. L. (1982). Category name and instance norms for 106 categories of various sizes. *The American Journal of Psychology*, 581–634. https://doi.org/10.2307/1422189

Melton, A. W. (1963). Implications of short-term memory for a general theory of memory. *Journal of Verbal Learning and Verbal Behavior*, *2* (1), 1–21. https://doi.org/10.1016/S0022-5371(63)80063-8

Mirman, D., Landrigan, J. F., & Britt, A. E. (2017). Taxonomic and thematic semantic systems. *Psychological Bulletin*, *143*(5), 499–520. https://doi.org/10.1037/bul0000092

Na, J., Grossmann, I., Varnum, M. E., Karasawa, M., Cho, Y., Kitayama, S., & Nisbett, R. E. (2020). Culture and personality revisited: Behavioral profiles and within-person stability in interdependent (vs. independent) social orientation and holistic (vs. analytic) cognitive style. *Journal of Personality*, *88*(5), 908–924. https://doi.org/10.1111/jopy.12536

Nairne, J. S. (1990). A feature model of immediate memory. *Memory & Cognition*, *18*(3), 251–269. https://doi.org/10.3758/BF03213879

Nairne, J. S. (2002). Remembering over the short-term: The case against the standard model. *Annual Review of Psychology*.

Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: Holistic versus analytic cognition. *Psychological Review*, *108*(2), 291. https://doi.org/10.1037/0033-295X.108.2.291

Oberauer, K. (2013). The focus of attention in working memory—from metaphors to mechanisms. *Frontiers in Human Neuroscience*, *7*, 673. https://doi.org/10.3389/fnhum.2013.00673

Paige, L. (2014). *Social interactions and the influence of cultural strategies on memory errors*. Unpublished manuscript. Brandeis University.

Popov, V., & Reder, L. M. (2020). Frequency effects on memory: A resource-limited theory. *Psychological Review*, *127*(1), 1–46. https://doi.org/10.1037/rev0000161

Postle, B., D'Esposito, M., & Corkin, S. (2005). Effects of verbal and nonverbal interference on spatial and object visual working memory. *Memory & Cognition*, *33*(2), 203–212. https://doi.org/10.3758/BF03195309

Schoemann, A. M., Boulton, A. J., & Short, S. D. (2017). Determining power and sample size for simple and complex mediation models. *Social Psychological and Personality Science*, *8*(4), 379–386. https://doi.org/10.1177/1948550617715068

Schwartz, A. J., Boduroglu, A., & Gutchess, A. H. (2014). Cross-cultural differences in categorical memory errors. *Cognitive Science*, *38*(5), 997–1007. https://doi.org/10.1111/cogs.12109

Szmalec, A., Verbruggen, F., Vandierendonck, A., & Kemps, E. (2011). Control of interference during working memory updating. *Journal of Experimental Psychology: Human Perception and Performance*, *37*(1), 137–151. https://doi.org/10.1037/a0020365

Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005a). An automated version of the operation span task. *Behavior Research Methods*, *37*(3), 498–505. https://doi.org/10.3758/BF03192720

Unsworth, S. J., Sears, C. R., & Pexman, P. M. (2005b). Cultural influences on categorization processes. *Journal of Cross-Cultural Psychology*, *36* (6), 662–688. https://doi.org/10.1177/0022022105280509

Uskul, A. K., Kirchner-Häusler, A., Vignoles, V. L., Rodriguez-Bailón, R., Castillo, V. A., Cross, S. E., Yalçın, M. G., Harb, C., Husnu, S., Ishii, K., Jin, S., Karamaouna, P., Kafetsios, K., Kateri, E., Matamoros-Lima, J., Liu, D., Miniesy, R., Na, J., Özkan, Z., … Uchida, Y. (2023). Neither eastern nor western: Patterns of independence and interdependence in Mediterranean societies. *Journal of Personality and Social Psychology*, *125*(3), 471–495. https://doi.org/10.1037/pspa0000342

Uskul, A. K., Kitayama, S., & Nisbett, R. E. (2008). Ecocultural basis of cognition: Farmers and fishermen are more holistic than herders. *Proceedings of the National Academy of Sciences*, *105*(25), 8552–8556. https://doi.org/10.1073/pnas.0803874105

Voss, A., Rothermund, K., Gast, A., & Wentura, D. (2013). Cognitive processes in associative and categorical priming: A diffusion model analysis. *Journal of Experimental Psychology: General*, *142*(2), 536–559. https://doi.org/10.1037/a0029459

Zhang, Y., & Verhaeghen, P. (2009). Glimpses of a one-speed mind: Focus-switching and search for verbal and visual, and easy and difficult items in working memory. Acta Psychologica, 131(3), 235-244. doi:10.1016/j.actpsy.2009.05.009