

awareness have on their later ability to recall it? People confront this situation all the time, whether one's goal is to simply avoid a mildly distracting thought, or to prevent oneself from being overwhelmed by unpleasant reminders. That people engage in such behavior is self-evident, but its consequences for episodic memory are not. What our work shows is that with time, and repeated effort, trying to keep an unwanted memory out of awareness does under some circumstances render that memory less accessible, even when people want to recall it. These findings have clear relevance to motivated forgetting.

Kihlstrom's letter also questions the potency of the suppression effect reported in the *Nature* article. Kihlstrom notes that after many suppression attempts, subjects could still recall many of the word pairs, suggesting that suppression was not very effective. This observation is misleading. Although subjects attempted to suppress items as many as 16 times, each attempt lasted only 4 seconds, with the total time spent suppressing an item barely exceeding one minute. That after such a brief interval, subjects were up to 10% worse at recalling the memories suggests a very effective process. Furthermore, the tendency reported in the article was for suppression to increase with repetitions. In naturalistic cases of memory avoidance, people are likely to persist in suppressing unwanted memories for more protracted periods than we tested in our study. Thus, there is ample reason to suspect that suppression can be effective with sustained effort.

However, it is also important to highlight what the work does not establish. We agree with Kihlstrom on several points. First, our work does not demonstrate unconscious repression. Those clinicians who believe in the instantaneous and automatic thrusting of traumatic memories into the unconscious will find little support in our work. Indeed, we suspect that most cases of motivated forgetting arise from persisting attempts to control awareness strategically. Second, our work does not yet establish whether inhibitory control processes are effective for emotionally charged memories. Undoubtedly, emotionally charged memories will be more intrusive and more difficult to suppress. Nevertheless, we suspect that emotional and neutral memories differ primarily in their degrees of intrusiveness, and that with time and persistence even emotional memories may be subject to suppression.

Some will disagree with the above conjectures. Such disagreement is reasonable, and we would like to encourage the field to pursue these questions empirically. What seems less useful is to classify repression as a myth and to discourage scientists from careful inquiry into its properties. Whether the processes reported in [5] and reviewed in [1] account for real cases of motivated forgetting is ultimately an empirical question that seems quite worthwhile to pursue.

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References

- 1 Levy, B.L. and Anderson, M.C. (2002) Inhibitory processes and the control of memory retrieval. *Trends Cogn. Sci.* 6, 299–305
- 2 Kihlstrom, J.F. (2002) No need for repression. *Trends Cogn. Sci.* 6, 502
- 3 Erdelyi, M.H. (1990) Repression, reconstruction, and defense: history and integration of the psychoanalytic and experimental frameworks. In *Repression and Dissociation: Implications for Personality Theory, Psychopathology, and Health* (Singer, J.L., ed.), pp. 1–31, University of Chicago Press
- 4 Erdelyi, M.H. (2001) Defense processes can be conscious or unconscious. *Am. Psychol.* 56, 761–762
- 5 Anderson, M.C. and Green, (2001) Suppressing unwanted memories by executive control. *Nature* 410, 131–134

Frames of reference and language concepts

The claim that language affects thought – the 'Whorfian Hypothesis' – has a long history, and over the years has elicited strong support as well as fierce criticism. Gallistel [1] reviewed some recent studies that tested the Whorfian hypothesis in the spatial domain, that is, whether differences in spatial language affected non-linguistic conceptualization of space.

Languages differ in the frames of reference used for describing spatial locations. Three distinct frames of reference have been identified: intrinsic, absolute and relative [2]. Some languages only use one of these, whereas others might use a combination of two, or even all three. Pederson *et al.* conducted a series of experiments demonstrating that speakers of a relative-frame language differed in

their performance in a memory task from speakers of an absolute-frame language [3]. When asked to recall and reproduce a display of toy animals, relative-frame speakers reproduced the display consistent with a relative frame of reference, whereas absolute speakers reproduced it in an absolute frame. This result is consistent with the Whorfian hypothesis. However, in a recent study, Li and Gleitman [4] argued that there was a confound in the Pederson *et al.* study. Li and Gleitman claimed that the difference in recall between the different language groups was due to the conditions in which the groups were tested: indoors versus outdoors. They presented empirical evidence that appeared to show that the differences Pederson *et al.*, reported were due to environmental features rather than differences between the languages.

However, since Gallistel's report, Levinson *et al.* [5] have published an article that refutes Li and Gleitman's claims. First, they show that across the language groups that Pederson *et al.* tested there was no confounding of test location: speakers behaved in accordance with the frame of reference of their language, regardless of whether they were tested indoors or outdoors. This is counter to the claims of Li and Gleitman. Secondly, they show that Li and Gleitman confounded absolute and intrinsic frames of reference in the experiments that they themselves conducted. When Levinson *et al.* made the appropriate distinction between these two frames of reference, and tested Dutch speakers, they found that Dutch speakers only ever responded in a way that was consistent with the way their language codes space. No environmental manipulation made Dutch speakers change to an absolute coding of space. Again, this is counter to the evidence presented by Li and Gleitman.

Gallistel wrote that all human beings perceive space in the same way and neurally encode space in the same way; furthermore, he stated that the brain has to encode spatial relations in several different coordinate frameworks. Given these facts, he asked how Whorfian effects would be instantiated in the brain. There are two important points to note about this.

First, neither Pederson *et al.* nor Levinson *et al.* make any claims about the *perceptual* abilities of different language groups; their claims are about *conceptual* representations. The claim is that the habitual use of particular linguistic

concepts modifies non-linguistic concepts. This is not such a surprising claim. Numerous studies in categorization have shown that experts have different underlying representations of their domain of expertise than novices – be it reading chest x-rays [6], sexing chickens [7], or categorizing musical instruments [8]. Experts use more subtle and differentiated features within their expert domain [9]. Nobody claims that experts *could not* categorize using the features that novices use – it is just that they *do not*. In the same way, if we conceive of language as a way of categorizing the world, then what Levinson *et al.* have shown is that languages differ in the way that they categorize the spatial domain. They do not claim that speakers could not use other ways of categorizing space; it is just that, habitually, they do not.

Second, Gallistel wrote that all brains encode spatial relations in the same way: this is because humans share common sensory and perceptual apparatus. In the same way, novices and experts share the same sensory and perceptual apparatus, and yet when the two groups view identical stimuli there are differences in the brain regions activated [10]. How are spatial concepts represented in the brain? We have yet to establish which brain regions are involved in the conceptual representations of intrinsic, relative and absolute frames of reference. It is a step further still, to show how neuronal representations differ, or are similar, between speakers with different frames of reference.

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References

- Gallistel, C.R. (2002) Language and spatial frames of reference in mind and brain. *Trends Cogn. Sci.* 6, 321–322
- Levinson, S.C. (1996) Language and space. *Annu. Rev. Anthropol.* 25, 353–382
- Pederson, E. *et al.* (1998) Semantic typology and spatial conceptualization. *Language* 74, 557–589
- Li, P. and Gleitman, L. (2002) Turning the tables: language and spatial reasoning. *Cognition* 83, 265–294
- Levinson, S.C. *et al.* (2002) Returning the tables: language affects spatial reasoning. *Cognition* 84, 155–188
- Christensen, E.E. *et al.* (1981) The effect of search time on perception. *Radiology* 138, 361–365
- Biederman, I. and Shiffrar, M.M. (1987) Sexing day-old chicks: a case study and expert systems analysis of a difficult perceptual-learning task. *J. Exp. Psychol. Learn. Mem. Cogn.* 13, 640–645
- Palmer, C.F. *et al.* (1989) How is a trumpet known? The 'basic object level' concept and the perception of musical instruments. *Am. J. Psychol.* 102, 17–37
- Johnson, K.E. and Mervis, C.B. (1997) Effects of varying levels of expertise on the basic level of categorization. *J. Exp. Psychol. Gen.* 126, 248–277
- Gauthier, I. *et al.* (2000) Expertise for cars and birds recruits brain areas involved in face recognition. *Nat. Neurosci.* 3, 191–197

Conception, perception and the control of action

Reply to Majid

The difference between conception and perception is murky. When I perceive an object to lie to the right of the sagittal plane of my head, do I necessarily conceive it to occupy that position in that frame of reference? Is it possible that I perceive it in that frame but conceive of it in another frame? The answer depends on what one understands concepts to be and how one imagines that they relate to percepts. That is murky and contentious ground. Somewhat less murky and contentious are the following questions:

- (1) Do different spatial frames of reference govern our actions under different (non-linguistic) circumstances?
- (2) Can the frequency with which a given frame of reference is invoked in our daily language determine which frame of reference we base our actions on, in some circumstances?
- (3) Are any such effects greater than the effects of the general usefulness of a given frame of reference where one happens to be acting?
- (4) Which way does causality flow? For example, do people living mostly outdoors on the side of a hill orient objects with respect to the hill because they so often refer to its slope in their everyday speech? Or do they so often refer to its slope because it is so often the relevant frame for their actions, including the actions of placing polarized (orientable) objects like hoes and rakes?

It seems likely that the answer to (2) is yes. However, I take the answer to (1) to be yes, also, and that is what Li and Gleitman demonstrated [1]. Different frames of reference govern the actions of ourselves *and* non-linguistic animals under different circumstances. That seems clear and certain. It would take more than another experiment to convince me that Dutch mariners are so conceptually imprisoned by their frequent use of egocentric spatial locutions that they cannot orient their ship in an absolute frame of reference. In short, the claim by Majid [2] that 'no environmental manipulation made Dutch speakers change to an absolute coding of space' cannot be taken to imply that no environmental manipulation *could* make them do so.

The well-established fact that non-linguistic circumstances can determine the frame of reference that governs animal and human actions suggests non-Whorfian answers to questions (3) and (4). It also makes me skeptical of the empirical validity of the claim that 'some languages use only one of these [frames of reference].' [2]. If English or Dutch speakers only ever used an egocentric frame of reference, then we should have to rename the East River 'The River In Front of You When You Stand on Manhattan Facing Brooklyn.' Before I believe that Tzeltal speakers use *only* absolute spatial terms (and, moreover, do not distinguish the two ends of the transverse axis), I want to read transcripts of Tzeltal travelers phoning home to tell their mothers which leg they have broken. If, as I believe, there are words or simple locutions in every language for every spatial frame of reference relevant to the daily actions of its speakers, then the direction-of-causality question becomes central. Mariners the world over, whatever their native language, talk and act in accordance with a ship-based frame of reference (fore–aft, starboard–port), but the rest of us do not. Such is the power of circumstance.

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References

- Li, P.W. and Gleitman, L.R. (2002) Turning the tables: language and spatial reasoning. *Cognition* 83, 265–294
- Majid, A. (2002) Frames of reference and language concepts. *Trends Cogn. Sci.* 6, 503–504