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BRIEF REPORT

The effects of prior knowledge on the encoding of episodic contextual details

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Abstract A positive relationship between prior knowledge and item memory is a consistent finding in the literature. In the present study, we sought to determine whether this relationship extends to episodic details that are present at the time of encoding, namely source memory. Using a novel experimental design, we were able to show both between- and within-subjects effects of prior knowledge on source memory. Specifically, the results revealed that the degree of prior knowledge positively predicted memory for source specifying contextual details. In addition, by including two conditions in which attention was divided either at encoding or retrieval, we were able to show that prior knowledge influences memory by affecting encoding processes. Overall, the data suggest that a priori knowledge within a specific domain allows attentional resources to be allocated toward the encoding of contextual details.

Keywords Episodic memory · Encoding effects · Prior knowledge

A consistent finding in the literature is that of a positive relationship between memory for domain-specific information and the level of prior knowledge within that domain. This memory advantage for domain-relevant information in one's field of expertise has been shown to be consistent across a wide range of areas such as text processing (Long, Prat, Johns, Morris, & Jonathan, 2008; Spilich, Vesonder, Chiesi, & Voss, 1979), chess grandmasters recalling the location of chess pieces (Chase & Simon, 1973), the recall of baseball-related information by baseball experts (Voss, Vesonder, & Spilich, 1980), and computer program code (McKeithen, Reitman, Rueter, & Hirtle, 1981). Although researchers in most studies have examined the effect of knowledge on item memory by examining recall and recognition performance, in the present study, we sought to determine whether prior knowledge has an impact on the ability to attribute a memory to a particular source.

According to the source monitoring framework (Johnson, Hastroudi, & Lindsay, 1993), decisions about the source of a particular memory can be made by either retrieving source-specifying contextual details that are bound with the item or by using supplemental information such as schemas or general knowledge. Regarding the latter, unlike previous research that has examined the impact of existing schemas on source monitoring decisions (Hicks & Cockman, 2003; Sherman & Bessenoff, 1999), in the present study, we examined the influence of prior knowledge on the encoding and retrieval of the episodic contextual features that are indicative of a particular source.

Prior knowledge has traditionally been thought to affect memory by supporting more effective organizational processes. Theorists in the area of skilled memory have suggested that having a high level of knowledge within a specific domain allows for the use of organized knowledge structures (schemas) into which new information can be incorporated and that form the basis for more efficient retrieval (Ericsson & Kintsch, 1995; Gobet & Simon, 1996; also see Kimball & Holyoak, 2000). Evidence for the impact of existing schemas on memory is not restricted to research in the area of skilled memory. For example, Konkle, Brady, Alvarez, and Oliva (2010) found that although recognition memory for visual objects was indeed

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good, memory performance declined as the number of category exemplars that were studied increased. Interestingly, they found that the interfering effects of semantic relatedness were mediated not by perceptual distinctiveness of the items but rather by the conceptual distinctiveness of the category. That is, the amount of variation in the subordinate category structure directly influenced the level of interference, indicating that the organizational structure within semantic memory affected performance.

Recently, however, Rawson and Van Overshelde (2008) argued that, although important, organizational processes alone are insufficient to account for skilled memory. In addition to organizational processes, they suggested that prior knowledge promotes the "item-specific processing of the properties that uniquely specify a particular item within a category and distinguish it from otherwise similar or related items" (Rawson & Van Overshelde, 2008, p. 647). This item-specific processing, along with organizational processing, encompasses the distinctive processing that is proposed to underlie skilled memory. That is, having a high degree of knowledge within a specific domain promotes access to and encoding of features that distinguish related items, thereby increasing the discriminability of target items in memory. In support of this theory, they found that distinctive processing (combination of categorization and pleasantness rating tasks) led to better recall of football-related information by high knowledge individuals than did organizational processing (categorization task).

Implicit in Rawson and Van Overshelde's (2008) theory is that prior knowledge affects the allocation of attentional resources available for the encoding of features that distinguish items. If existing knowledge structures related to to-be-remembered items allow item-identifying information to be quickly and efficiently encoded, attentional resources could then be focused on encoding the episodic details unique to the item. In the present study, we sought to test this hypothesis by examining the relationship between prior knowledge and memory for episodic (i.e., source) details.

Although previous research into the relationship between prior knowledge and memory has used between-subjects designs (Long et al., 2008; McKeithen et al., 1981; Rawson & Van Overshelde, 2008; Spilich et al., 1979), we used a within-subjects design during which participants studied simple pictures of exemplars from a number of categories that they had previously rated for their level of knowledge. Location of the items presented at study (left or right side of the screen) was used as the contextual element because it is an extrinsic attribute, and it has been proposed that the encoding and/or retrieval of extrinsic details requires greater attentional resources (Troyer & Craik, 2000). Thus, if one's level of prior knowledge regarding an item frees attentional resources and allows one to focus on distinct details of the item, then a clear relationship should be seen between knowledge level and source memory performance. Additionally, if prior knowledge influences memory by encouraging item-specific processing at encoding, then no relationship between knowledge and source memory should be seen if attention is sufficiently divided at encoding. To this end, we included two divided attention conditions. In one, a concurrent task was performed at encoding, and in the other, the concurrent task was performed during the retrieval phase of the experiment.

Method

Participants

A total of 111 undergraduate students from the University of Georgia participated in partial fulfillment of a research appreciation course requirement. Participants were randomly assigned to one of the three between-subjects conditions and were tested individually in sessions lasting approximately 30 min. The number of participants in the control, divided attention (DA)-encoding, and DA-retrieval conditions were 37, 35 and 39, respectively.

Materials

Seven categories were used, from which all stimuli were exemplars. The categories used were chosen because they were likely to show large individual differences in knowledge ratings based upon pilot data. The seven categories used were flowers, precious stones, boats, fish, dogs, birds, and U.S. states.

For all but one of the categories, the 10 most commonly reported category exemplars— based upon the Van Overschelde, Rawson, and Dunlosky (2004) norms—for which appropriate pictures could be located were used as stimuli. Because there are no norms for the "dog" category, exemplars were chosen on the basis of our assessment of commonness. To create the 70 stimuli, an Internet search for a picture of each exemplar was conducted. Images were used as stimuli if they contained the entire object from a perspective that would allow one to identify it and if the object was located on a white background with no other distinct details present. The images used for the U.S. states category were chosen if they contained only a black outline of the state on a white background. Each of the pictures was then resized to 250 × 250 pixel images.

Procedure

The initial phase of the experiment required each participant to rate his or her perceived knowledge of and ability to discriminate between items within each of the seven categories on a scale of 1–6 (1 = *no knowledge*, 6 = *extremely knowledgeable*). Each category label was presented individually and in random order in the center of the screen. Once all seven ratings had been made, the instructions for the study phase were presented. Participants were told to study a number of presented images for a later unspecified memory test. Images were presented for 3 s each, separated by a 500-ms interstimulus interval. The order of presentation and location was pseudorandomized with the restriction that no two members of a category were presented sequentially and that no more than four exemplars from a given category were studied on the same side of the screen. During the study phase, participants were presented with seven exemplars from each of the seven categories, resulting in 49 study items. The other three items from each of the categories served as distractor items during the test phase. Which items served as studied items and distractors was determined randomly for each participant.

After the study period, participants completed a 5-min distractor task involving multiplication problems; the test instructions were then provided. During the test phase, participants saw each of the 70 items (49 old, 21 new) presented individually in the center of the screen. For each item, recognition responses were to be made on the basis of confidence ratings on a scale of 1–6 (1 = *very sure new*, 2 = *moderately sure new*, 3 = *a little sure new*, 4 = *a little sure old*, 5 = *moderately sure old*, 6 = *very sure old*). For any item that was given an "old" response (ratings 4, 5, 6), a source judgment for that item was then required. Source judgments were also to be made on a 1–6 scale on the basis of confidence (1 = *very sure left*, 2 = *moderately sure left*, 3 = *a little sure left*, 4 = *a little sure right*, 5 = *moderately sure right*, 6 = *very sure right*). If a "new" (responses 1, 2, 3) recognition response was made, no source judgment was required, and the next test item was presented.

The three between-subjects conditions differed only with respect to whether and during which phase of the experiment participants performed a concurrent ongoing task. In the control condition, no secondary task was performed. In the DA-encoding condition and DA-retrieval conditions, the secondary task was performed only during those respective phases of the experiment. No group performed the concurrent task during both encoding and retrieval. The concurrent task was a random number generation activity (e.g., Baddeley, 1966; Hicks & Marsh, 2000). Participants in the divided attention conditions were instructed that whenever they heard a beep, they should randomly generate a digit between 0–9 and report that number to the experimenter. Both RNG conditions were given the instructions for performing this task after the rating phase and before the study instructions were given. A 30-s RNG practice phase was next performed during which participants in the DA conditions performed the RNG free of any other ongoing task. The RNG task required participants to generate and report digits every 2 s. The control condition did not receive these instructions or perform the RNG; however, because the RNG instructions and practice were done before the study phase, any differences in performance could not be due to differences in the length of the retention interval.

Because participants in two of the conditions had their attention divided, differences in both recognition and source memory performance—when compared with the control condition— were expected. In order to ensure that differences in source memory performance were not confounded by differences in recognition rates, average conditional source identification measure (ACSIM) scores were used as the dependent variable for source memory performance. ACSIM scores are calculated by dividing the proportion of studied items assigned to the correct source by the proportion of studied items correctly identified as "old," regardless of source assignment (Murnane & Bayen, 1996). As such, ACSIM scores represent the proportion of recognized items assigned to the correct source. Both recognition hit rates and ACSIM scores were calculated by collapsing over the confidence levels for a particular response.

Results

Knowledge ratings

The mean (standard deviation) knowledge ratings for the control, DA encoding, and DA retrieval conditions were 3.78 (.79), 3.64 (.81), and 3.65 (.68), respectively, and did not differ significantly, $F(2, 108) < 1.00$, $p = .70$, $\eta_p^2 < .01$. Furthermore, mean knowledge ratings were somewhat consistent across categories and ranged from 3.13 to 4.13. Overall, 23% of responses were in the low range (1 and 2), 42% in the intermediate range (3 and 4), and 35% in the high range (5 and 6).

Concurrent task performance

The participant-generated digit sequences from the two DA conditions were analyzed for redundancy and randomness (for further information regarding these measures, see Towse & Neil, 1998). The DA-encoding and DA–retrieval conditions had virtually identical randomness scores (.543 and .542, respectively). Additionally, both conditions showed very little redundancy (for both conditions, $R < 1\%$). These analyses indicate that the two DA conditions performed similarly on the concurrent task.

Recognition memory

Although our main focus is on source memory performance, a brief summary of recognition memory performance is warranted. Recognition hit rates (HR), false alarm rates (FAR), and d' scores were calculated separately for categories that were given low (1 and 2), intermediate (3 and 4), and high (5 and 6) knowledge ratings, and are presented in Table 1. The mean d' scores were submitted to a 3 (prior knowledge level: low vs. intermediate vs. high) × 3 (condition) repeated measures ANOVA that revealed a main effect of condition, F (2, 84) = 14.88, p < .001, η_p^2 = .26, indicating that dividing attention had a negative impact on performance. As can be seen, dividing attention at encoding had the greatest influence on recognition memory. There was no significant effect of prior knowledge, F(2, 168) = 1.78, p = .17, η_p^2 = .02. Although not statistically significant, the pattern of performance indicates that as knowledge level increased, so did participants' ability to discriminate between studied items and lures, which is consistent with previous findings indicating an effect of prior knowledge on item memory. The knowledge level by condition interaction was not significant, F(4, 168) < 1.00, p = .95.

Relationship between knowledge and source memory

A regression analysis, which included participants' average knowledge ratings as the sole predictor of source memory performance (ACSIM scores) without regard to condition, produced a significant fit to the data, R^2 = .07, F(1, 109) = 8.69, p < .01. To determine whether there was an effect of condition, a second model—which included weighted effect codes for the three conditions (with the control condition set as the base group) as predictors in addition to knowledge ratings was tested. This model, too, provided a significant fit to the data, R^2 = .21, F (3, 107) = 9.69, p < .001. Importantly, the R^2 values of these two models were significantly different, F = 6.27, p < .001, indicating that the model that included condition as predictors fit the data significantly better than the model that used knowledge ratings alone. Furthermore, the coefficients indicated a significant effect of divided attention at encoding, t = -3.29, p = .001. However there was no significant effect of divided attention at retrieval, t = .846, p = .40.

For ease of comparison, Fig. 1 presents plots of the observed data along with the best fitting linear regression lines for each of the conditions separately.[1] Similar intercepts across the control and DA-retrieval conditions were observed, .46 and .40, respectively. The intercept for the DA-encoding condition was .60. In the control condition, the slope was reliably different from zero, R^2 = .25, B = .07, t(35) = 3.44, p < .01, indicating that level of prior knowledge was a significant predictor of source memory performance, with better performance for participants who gave higher average knowledge ratings. The slope for the DA-retrieval condition was similar to that in the control condition and was marginally different from zero, R^2 = .09, B = .065, t(37) = 1.92, p < .07. However, in the DA-encoding condition, knowledge ratings were not a significant predictor of ACSIM scores, R^2 < .001, B = -.003, t(33) = -.12, p = .90. Together, these analyses indicate that when attention was not divided at encoding, there was a positive relationship between knowledge and source memory performance. However, when attention is divided at encoding and processing resources are limited, the relationship fails to emerge.

One limitation of the preceding analysis was that it examined only between-subjects effects, and the implications that can be drawn are limited. Better memory performance may have been the result of more knowledge, or because those with better overall memory are more knowledgeable. To further explore this relationship, we next turn to an examination of the within-subjects effects.

As with the measures of recognition memory, mean ACSIM scores for the three conditions were calculated separately for categories that were given low, intermediate, and high knowledge ratings and are presented in Table 2. Only those participants who rated at least one category within each of the knowledge levels (low, intermediate, and high) were included in the following analyses. This requirement resulted in 32, 28, and 27 participants remaining in the control, DA-encoding, and DA-retrieval conditions, respectively. The ACSIM scores for the three knowledge levels were submitted to a 3 (prior knowledge level: low vs. intermediate vs. high) × 3 (condition) repeated measures

Table 1 Mean recognition hit rates (HR), false alarm rates (FAR), and d' scores for items from low, intermediate, and high knowledge areas for each condition

	HR *M SEM*	FAR *M SEM*	d' *M SEM*
Control	.75 .02	.07 .02	2.28 .11
Low	.75 .03	.12 .04	2.26 .18
Intermediate	.72 .03	.07 .02	2.25 .16
High	.77 .03	.05 .02	2.55 .13
DA Encoding	.59 .02	.17 .02	1.31 .09
Low	.53 .03	.18 .04	1.18 .18
Intermediate	.59 .03	.16 .03	1.38 .13
High	.58 .03	.17 .03	1.32 .15
DA Retrieval	.69 .03	.15 .02	1.78 .15
Low	.67 .03	.16 .04	1.72 .18
Intermediate	.67 .03	.12 .04	1.91 .16
High	.73 .03	.15 .04	2.00 .19

[1] The control condition was best fit by a polynomial regression, but the quadratic factor did not produce a significantly better fit than the linear model for either of the divided attention conditions. For consistency, we present only the linear models.

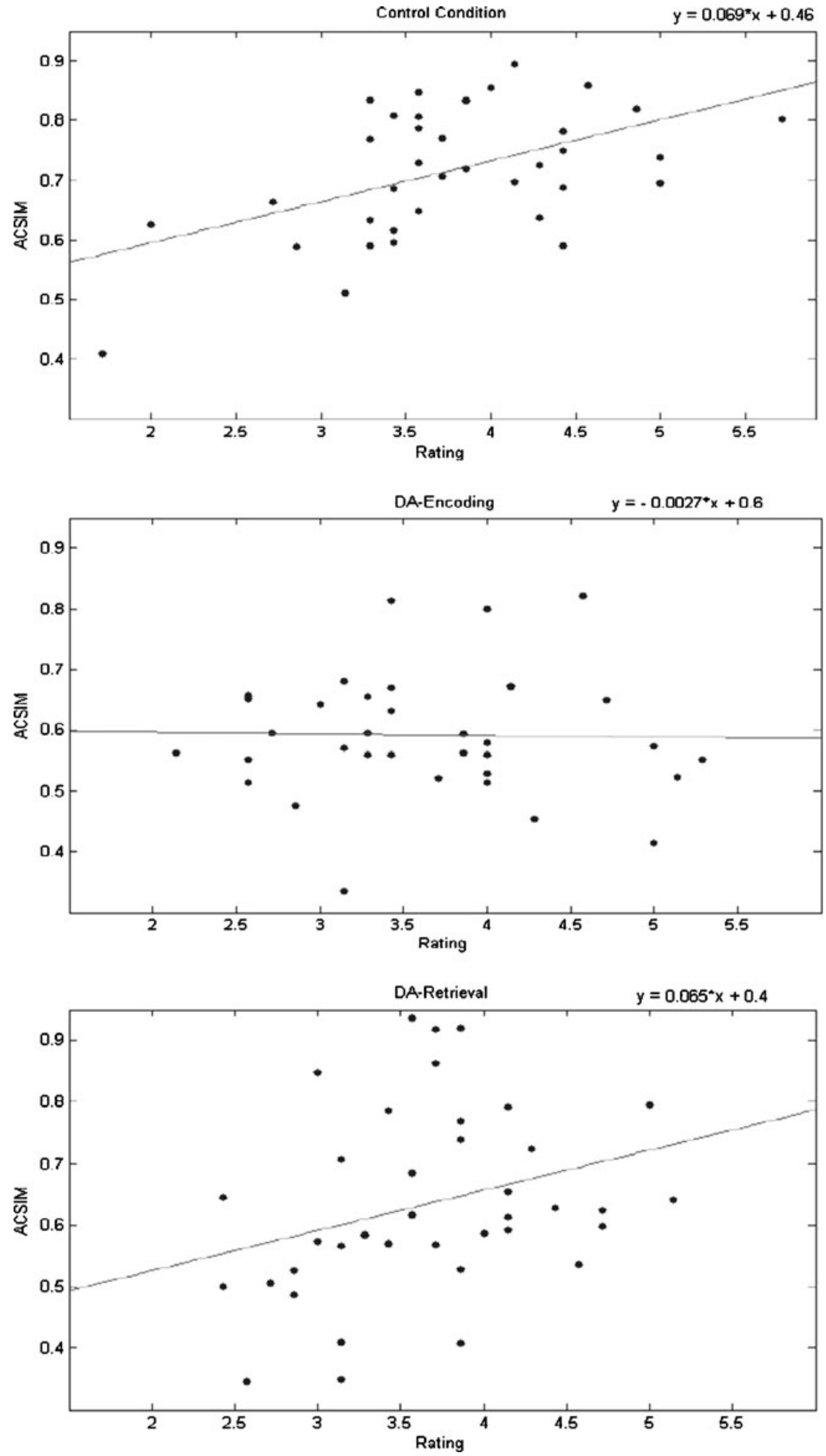

Fig. 1 Plots of source ACSIM scores by knowledge ratings and the best-fitting linear regression line for each of the conditions. Each point represents a participant's mean source ACSIM score plotted against mean knowledge rating

ANOVA that revealed main effects of condition, $F(2, 84) = 7.93$, $p = .001$, $\eta_p^2 = .159$, and prior knowledge, $F(2, 168) = 8.32$, $p < .001$, $\eta_p^2 = .09$. The Knowledge Level × Condition interaction was marginally significant, $F(4, 168) = 2.17$, $p = .07$, $\eta_p^2 = .05$.

Direct comparisons revealed that overall source memory performance (averaged across all three knowledge categories) was significantly higher in the control condition than in both the DA-encoding and DA-retrieval conditions, $t(58) = 5.05$ and $t(57) = 2.53$, respectively, $ps < .01$, $ds > .65$. The lower performance in both of the conditions that employed a secondary task as compared with the control condition indicates that our attempt to divide attention was successful.

Table 2 Mean source memory accuracy for items from low, intermediate, and high knowledge areas for each condition

Condition	ACSIM Scores			
	Low *M SEM*	Intermediate *M SEM*	High *M SEM*	Overall *M SEM*
Control	.62 .03	.72 .03	.80 .03	.73 .02
DA-Encoding	.58 .04	.57 .04	.59 .04	.58 .02
DA-Retrieval	.57 .04	.63 .04	.71 .03	.64 .03

Given that performance was lower in the two divided-attention conditions, we limit the remaining analyses to within-group comparisons. As can be seen by examining Table 2, performance increased as knowledge level increased in both the control and DA-retrieval conditions. However, no such pattern can be discerned for the DA-encoding condition. Direct comparisons revealed that, in the control condition, source memory performance on exemplars from high knowledge categories was significantly enhanced relative to low knowledge categories, $t(31) = 4.05$, $p < .001$, $d = 1.45$. Similarly, there was a significant difference in performance between high and low knowledge areas for those participants who performed the concurrent task during retrieval, $t(26) = 2.96$, $p < .01$, $d = 1.16$. However, no difference in performance was seen when the same analysis was conducted for the DA-encoding condition, $t(27) = .07$, $p = .94$, $d = .02$. Within the control condition, performance on intermediate knowledge items was significantly above that of the low knowledge items, $t(31) = 2.81$, $p < .01$, $d = 1.01$. However, although numerically higher, the intermediate level was not significantly different than the low level for the DA-retrieval condition, $t(26) = 1.38$, $p = .17$, $d = .54$. Additionally, no difference in performance across the low and intermediate knowledge levels was seen in the DA-encoding condition, $t(27) = 0.38$, $p = .70$, $d = .14$.

Discussion

The present study was undertaken to examine the relationship between prior knowledge and the retrieval of episodic details—namely, source memory. Similar to previous findings that have shown a positive influence of prior knowledge on item memory (Ricks & Wiley, 2009; Rawson & Van Overschelde, 2008; Van Overschelde, Rawson, Dunlosky, & Hunt, 2005) the present results showed that a strong positive relationship existed between prior knowledge and source memory. This relationship was evidenced in both between- and within-subjects analyses in the control and DA-retrieval conditions. The between-subjects regression analyses for these two conditions revealed that average knowledge ratings were a reliable predictor of overall source memory performance. The within-subjects effects for the control and DA-retrieval conditions were evidenced by significantly better source memory for items from categories with high relative to low reported knowledge.

Until recently, the effect of prior knowledge on memory has been explained in terms of organizational processes. That is, existing knowledge structures in memory allow for greater processing and organization of items within that domain. The present finding that domain knowledge resulted in improved memory for episodic details cannot be fully explained by the use of semantic knowledge structures alone. A better account of the present data comes from Rawson and Overschelde's (2008) *distinctiveness theory*, which argues that prior knowledge aids memory not only because it promotes organizational processes but also because it encourages item-specific processing. Increased item-specific processing would promote memory for extrinsic contextual details associated with items if it is those details that help distinguish items. Similar evidence for this phenomenon comes from Ricks and Wiley (2009) who, while examining the relationship between expertise and working memory capacity for domain-related information, found that high knowledge individuals had better memory for the order in which the items were presented than did low knowledge individuals.

The present work also extends the distinctiveness theory by providing evidence that prior knowledge allows for greater item-specific processing because it frees attentional resources that can be allocated to encoding contextual details associated with the item. That is, prior knowledge promotes more efficient encoding of item information, allowing attention to be directed toward the contextual elements of the to-be-remembered item. This evidence comes from the divided attention conditions in the present experiment. Although overall performance was lower in the two divided attention conditions, the positive relationship between knowledge and source memory was still present when attention was divided at retrieval. However, when processing resources were sufficiently taxed at encoding, the relationship failed to emerge. These results suggest that improved source memory for items from high knowledge areas was the result of attention-dependent encoding processes.

Conclusion

In the present study, we have shown that there is a positive relationship between prior knowledge and the extent to which source specifying contextual details are encoded. Given the present results, it is clear that in addition to better semantic processing, the level of prior knowledge is related to the amount of cognitive resources that are available for the encoding of contextual details. The availability of attentional resources for the encoding of contextual details is likely related to the cognitive load required to encode the item. Through promoting more efficient encoding of item information, prior knowledge frees cognitive resources for encoding more extrinsic details. To our knowledge, the present experiment is the first to show within-subjects effects of prior knowledge on memory. Beyond the implications for theories of encoding, these results show that memory researchers should take caution in choosing stimuli because differences in a priori knowledge both within and between participants could have a great impact on the results.

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