modified source procedure of Kirwan *et al.* [6] and Wais *et al.* [7] because source memory is neither necessary nor sufficient for recollection, so the presence of recollection cannot be reliably determined. Therefore, a safe interpretation of these results is not possible. However, if the most confident level of familiarity supports recognition as accurately as that supported by recollection and making the two kinds of judgement is equally rapid, then the strength confound has been avoided. We have argued [3] that in the only published study in which this has been done successfully [8], we found that recollection activated the hippocampus significantly more than strength-matched scene familiarity, whereas familiarity of different strengths modulated perirhinal cortex activity but had no differential effect on the hippocampus. The only plausible explanation of this finding is that the hippocampus selectively mediates recollection, so it is incorrect to claim that nearly all studies controlling for the strength confound indicate that the hippocampus mediates familiarity as well as recollection. However, it remains to be explored to what extent this selectivity is stimulus-dependent.

References

1 Wixted, J.T. and Squire, L.R. (2011) The medial temporal lobe and the attributes of memory. *Trends Cogn. Sci.* 15, 210–217
2 Murray, E.A. and Wise, S.P. (2004) What, if anything, is the medial temporal lobe, and how can the amygdala be part of it if there is no such thing? *Neurobiol. Learn. Mem.* 82, 178–198
3 Montaldi, D. and Mayes, A.R. (2010) The role of recollection and familiarity in the functional differentiation of the medial temporal lobes. *Hippocampus* 20, 1291–1314
4 Norman, K.A. and O'Reilly, R.C. (2003) Modeling hippocampal and neocortical contributions to recognition memory: a complementary learning systems approach. *Psychol. Rev.* 104, 611–646
5 Song, Z. *et al.* (2011) Impaired capacity for familiarity after hippocampal damage. *Proc. Natl. Acad. Sci. U.S.A.* 108, 9655–9660
6 Kirwan, C.B. *et al.* (2008) Activity in the medial temporal lobe predicts memory strength, whereas activity in the pre-frontal cortex predicts recollection. *J. Neurosci.* 28, 10541–10548
7 Wais, P.E. *et al.* (2010) In search of recollection and familiarity signals in the hippocampus. *J. Cogn. Neurosci.* 22, 109–123
8 Montaldi, D. *et al.* (2006) The neural system that mediates familiarity memory. *Hippocampus* 16, 504–520

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Letters Response

The familiarity/recollection distinction does not illuminate medial temporal lobe function: response to Montaldi and Mayes

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Montaldi and Mayes [1] write that the distinction between recollection and familiarity is critical for understanding medial temporal lobe function. They begin by suggesting that the hippocampus has a role in pattern completion. We agree. However, they link pattern completion to recollection, which overlooks the possibility that familiarity might also depend on pattern completion. Furthermore, even if one assumes that pattern completion implies recollection, the idea that the hippocampus supports pattern completion does not imply that it cannot also support other memory processes.

Whether familiarity involves pattern completion or not, when strong recollection is compared to equally strong familiarity, much evidence suggests that the hippocampus supports both processes [2–6]. Montaldi and Mayes [1] disagree. In their view our source memory studies that eliminate the memory strength confound [2–4] are not compelling because source memory procedures have limitations. However, source memory studies that do not control for memory strength have often been cited in support of the idea that the hippocampus selectively subserves recollection, even by these authors [7]. We simply eliminated the strength confound and then used the same logic for interpretation that one finds in many earlier studies. The main limitation of the source memory procedure is that even when a particular source question is answered incorrectly (suggesting a failure of recollection) it is possible that some task-irrelevant source recollection has occurred. All methods of measuring recollection and familiarity have inherent limitations, and converging methods must be used. The strength confound has been a limitation of many of these methods, and this particular limitation can and should be corrected.

Montaldi and Mayes [1] would also disqualify from consideration our recent studies with amnesic patients that eliminated the strength confound [4,5] because those patients are already known to have a familiarity deficit. In their view, nothing new can be learned from these patients, and discussion should now be limited to other hippocampal patients who are thought to have preserved familiarity. This is a puzzling proposal. If we already know which hippocampal patients have preserved familiarity and which

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do not (usually based on methods that involve a strength confound), then no further testing of any patients would be needed. One reason for apparent discrepancies in the literature might be that the methods used previously to assess recollection and familiarity were often flawed. As novel methods of assessing recollection and familiarity are developed, every relevant patient should be tested and conclusions should be based on the evidence from all patients.

Finally, Montaldi and Mayes [7] attempted to equate for memory strength in one Remember/Know study and reported that hippocampal activity was elevated only for recollection-based decisions. Their results, as originally reported [7], actually demonstrated the typical strength confound between remembering and knowing in that accuracy was not equated (see [8]). A later reanalysis of the behavioral data in a review article suggested that accuracy was equated after all [9]. The difficulty is that the functional magnetic resonance imaging analysis [7], which compared strong recollection to strong familiarity, was problematic. First, no minimum cluster size was used. Second, two small hippocampal clusters (one containing 2 voxels and the other containing 6 voxels) were identified but only when a more lenient threshold was used than was used for all the other data analyses [7]. Third, and inconsistent with current standards, no correction for multiple comparisons was used. Although the results of this particular study are unconvincing, controlling for memory strength using the Remember/Know procedure is a rare and much-needed experimental approach [8]. We recommend that more studies be carried out using this strategy. Setting aside the finding reported by Montaldi and Mayes [7], we cannot identify a single study that matched for memory strength and did not find that the hippocampus supports both recollection and familiarity ([2–6]; see also [10]).

References

1 Montaldi, D. and Mayes, A.R. (2011) Familiarity, recollection and medial temporal lobe function: an unresolved issue. *Trends Cogn. Sci.* 15, 339–340
2 Wais, P.E. *et al.* (2010) In search of recollection and familiarity in the hippocampus. *J. Cogn. Neurosci.* 22, 109–123
3 Kirwan, C.B. *et al.* (2008) Activity in the medial temporal lobe predicts memory strength, whereas activity in the prefrontal cortex predicts recollection. *J. Neurosci.* 28, 10541–10548
4 Kirwan, C.B. *et al.* (2010) A demonstration that the hippocampus supports both recollection and familiarity. *Proc. Natl. Acad. Sci. U.S.A.* 107, 344–348
5 Song, Z. *et al.* (2011) Impaired capacity for familiarity after hippocampal damage. *Proc. Natl. Acad. Sci. U.S.A.* 108, 9655–9660
6 Wais, P. (2011) Hippocampal signals for strong memory when associative memory is available and when it is not. *Hippocampus* 21, 9–21
7 Montaldi, D. and Mayes, A.R. (2006) The neural system that mediates familiarity memory. *Hippocampus* 16, 504–520
8 Wixted, J.T. *et al.* (2010) Measuring recollection and familiarity in the medial temporal lobe. *Hippocampus* 20, 1195–1205
9 Montaldi, D. and Mayes, A.R. (2010) The role of recollection and familiarity in the functional differentiation of the medial temporal lobes. *Hippocampus* 20, 1291–1314
10 de Zubicaray, G. *et al.* (2011) Memory strength effects in fMRI studies: a matter of confidence. *J. Cogn. Neurosci.* 23, 2324–2335

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Book Review

Thinking about possibilities

Lines of Thought: Central Concepts in Cognitive Psychology by Lance J. Rips, Oxford University Press, 2011. $69.95 (Hardback, 480 pages) ISBN13: 9780195183054, ISBN10: 0195183053

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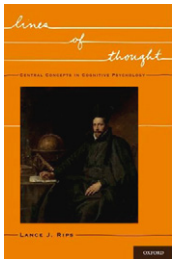

Some of the most striking findings in science are those that upend common wisdom: the Earth is not flat, the Sun does not revolve around the Earth, and heavier objects do not fall faster than lighter objects. In *Lines of Thought*, Lance Rips challenges a bedrock assumption in cognitive science, namely, that cognition is built up from perception. Psychologists often assume that perceptual information is the foundation for thought: prior sensory and perceptual experiences are the primitives out of which people form concepts, categorize the world around them, understand sentences and draw logical inferences. This empiricist perspective has had a resurgence in recent years [1–3], in part due to the discovery that humans are astonishingly sensitive to subtle patterns and structure in experience [4].

By contrast, Rips argues that human thought cannot be derived from empirical experiences alone. He observes that much of how we think entails 'modal cognition', that is: 'what *might* or *must* be true – not just about what is actually true' (p. vii). In a probing analysis of concepts of individual identity, numbers, causation, categories and reasoning, *Lines of Thought* provides compelling evidence that modal cognition is not merely a frill but is deeply implicated in every aspect of thought. Mathematical principles concern inherently abstract entities (numbers and sets) that have no instantiation in the physical world. Causal relations apply not only to physical objects, such as billiards and gears, but also to mental states, sound waves and light beams. Generic statements, such as 'dogs are four-legged', abound despite the fact that we cannot experience the abstract set of 'dogs' (past, present, future and hypothetical) [5,6]. Direct perception therefore falls short when it comes to representing numbers, causes or kinds.