Correspondence: Dr Grabli, Groupe hospitalier Pitié-Salpêtrière, 47 Boulevard de l'Hôpital, Paris 75013, France (david.grabli@psl.aphp.fr).
Financial Disclosure: None reported.

1. Vidailhet M, Vercueil L, Houeto JL, et al; French Stimulation du Pallidum Interne dans la Dystonie (SPIDY) Study Group. Bilateral deep-brain stimulation of the globus pallidus in primary generalized dystonia. *N Engl J Med*. 2005; 352(5):459-467.
2. Vidailhet M, Yelnik J, Lagrange C, et al; French SPIDY-2 Study Group. Bilateral pallidal deep brain stimulation for the treatment of patients with dystonia-choreoathetosis cerebral palsy: a prospective pilot study. *Lancet Neurol*. 2009; 8(8):709-717.
3. Kupsch A, Benecke R, Müller J, et al; Deep-Brain Stimulation for Dystonia Study Group. Pallidal deep-brain stimulation in primary generalized or segmental dystonia. *N Engl J Med*. 2006;355(19):1978-1990.
4. Foncke EM, Cath D, Zwinderman K, Smit J, Schmand B, Tijssen M. Is psychopathology part of the phenotypic spectrum of myoclonus-dystonia? a study of a large Dutch M-D family. *Cogn Behav Neurol*. 2009;22(2):127-133.

Music and Semantic Dementia

The recent study by Weinstein and colleagues[1] provides further evidence that semantic memory for music may be relatively spared in semantic dementia (SemD). This issue is both clinically and neurobiologically relevant. Music may be a potential island of meaning in the increasingly meaningless world inhabited by patients with SemD. More fundamentally, the apparent sparing of music knowledge despite a "pan-modal" breakdown of sensory and conceptual knowledge is likely to hold a clue to the nature of the core deficit underpinning SemD.

We have presented evidence[2] that knowledge of melodies and musical notation may be spared in SemD, whereas knowledge of musical instruments and emotions is affected comparably with other knowledge categories. These findings support the interpretation offered by Weinstein and colleagues[1] that it appears to be the more abstract aspects of music that are relatively resistant to the disintegration of semantic memory in SemD. More specifically, musical compositions (like mathematical formulae, but unlike words and objects) have an intrinsic meaning that does not depend on associations with other objects in the world at large. Semantic dementia may target brain systems that support world-based knowledge systems while sparing other kinds of symbolic knowledge. The brain substrates that support semantic memory for music remain to be defined. The distinctive properties of music need not rest entirely with its abstract nature; music is generally emotionally engaging, and it remains unclear how far emotional content may interact with (or facilitate) semantic processing.

Although an understanding of music is universal among human societies, musical competence is highly variable, and this creates an important practical problem for the clinical and neuroscientific study of music. Musical semantic memory is usually studied in individuals with musical training, and conclusions based on cases of specialized knowledge are necessarily qualified. There is only a single case study demonstrating preserved musical semantic memory in a musically untrained individual with SemD.[3] Substantiation of these intriguing observations in the wider population of patients with SemD will be an important direction for future work.

Jason D. Warren, PhD, FRACP
Julia C. Hailstone, BA(Hons)
Rohani Omar, MA, MRCP

Author Affiliations: Dementia Research Centre, Institute of Neurology, University College London, London, England.
Correspondence: Dr Warren, Dementia Research Centre, Institute of Neurology, University College London, Queen Square, London WC1N 3BG, England (jwarren@drc.ion.ucl.ac.uk).
Financial Disclosure: None reported.

1. Weinstein J, Koenig P, Gunawardena D, McMillan C, Bonner M, Grossman M. Preserved musical semantic memory in semantic dementia. *Arch Neurol*. 2011;68(2):248-250.
2. Omar R, Hailstone JC, Warren JE, Crutch SJ, Warren JD. The cognitive organization of music knowledge: a clinical analysis. *Brain*. 2010;133(pt 4): 1200-1213.
3. Hailstone JC, Omar R, Warren JD. Relatively preserved knowledge of music in semantic dementia. *J Neurol Neurosurg Psychiatry*. 2009;80(7):808-809.

In reply

We thank Warren and colleagues for their insightful comments on the long-term representation of meaningful knowledge about music, objects, and quantities. We described a dissociation between object knowledge and knowledge of music meaning in a patient with SemD.[1] In an attempt to use our observation to support a unifying characterization of the deficit in SemD, Warren et al forward the intriguing hypothesis that object knowledge is compromised in SemD because it depends on representations in the world, while formal music knowledge and number knowledge may be relatively preserved in SemD because these are self-contained semantic systems independent of world knowledge. This hypothesis may help explain the dissociation of music melody and notation from musical instruments and musically mediated emotion that Warren and colleagues recently observed.[2] We described a double dissociation in SemD and corticobasal syndrome several years ago that may be interpreted as consistent with Warren's hypothesis; patients with SemD were relatively impaired on a measures of object knowledge, while patients with corticobasal syndrome were relatively impaired in number knowledge.[3]

It is appealing to strive for a unifying theme that characterizes the remarkable deficit seen in SemD, and we agree with Warren that, to some degree, patients with SemD have a relatively greater deficit for concepts strongly grounded in the world relative to knowledge of more abstract concepts. This interpretation is consistent with findings by several investigators of a "reversal of the concreteness effect" in some patients with SemD, whereby patients show the reverse of the universally observed finding that abstract words and concepts tend to be more difficult than concrete words and concepts.[4] This hypothesis also may be consistent with SemD patients' relatively preserved knowledge of other "abstract" domains, including function words, syntax, numbers, and music. However, the "world-based knowledge systems" hypothesis may require additional clarification given that many of these more abstract forms of knowledge maintain some degree of grounding in the world. Numerosity may be a self-contained system of knowledge, but quantity has meaning in the real world in

Downloaded from www.archneurol.com at University of Pennsylvania, on August 8, 2011
©2011 American Medical Association. All rights reserved.

so far as it refers to the quantity or magnitude of a set of objects. Within the domain of music, there is debate about the essence of musical meaning. Some assert that meaning in music emerges directly from its ability to reflect emotions. Others argue that music meaning is related in part to the formal structure of music.[5] *Even abstract concepts derive their meanings in part from world-based information.*

The account of SemD that we prefer focuses on the neuroanatomic distribution of disease. Here, the ventral and inferolateral distribution of anterior temporal disease seen early in the course of SemD appears to preferentially degrade visual association cortex. This area may store the representations of visual-perceptual features that play a crucial role in object knowledge. This is consistent with several studies directly relating visually mediated object knowledge to atrophy of anterior and ventral temporal regions.[4,6] *In contrast, the essential knowledge that underlies meaning within the domains of music and number appears to be represented elsewhere in the brain.*

Murray Grossman, MD, EdD
Michael F. Bonner, BS
Jessica Weinstein, BA

Author Affiliations: Department of Neurology, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania.
Correspondence: Dr Grossman, Department of Neurology, Hospital of the University of Pennsylvania, 3400 Spruce St, 2 Gibson, Philadelphia, PA 19104-4283 (mgrossma@mail.med.upenn.edu).
Financial Disclosure: None reported.

1. Weinstein J, Koenig P, Gunawardena D, McMillan C, Bonner M, Grossman M. Preserved musical semantic memory in semantic dementia. *Arch Neurol*. 2011; 68(2):248-250.
2. Omar R, Hailstone JC, Warren JE, Crutch SJ, Warren JD. The cognitive organization of music knowledge: a clinical analysis. *Brain*. 2010;133(pt 4): 1200-1213.
3. Halpern CH, Glosser G, Clark R, et al. Dissociation of numbers and objects in corticobasal degeneration and semantic dementia. *Neurology*. 2004;62 (7):1163-1169.
4. Bonner MF, Vesely L, Price C, et al. Reversal of the concreteness effect in semantic dementia. *Cogn Neuropsychol*. 2009;26(6):568-579.
5. Koelsch S. Neural substrates of processing syntax and semantics in music. *Curr Opin Neurobiol*. 2005;15(2):207-212.
6. Mion M, Patterson K, Acosta-Cabronero J, et al. What the left and right anterior fusiform gyri tell us about semantic memory. *Brain*. 2010;133(11): 3256-3268.

Atrophy After Traumatic Axonal Injury

We read with great interest the recent article by Warner et al[1] in which the authors analyzed the spatial distribution of cortical and subcortical volume loss in patients with diffuse traumatic axonal injury and assessed the relationship between regional atrophy and functional outcome. The authors reported that decreases in volume were seen in several brain regions including the amygdala, hippocampus, thalamus, corpus callosum, putamen, precuneus, postcentral gyrus, paracentral lobule, and parietal and frontal cortices, and described that posttraumatic volume loss may occur primarily as a consequence of axonal injury. We wish to provide further comment on this issue. The cingulum bundle (CB) is a white matter tract that underlies the cingulate cortex, and all connections entering and exiting the cingulate gyrus pass through this bundle. These pathways include projections between prefrontal and parahippocampal cortices and projections to the median raphe nucleus that terminate in the dorsal hippocampus, and the CB is involved in attention, emotions, spatial orientation, and memory. Recently several authors reported that the CB is susceptible to traumatic axonal injury because of its long, coursing nature, and this injury is detectable by diffusion tensor imaging in studies involving mild to severe traumatic brain injury at both an acute and chronic phase.[2-4] However, the authors unexpectedly reported that atrophies were not seen in any cingulates. This fact may conflict the authors' hypothesis that posttraumatic volume loss may occur primarily as a consequence of axonal injury. We suggest that a study of the relationship between diffusion tensor imaging findings at an acute stage and the following atrophy (especially in the cingulate cortex or the CB) should be performed with the authors' great method in the future.

Satoru Takeuchi, MD
Hiroshi Nawashiro, MD

Author Affiliations: Department of Neurosurgery, National Defense Medical College, Japan.
Correspondence: Dr Takeuchi, Department of Neurosurgery, National Defense Medical College, 3-2 Namiki, Tokorozawa, Saitama 359-8513, Japan (drne776@ndmc.ac.jp).
Financial Disclosure: None reported.

1. Warner MA, Youn TS, Davis T, et al. Regionally selective atrophy after traumatic axonal injury. *Arch Neurol*. 2010;67(11):1336-1344.
2. Bendlin BB, Ries ML, Lazar M, et al. Longitudinal changes in patients with traumatic brain injury assessed with diffusion-tensor and volumetric imaging. *Neuroimage*. 2008;42(2):503-514.
3. Rutgers DR, Toulgoat F, Cazejust J, Fillard P, Lasjaunias P, Ducreux D. White matter abnormalities in mild traumatic brain injury: a diffusion tensor imaging study. *AJNR Am J Neuroradiol*. 2008;29(3):514-519.
4. Wu TC, Wilde EA, Bigler ED, et al. Evaluating the relationship between memory functioning and cingulum bundles in acute mild traumatic brain injury using diffusion tensor imaging. *J Neurotrauma*. 2010;27(2):303-307.

Downloaded from www.archneurol.com at University of Pennsylvania, on August 8, 2011
©2011 American Medical Association. All rights reserved.