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BRIEF REPORT

Differential Attentional Costs of Encoding Specific and Gist Episodic Memory Representations

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Theories of episodic memory posit that more attentional resources are needed for encoding specific compared to gist representations. This position has been challenged by recent findings of similar divided attention (DA) at encoding costs on both specific and gist representations. However, the disrupting effects of DA on specific representations may emerge under less difficult DA conditions than those under which effects on gist representations emerge. The present study addressed this possibility by manipulating the difficulty of a concurrent DA task (low, intermediate, or high difficulty) during encoding among 176 young adult participants, who encoded face-scene pairs under either full attention or one of the three levels of DA. During retrieval, participants discriminated intact pairs from recombined pairs that varied in how similar they were to studied pairs. Results, interpreted using a multinomial-processing-tree model of specific and gist memory, showed that the disrupting effects of DA on specific representations emerged under less difficult attentional loads (intermediate-demanding condition) compared to those under which gist representations were disrupted (high-demanding condition). These findings reinforce the suggestion of differential attentional demands for specific and gist representations and also provide insights into attentional resource theories of adult age-related cognitive decline.

Public Significance Statement

Understanding how attention influences the representational quality of episodic memory is important given the ubiquity of the attention–memory relationship across multiple facets of our daily lives. The present study demonstrates that attention during encoding is critical for establishing specific, detailed representations of an episode, as well as more general, meaning-based representations. However, the attentional demands to encoding specific representations are greater than those to encode general representations, which may explain why our memories become less specific in old age.

Keywords: memory, divided attention, specific, gist

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One of the most fundamental relations in human cognition is that between attention and memory (Cowan et al., in press), which has been investigated in studies of working memory (Cowan, 2019), long-term memory (Craik et al., 1996), intelligence (Conway et al., 2003), reading comprehension (Arrington et al., 2014), neuropsychology (Moscovitch & Umilta, 1990), childhood development (Forsberg et al., 2022), and adult aging (Greene et al., 2020). A core component of this relationship is the degree to which attention is needed to encode episodic memories—or memories for events occurring in a specific time and place (Tulving, 1983)—at both specific/detailed and general/gist levels of representation. Leading theories of memory representation, such as fuzzy-trace theory (Brainerd & Reyna, 1990, 2004), posit that the encoding of specific representations requires a greater commitment of attention than the encoding of gist representations, which are thought to be encoded relatively automatically (cf., McClelland & Rumelhart, 1985).

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The ideas discussed in this paper have not been disseminated previously. Data and analysis scripts are available at: https://osf.io/y8kx6/.

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Nathaniel R. Greene served as the lead for data curation, formal analysis, software, writing–original draft and contributed equally to methodology, and served in a supporting role for writing–review and editing. Moshe Naveh-Benjamin contributed equally to supervision, writing–review and editing, and served in a supporting role for methodology. Nathaniel R. Greene and Moshe Naveh-Benjamin contributed equally to conceptualization, project administration, and investigation.

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Supporting evidence for this position comes from early studies employing divided attention (DA) manipulations, in which participants complete a secondary task while encoding memoranda for a later memory test. For example, Rabinowitz et al. (1982) found that, compared to full attention (FA) at encoding, young adults under DA at encoding were less capable of using specific cues generated during encoding but not general cues (e.g., "a type of fruit") to retrieve studied words associated with those cues. Odegard and Lampinen (2005) found that DA at encoding impaired young adults' ability to rely on specific representations of studied words to correctly recognize old words and to reject similar lures, but DA did not affect gist memory parameters of a conjoint recognition (Brainerd et al., 1999) model.

Recent studies have challenged the theoretical assumption that gist representations are less attentional-demanding than specific representations (Greene & Naveh-Benjamin, 2022a, 2022b; Greene et al., 2022). Whereas earlier studies examined the effects of DA on specific and gist representations for item memory, the studies by Greene and Naveh-Benjamin focused on the effects of DA on specific and gist representations for associations between components of an episode (i.e., between a face and a scene, simulating *where* someone had been encountered; Gruppuso et al., 2007), which is a core feature of episodic memory (Tulving, 1983). In their paradigm, participants studied face-scene pairs (e.g., an old woman paired with a classroom) and later discriminated old pairs from highly similar lures (e.g., the old woman with a different classroom), less similar lures (e.g., the old woman with a school cafeteria), and dissimilar/unrelated lures (e.g., the old woman with a park). When young adults encoded the pairs under DA, there were not only the expected deficits in the ability to remember the specific association (e.g., "the old woman was with the first classroom") but also in the ability to remember the gist of the association (e.g., "the old woman was with a classroom"). Moreover, the DA-induced deficits in specific and gist memory were comparable in magnitude, as estimated by a conjoint recognition model.

To summarize, there are currently mixed findings on whether the encoding of specific representations is more attentional-demanding than the encoding of gist representations, with studies of item memory supporting this position and studies of associative memory challenging it. These latter findings may draw into question the suitability of fuzzy-trace theory as a general theory of memory representations because its predictions do not seem to hold up for a core aspect of episodic memory. More broadly, these findings suggest that the encoding of not only specific but also gist episodic memory representations require some commitment of attention, which is opposed to earlier held views that gist representations are encoded automatically (Rabinowitz et al., 1982; cf., McClelland & Rumelhart, 1985).

Critically, studies measuring effects of DA on specific and gist representations have all used concurrent DA tasks with only one difficulty level, such as a widely used (e.g., Greene et al., 2021; Kilb & Naveh-Benjamin, 2007; Naveh-Benjamin et al., 2003, 2014) three-choice auditory reaction time (RT) task (Greene & Naveh-Benjamin, 2022a, 2022b). This limits out understanding of whether *differential* attentional demands are placed on encoding specific versus gist representations, especially for associations between components of an episode, given that deficits in both types of representations emerge under a single difficulty level. A less demanding version of the concurrent task might disrupt specific but not gist representations, which would suggest a gradient of attentional resources for encoding different levels of representation.

Thus, in the present study, we manipulated the difficulty of the concurrent DA task to examine whether, under less demanding DA conditions, deficits in both specific and gist representations would emerge, as they do under highly demanding conditions (Greene & Naveh-Benjamin, 2022a, 2022b), or if DA would differentially disrupt specific but not gist representations. If the latter occurs, this will reinforce and extend support for fuzzy-trace theory's prediction of differential attentional costs of encoding specific and gist representations to associative memory. In contrast, if effects of DA on specific and gist representations both emerge under the same difficulty level, regardless of how attentionally demanding the task is, this will produce stronger evidence refuting an important tenet of fuzzy-trace theory in the context of associative memory, potentially limiting the generality of this leading theory of memory representations. Moreover, findings of equivalent disrupting effects of DA on specific and gist memory under any difficulty level may lead to an alternative conceptualization of the relationship between attention and memory, opposed to earlier established positions that gist representations of an episode are encoded automatically (Rabinowitz et al., 1982) in part because such representations are primitive features of the memory system (McClelland & Rumelhart, 1985). Instead, these findings would indicate that the encoding of gist representations places comparable demands on attention as the encoding of specific representations of an episode.

Method

Transparency and Openness

This study was not preregistered. Scene stimuli are available at https://bradylab.ucsd.edu/. Data and analysis scripts are available at https://osf.io/y8kx6/.

Participants

Two hundred and twelve participants from introductory psychology classes participated in exchange for research credits. Study procedures were approved by the University of Missouri Institutional Review Board. Data from 36 participants were not included in the analyses as 28 participants ($n = 8$, 6, and 14 in the one-tone, two-tone, and three-tone DA conditions, respectively) did not complete the concurrent tone task on >50% of trials, and eight participants (two per condition) left the online experiment running for several days. The final sample size was 176 participants, assigned randomly to the four attention conditions (see Table 1). Most participants in each condition identified their sex as female, and there was no significant difference in the proportion of females between the FA/one-tone DA and two-tone/three-tone DA conditions, $\chi^2(1) = 1.81$, $p = .178$. Most participants in each condition identified their race as White/Caucasian (81.4%–91.11% of participants in each condition; see Table S1 in the online supplemental materials). Details about sample size determination can be found in the online supplemental materials.

Materials and Procedure

The stimuli and basic procedure mirrored those used in prior studies measuring effects of DA on specific and gist representations of episodic associations (Greene & Naveh-Benjamin, 2022a, 2022b; Greene et al., 2022). Face-scene pairs were created by pairing

Table 1
Demographic Statistics

Attention	*n*	Age	Years of education	Female (%), male (%), nonbinary (%)[a]
FA	46	18.84 (1.67)	12.63 (1.25)	63.03, 36.97, 0
One-tone DA	45	18.56 (0.94)	12.54 (1.01)	66.67, 33.33, 0
Two-tone DA	42	18.93 (1.20)	12.89 (1.17)	76.19, 21.43, 2.38
Three-tone DA	43	18.65 (1.15)	12.52 (1.07)	74.42, 23.26, 2.33

Note. Values for age and years of education are mean (*SD*) in years. FA = full attention; DA = divided attention.
[a] Participant sex was assessed with a four-option multiple choice question asking participants to indicate which sex they identified as from the options "female," "male," "nonbinary," or "prefer not to say." No participants chose the fourth option.

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pictures of faces, evenly divided among young and old and male and female faces, from the FACES database (Ebner et al., 2010) with pictures of scenes from a categorized scene pool (Konkle et al., 2010), resulting in 108 pairs. Stimuli for the concurrent DA task were low-pitched (200 Hz), medium-pitched (800 Hz), and high-pitched (1,000 Hz) tones. The experiment was programmed and administered online via PsyToolkit (Stoet, 2010, 2017).

Each of the eight experimental and one practice block was divided into study and test phases (see Figure 1). Each study phase featured 12 unique face-scene pairs (presented sequentially for 4 s each), with six scene categories (half indoor and half outdoor), each with two exemplars (e.g., two parks and two kitchens) that were paired with a different face. Participants were instructed to intentionally learn the face-scene pairs in preparation for a memory test. In the DA conditions, participants were instructed to equally prioritize responding quickly and accurately to the tone task while studying the face-scene pairs. Tones played for 200 ms through computer speakers approximately every 2 s, and participants responded with a key press ("v," "b," or "n" for low-, medium-, or high-pitched tones, respectively). The one-tone DA condition featured a simple RT task, in which participants heard and responded only to medium-pitched tones. The two-tone and three-tone DA conditions featured choice RT tasks, consisting of discriminating low- and high-pitched tones (two-tone condition) or all three tones (three-tone condition). Participants in the DA conditions also completed a baseline phase of the tone task before and after the main experimental phase.

An interpolated activity task involving verifying whether arithmetic problems were solved correctly (e.g., "$3 \times 4 = 12$?") or incorrectly (e.g., "$5 \times 6 = 32$?") occurred for 60 s between the study and test phases. The test phase for each block was untimed and consisted of 12 pairs, divided into four intact, four related, two unrelated-within, and two unrelated-opposite pairs per block. There were no new faces and scenes presented during the test, as the tests were on associative rather than item memory. Intact pairs were identical to studied pairs (e.g., the old woman with the desert in Figure 1). Related pairs, which were highly similar to studied pairs, featured faces repaired with the *other* scene exemplar from the specific scene category with which the faces had originally been paired (e.g., the young man appears with a different dining room at test than at study in Figure 1). Unrelated-within pairs, which were less similar to studied pairs, featured faces repaired with scenes from within the same *broader* indoor or outdoor category as the original scene associated with each face (e.g., the young man, who was paired with a park during the study, appears with a desert scene—a different type of outdoor setting—at test in Figure 1). Unrelated-opposite pairs were dissimilar to studied pairs as they featured faces repaired with scenes from the *opposite* broader indoor or outdoor category as the original scene associated with each face (e.g., the young woman, who appeared with an outdoor desert scene during the study, appears with an indoor lobby scene at test in Figure 1). Participants indicated whether each test pair was "intact," "related," or "unrelated" by selecting one of these labeled options appearing below each pair. They were instructed to respond "intact" to any pair they thought was identical to a pair they studied, to respond "related" to any pair in which a face appeared with the same specific type of scene (e.g., airports) as the original scene associated with that face, and to respond "unrelated" to any other pair. Thus, the correct response for unrelated-within pairs, like unrelated-opposite pairs, was "unrelated," but participants may more often conflate these pairs as being "intact" or "related" if they remember only a fuzzy, imprecise representation of the original pairing (e.g., "the young man had been with a nature setting").

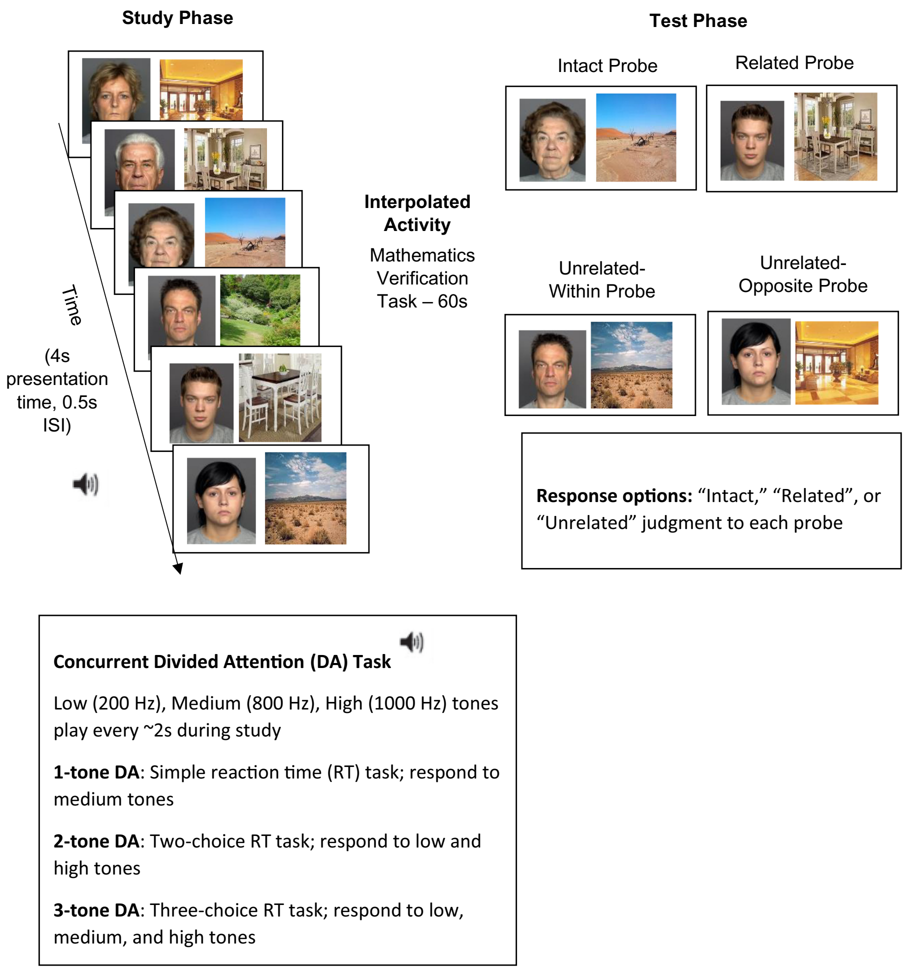
Analyses

Analysis of variance (ANOVA) on proportion correct is reported in the online supplemental material. To test whether there were differential effects of the load of DA on specific and gist memory representations, we used the multinomial-processing-tree (MPT) model depicted in Figure 2, which has been applied previously to data from the associative specificity recognition procedure (Greene & Naveh-Benjamin, 2020, 2022a, 2022b, 2023c).

The model includes parameters indexing the probability of remembering specific representations (V_i and V_r) or gist representations (G_i and G_r) of studied pairs. When gist is retrieved, participants guess whether the test pair is "intact" (probability a) or "related" (probability $1 - a$). Participants may erroneously endorse unrelated-within pairs as being "intact" or "related" if they remember only fuzzy representations (parameter F) of studied pairs (e.g., remembering the young man had been paired with a nature scene but not remembering what type of nature scene). Parameter b indexes the probability that participants will decide, "I do not remember this face being paired with this type of scene, but perhaps I am wrong," and thus guess "intact" or "related." Conversely, with probability $1 - b$, participants respond "unrelated." This is not to say that all correct "unrelated" responses to unrelated-within and unrelated-opposite probes occur due to guessing. Rather, sometimes, when participants think that the face-scene pair presented at test is not a match at a specific or general level of representation to what they studied, they may still guess that the pair *could* be "intact" or "related."

Model parameters were estimated in each attention condition separately under a hierarchical Bayesian estimation routine (see the online

Figure 1
Schematic of Procedure



Note. Each block consisted of a study phase featuring 12 unique face-scene pairs (six depicted for display purposes), a period of interpolated activity spanning 60-s, and a test phase featuring four types of test pairs (see text for details). During the study, participants in the divided attention conditions, but not in the full attention condition, simultaneously completed an auditory RT task, involving either simple RT (one-tone condition), two-choice RT (two-tone condition), or three-choice RT (three-tone condition), as explained in the insert. Faces depicted in the figure are approved for displaying research methodology per Clause 7 of the FACES Platform Release Agreement. RT = reaction time. See the online article for the color version of this figure.

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supplemental materials for technical details) using the TreeBUGS package in R (Heck et al., 2018; R Core Team, 2022). Parameter estimates were compared for each of the DA conditions relative to the FA condition by subtracting the posterior samples of a given parameter estimated under DA (e.g., in the one-tone condition) from the posterior samples of that parameter estimated under FA. If >95% of posterior samples obtained from the subtraction method differed between the two conditions, we concluded that there was credible evidence for an effect of DA on the indicated parameter.

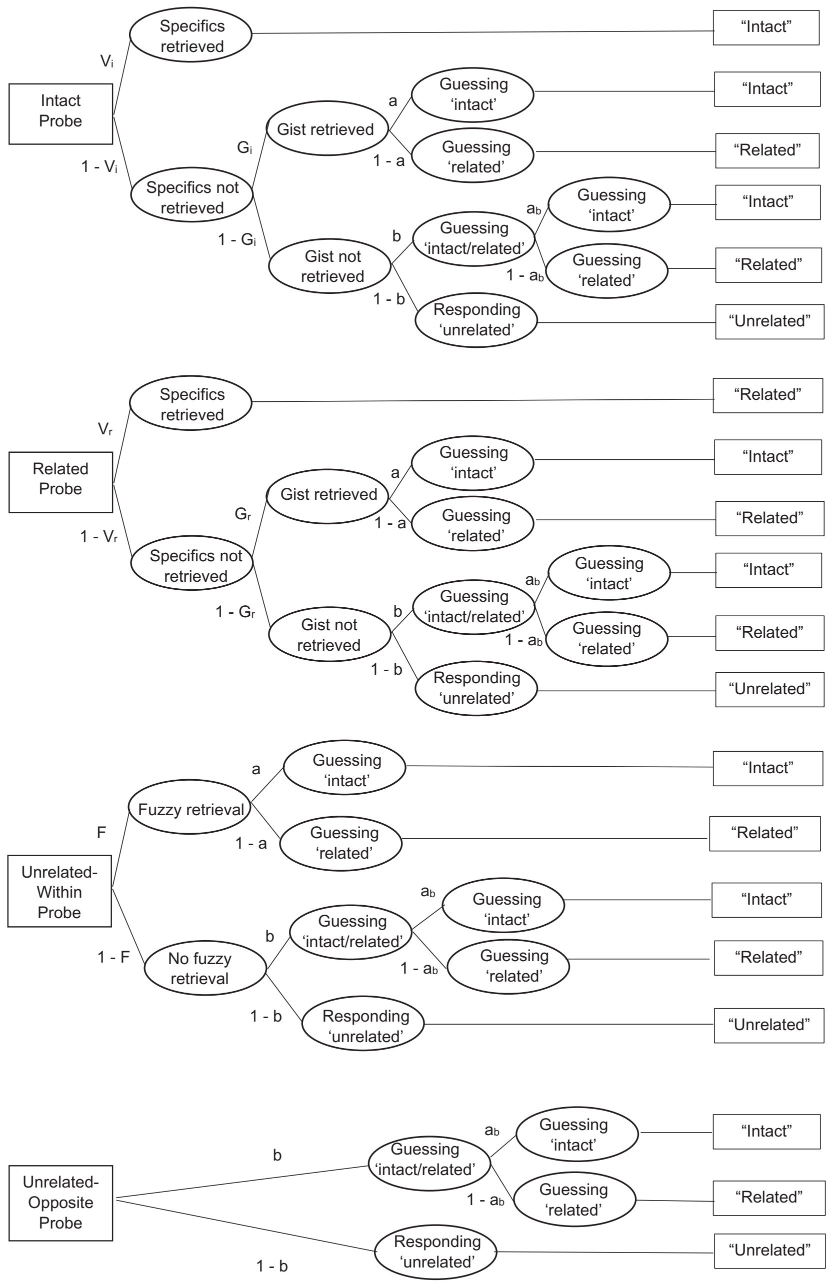
Results

Parameter estimates of the MPT model for each attention condition are listed in Table 2. Figure 3 shows the posterior densities of the model's memory parameters (except for parameters V_r and F, which were near 0 in each condition, so we do not discuss them further here).

Table 3 lists the difference scores of each DA condition relative to FA for each of the memory parameters depicted in Figure 3 (see Table S3 in the online supplemental materials for differences in response bias parameters). There was a striking differential effect of DA on specific and gist memory representations. Effects of DA, relative to FA, on specific representations (parameter V_i) occurred initially under a less difficult load (two-tone DA) than did effects of DA on gist memory (parameter G_r), which only emerged under the most difficult load (three-tone DA). The results obtained by comparing the three-tone DA condition to the FA condition replicate prior studies of the effects of DA on specific and gist memory

Figure 2

Schematic of Simplified Conjoint Recognition Multinomial Processing Tree Model for Estimating Specific and Gist Memory



Note. Simplified conjoint recognition MPT model (Stahl & Klauer, 2008) for estimating the contributions of specific and gist memory. Memory probes (intact, related, and unrelated) are presented as boxes on the left; the presentation of a given memory probe activates cognitive processes, which are depicted in a branch-like structure for each probe, culminating in one of the three possible response options in the boxes on the right. Parameters represent the probability of a given process occurring. Parameters V_i and V_r denote the probability of specific/verbatim retrieval given an intact or a related probe, respectively. Parameters G_i and G_r denote the conditional probability of gist retrieval, when participants fail to retrieve verbatim memory, given an intact or a related probe, respectively. Parameter F corresponds to the probability of retrieving a fuzzier representation when shown an unrelated-Within pair. Parameter a denotes the probability of guessing "intact" rather than "related" when gist memory is retrieved. Parameter a_b denotes the probability of guessing "intact" rather than "related" even when gist memory is not retrieved. Parameter b denotes the probability of responding either "intact" or "related." MPT = multinomial-processing-tree.

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Table 2
Population-Level Parameter Estimates [95% Credible Intervals] of the MPT Model

Parameter	FA	DA one-tone	DA two-tone	DA three-tone
V_i	0.62 [0.52, 0.72]	0.54 [0.46, 0.61]	0.44 [0.32, 0.54]	0.42 [0.29, 0.53]
V_r	0.06 [0.00, 0.17]	0.03 [0.00, 0.10]	0[a]	0.02 [0.00, 0.06]
G_i	0.46 [0.37, 0.54]	0.50 [0.42, 0.57]	0.53 [0.45, 0.60]	0.46 [0.36, 0.55]
G_r	0.71 [0.63, 0.79]	0.64 [0.55, 0.72]	0.64 [0.56, 0.70]	0.58 [0.49, 0.66]
F	0.02 [0.00, 0.05]	0.04 [0.00, 0.09]	0.03 [0.00, 0.09]	0.04 [0.00, 0.10]
A	0.36 [0.30, 0.41]	0.30 [0.26, 0.35]	0.43 [0.36, 0.50]	0.41 [0.36, 0.46]
a_b	b	b	0.28 [0.21, 0.33]	b
B	0.26 [0.19, 0.33]	0.29 [0.24, 0.34]	0.28 [0.23, 0.33]	0.34 [0.27, 0.42]

Note. MPT = multinomial-processing-tree; FA = full attention; DA = divided attention. V_i = probability of specific/verbatim retrieval given an intact probe; V_r = probability of specific/verbatim retrieval given a related probe; G_i = probability of gist retrieval given an intact probe; G_r = probability of gist retrieval given a related probe; F = probability of fuzzy retrieval given an unrelated-within probe. a = probability of guessing "intact" when gist is retrieved. a_b = probability of guessing "intact" in nongist retrieval states; b = probability of responding "intact/related" when there is no verbatim or gist information.
[a] V_r was constrained to 0 in the two-tone DA condition due to initial model misfit (see the online supplemental materials for details). [b] Parameters a and a_b were set to equality in the FA, one-tone DA, and three-tone DA conditions due to initial model misfit (see the online supplemental materials).

representations, which showed deficits in both V_i and G_r but not in G_i (Greene & Naveh-Benjamin, 2022a, 2022b).[1]

Finally, we measured differences in RT and accuracy on the secondary task across the levels of DA (see Table S4 in the online supplemental materials). RT increased with increasing number of tones to be discriminated, and under baseline, there were decreases in response accuracy for the three-tone relative to the two-tone condition. Thus, as the number of tones to be discriminated increased, performance on the concurrent task decreased.

Discussion

The present study provides the strongest evidence to date that more attention is needed to encode specific than gist representations of an episode, supporting a key principle of fuzzy-trace theory (Brainerd & Reyna, 1990). However, in contrast to earlier held views that gist representations are encoded automatically (Rabinowitz et al., 1982), some, albeit smaller, commitment of attention is also necessary to encode gist representations. Although earlier studies with young adults showed effects of DA at encoding on specific but not gist representations of items (Odegard & Lampinen, 2005; Rabinowitz et al., 1982), those studies did not focus on a core aspect of episodic memory—the associative binding of components of an episode which is essential to episodic memory (Tulving, 1983). Recent associative recognition studies that have used a difficult three-choice secondary task have found equivalent disrupting effects of DA on specific and gist representations (Greene & Naveh-Benjamin, 2022a, 2022b; Greene et al., 2022).

Building on these earlier studies (all of which used concurrent DA tasks with only one difficulty level), our manipulation of the difficulty of the concurrent DA task showed that, under the lightest load (one-tone simple RT), there were no disrupting effects on specific or gist representations. Under intermediate loads of DA (two-tone choice RT), deficits in specific but not gist memory emerged. Only under the highest load of DA (three-tone choice RT) did deficits in gist memory also emerge. These results show disrupting effects on specific representations emerge under lighter attentional loads of the secondary task than those on which gist representations are disrupted. Future studies may consider also manipulating the emphasis on encoding specific or gist representations on the primary task, though the use of an intentional learning paradigm with conjoint recognition tests in the present study likely encouraged participants to attempt to encode both types of representation, which was made more difficult as the attentional demands of the concurrent DA task increased.

Implications of these findings include that they provide indirect yet important evidence in favor of depleted attentional resource theories of cognitive aging (Craik & Byrd, 1982), which attribute adult age-related memory deficits to general decline in attention (e.g., Hasher & Zacks, 1988; Light & Anderson, 1985). Aging is associated with diminished specific but not gist episodic memory representations (Greene & Naveh-Benjamin, 2020, 2023a). Earlier results of DA with young adults (an attempt to simulate depleted attentional resources) did not perfectly match these age-related deficits (Greene & Naveh-Benjamin, 2022a, 2022b), but the present study provides a clearer picture: Specific representations require more attentional resources to encode, but gist representations also require some. Older adults may allocate most of their limited attentional resources to encoding gist representations.

Moreover, findings of the present study speak to the attentional demands of encoding specific and gist representations for visual associations of face-scene pairs, simulating an important hallmark of episodic memory: The ability to remember where a person was previously encountered (Gruppuso et al., 2007). These findings may have implications for eyewitness memory, which often involves remembering who was where, by showing that under stress of witnessing a crime, the amount of attention left for an individual to devote to encoding could influence their ability to remember not only

[1] DA disrupts the type of representation that a given memory probe most strongly elicits (specific representations for intact probes, gist representations for related probes). Although both gist parameters are *conditionally* reached only when specific representations are not retrieved (see Figure 2), the probability of first retrieving specific representations is much reduced for related than intact probes, so the probability that individuals must rely on gist rather than specific representations is much greater for related than intact probes.

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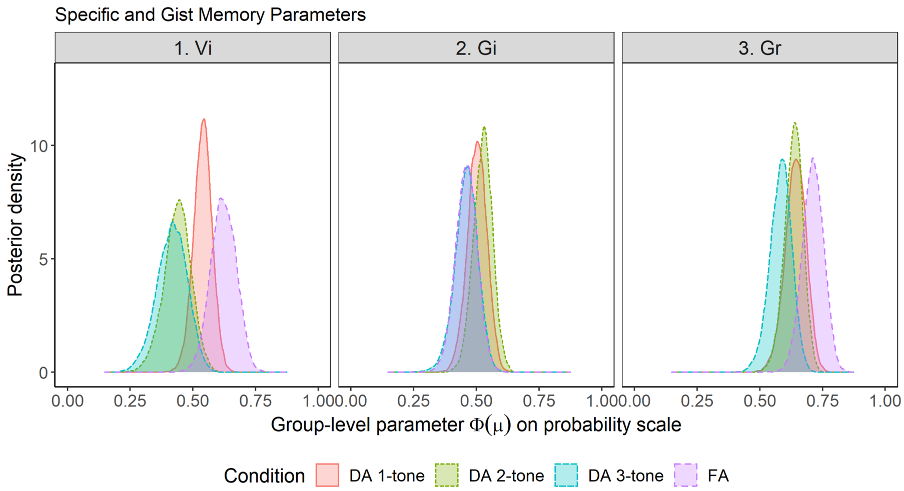
Figure 3

Posterior Densities of the Specific and Gist Memory Parameters in Each Attention Condition



Note. Posterior densities represent the most probable value and degree of uncertainty (95% credible interval) in each parameter. Densities that are more peaked convey less uncertainty in the true value of a given parameter. The degree of overlap between distributions from different conditions can be quantified (see text for details) to determine whether there were credible differences in > 95% of posterior samples. Only memory parameters V_i (probability of specific retrieval when shown an intact pair), G_i (probability of gist retrieval when shown an intact pair), and G_r (probability of gist retrieval when shown a related pair) are depicted, as estimates of the remaining memory parameters (V_r and F) were near 0 (see Table 2). DA = divided attention; FA = full attention. See the online article for the color version of this figure.

specifically but also in general where they saw someone before. The extent to which these findings would generalize to other types of memories, such as memories for narratives for which encoding the gist rather than specifics is more important for comprehension (van Dijk & Kintsch, 1983), remains to be determined in future studies.

Finally, results of the present study may be informative to understanding how specific and gist representations are encoded (cf., Greene & Naveh-Benjamin, 2023c), be it in a parallel fashion (as predicted by fuzzy-trace theory; Brainerd & Reyna, 1990) or in a serial fashion (as predicted by verbatim-gist serial dependency models; van Dijk & Kintsch, 1983). Given that specific representations were more vulnerable to disruption from DA under lighter loads than gist representations were, these findings seem more aligned with the parallel than serial assumptions. Under the serial model, disrupting effects on encoding of specific representations would be expected to result in potentially *greater* disrupting effects on later-established gist representations.

Table 3

Difference Scores for the Specific and Gist Parameters Obtained From Subtracting Posterior Samples of the DA Conditions From the FA Condition

Parameter	FA–DA one-tone	FA–DA two-tone	FA–DA three-tone
V_i	0.08 [−0.04, 0.20]	**0.18 [0.05, 0.33]**	**0.21 [0.05, 0.37]**
G_i	−0.04 [−0.16, 0.07]	−0.07 [−0.18, 0.05]	0.00 [−0.12, 0.13]
G_r	0.07 [−0.05, 0.19]	0.08 [−0.03, 0.19]	**0.13 [0.01, 0.25]**

Note. Difference scores were obtained by subtracting posterior samples of each DA condition from the FA condition. Bolded difference scores correspond to a credible difference between FA and DA in >95% of posterior samples. DA = divided attention; FA = full attention; V_i = probability of specific/verbatim retrieval given an Intact probe; G_i = probability of gist retrieval given an Intact probe; G_r = probability of gist retrieval given a Related probe.

Constraints on Generality

It is important to keep in mind that our study was conducted with college students and thus results may not generalize to individuals with more limited memory capabilities, like older adults. In addition, although the present study informs our understanding of the attentional demands to encode face-scene memory, future work will be needed to determine whether these results generalize to other types of complex episodic associations, such as person-action memory (i.e., who did what).

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