The Cognitive Neuroscience of Aging and Culture

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ABSTRACT—***Research into the cognitive neuroscience of aging has revealed exciting and unexpected changes to the brain over the lifespan. However, studies have mostly been conducted on Western populations, raising doubts about the universality of age-related changes. Cross-cultural investigation of aging provides a window into the stability of changes with age due to neurobiology, as well as into the flexibility of aging due to life experiences that impact cognition. Behavioral findings suggest that different cultures process distinct aspects of information and employ diverse information-processing strategies. The study of aging allows us to identify those age-related neural changes that persist across cultures as well as the changes that are driven by culture-specific life experiences.***

KEYWORDS—*cognition; aging; culture; cognitive neuroscience*

There is compelling evidence for differences in cognitive function as a result of culture (Nisbett & Masuda, 2003). Behavioral evidence suggests that, because of cultural norms that focus on relationships and group function, East Asians develop a bias to monitor their environment more than Westerners do, resulting in greater attention to context (such as a picture's background) and more holistic encoding of stimuli. In contrast to East Asians, the individualistic society of Westerners produces a bias to attend more to focal objects and to engage in more analytic information processing (reviewed by Nisbett & Masuda, 2003).

In the present paper, we examine what is known and what can be learned about cognitive processes and human development from a joint exploration of culture and aging variables, and we show how neuroscience approaches to this issue can be particularly informative. The joint examination of cultural differences in a lifespan sample of adults permits an assessment of the interplay of experience (through culture) with neurobiology (through aging) in sculpting the neurocognitive system. Neuroimaging data indicate that the aging brain is different from the young adult brain, with the former continuously changing and adapting to its diminished efficiency (Reuter-Lorenz & Lustig, 2005). When aged brains show broad similarities across cultures in terms of neural recruitment patterns and structural integrity, we can be almost certain that these changes, relative to young brains, represent biological aging. If older adults, however, exhibit differences in neural circuitry and activation as a function of culture, this is likely because of experience and gives us a window into the plasticity of the aging neurocognitive system. Relatively little is known, behaviorally or neurally, about cultural differences in cognitive aging. The extant data involves contrasts between Western and East Asian cultures, and thus we limit our discussion to these cultures.

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BEHAVIORAL EVIDENCE FOR DIFFERENCES IN COGNITIVE PROCESSES AS A FUNCTION OF AGE AND CULTURE

When one examines behavioral data on cognitive aging, the picture is one of decreased efficiency in basic cognitive processes such as speed, working memory, and long-term memory, although knowledge remains preserved or even grows (see Fig. 1). A framework for understanding the joint impact of culture and aging on cognition was proposed by Park, Nisbett, and Hedden (1999), taking into account these different cognitive domains. Park et al. (1999) propose that it is important to consider the distinction (discussed by Baltes, 1987) between basic cognitive hardware or *mechanics*—such as speed, working memory, and inhibition—and acquired knowledge (described as software or cognitive *pragmatics*) in understanding the impact of culture on cognitive aging. Park et al. (1999) suggest that when young adults evidence cultural differences in cognitive pragmatics, the differences will magnify with age, because they are based on acquired knowledge and older adults have more experience with the culture than younger adults do. Conversely, differences in basic processes (mechanics) that occur in young people will be minimized with age, as age-related decreases in capacity will operate to limit flexibility in mental operations, resulting in more similarity across cultures with age. Research on old and young Chinese and Americans have provided some support for this model. For example, Hedden et al. (2002) studied backward digit span, which assesses participants' ability to manipulate a series of numbers in working memory and to repeat the numbers back in the reverse order in which they were originally presented. For this cognitive mechanic, the researchers found larger culture differences in young people than in old people. In contrast, Gutchess, Yoon, et al. (in press) examined the use of strategies for categorical clustering in a memory task (a strategy largely based on world knowledge) and found larger culture differences in old people than in young people.

Although cultural differences in cognition do exist, the behavioral evidence to date suggests that the impact of aging on cognitive mechanics is much greater than the impact of culture. Park et al. (1999) conducted a large study of young and old Chinese and Americans, and collected multiple measures of speed and working memory. They developed separate structural models for each of the four groups and found larger differences in the structural models due to age than due to culture. Similarly, in a study of source memory, in which subjects recalled the identity of speakers presenting facts in a video, no differences in source memory were observed as a function of culture, but large age differences were reported (Chua, Chen, & Park, in press). Likewise, elderly adults of both cultures recalled similar numbers of words in a free-recall task and recalled significantly fewer words than young people of both cultures did, even though American elderly evidenced greater use of a categorical clustering strategy (Gutchess, Yoon et al., in press).

The relatively modest impact of culture and the strong effects of age on cognitive mechanics suggest that biological aging primarily drives age-related differences in resource-demanding, strategic functions. In contrast to these findings, the impact of culture, relative to age, on knowledge-based structures shows almost a complete reversal, with culture assuming a much larger role than age. In a recent study, Yoon et al. (2004) provided young and old Chinese and young and old Americans with the names of 105 categories. Subjects provided five exemplars for each category, providing a careful mapping of category structure as a function of age and culture. The results indicated that there were only 13 categories that were culturally equivalent across both age groups. Category exemplars were far more similar across age groups within a culture. Thus, in the development of knowledge structures, culture is much more important than age, suggesting that discriminating between types of cognitive processes is critical to understanding the impact of culture on cognitive aging. (Complete norms for categories, as well as for picture naming, which have been used in other studies, are available online at http://agingmind.cns.uiuc.edu/ourresearch_cfdb.html.)

PATTERNS OF NEUROCOGNITIVE AGING

Neuroimaging techniques have added to our understanding of the aging mind. Consistent with behavioral data showing decreases in cognitive function (see Fig. 1), structural brain imaging reveals that the frontal cortex and, to a lesser extent, the medial temporal cortex exhibit significant loss of volume with

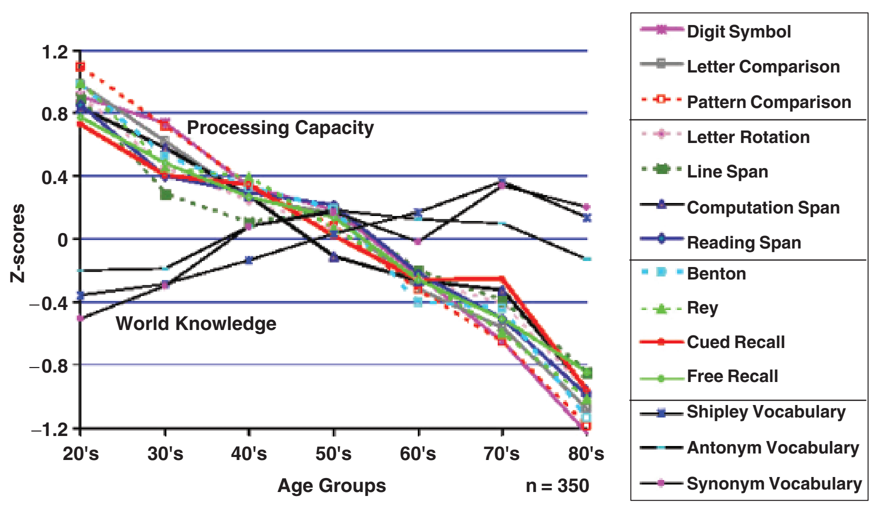

Fig. 1. The aging mind, showing regular decreases in various measures of processing capacity (including speed of processing, working memory, and long-term memory measures) but maintenance, or perhaps even augmentation, of knowledge of the world (as measured by vocabulary tests) over the lifespan. Adapted from "Models of visuospatial and verbal memory across the adult life span," by D.C. Park, G. Lautenschlager, T. Hedden, N.S. Davidson, A. Smith, and P.K. Smith, 2002, *Psychology & Aging*, *17*, p. 305. Copyright 2002 by the American Psychological Association. Adapted with permission.

age. In the face of declines in many cognitive systems, one might expect that neural activation would systematically decrease, paralleling the behavioral changes. Functional neuroimaging, however, has revealed that the aging brain is a dynamic system and that when young and old adults perform the same task, (a) neural activation is distributed across more brain sites and structures in old adults compared to young adults, (b) older adults frequently engage the same region in two hemispheres for tasks in which younger adults activate only one hemisphere, and (c) sometimes older adults show greater activation than young adults in the identical neural regions (Reuter-Lorenz & Lustig, 2005). Advances in neuroimaging have been largely responsible for views suggesting that the aging brain has residual plasticity, or cognitive reserve that can be utilized to reorganize neural circuitry to respond to the challenge of neurobiological aging.

Coincident with evidence that the brain responds to the challenge of neurobiological aging by reorganizing are neuroimaging findings suggesting that neural structures may develop or change in response to sustained exposure to stimuli or repetitive events. For example, merely 3 months of juggling training increased grey matter, relative to the brains of nonjugglers (Draganski et al., 2004)—increases that were maintained 3 months later without additional juggling practice.

DEVELOPING A COGNITIVE NEUROSCIENCE OF CULTURE AND AGING

Evidence that experience affects neural functions and structures leads logically to the notion that differences in cultural values and customs could affect development of neural activation patterns, as well as create differences in the size of various neural structures (Park & Gutchess, 2002). In the first exploration of cultural differences in neural function, we hypothesized that East Asians and Westerners would differentially engage neural hardware in the ventral visual cortex that is specialized for processing different elements of a scene. Using functional magnetic resonance imaging (fMRI), we found that Americans showed more engagement of object-processing areas in the ventral visual cortex than did Chinese (Gutchess, Welsh, Boduroglu, & Park, in press). This pattern is consistent with behavioral evidence that Westerners show a bias to process object information whereas East Asians preferentially process background information (Nisbett & Masuda, 2003). In a later fMRI study, we presented young and old Singaporeans of Chinese descent with complex pictorial scenes and examined how specialized areas within the ventral visual cortex adapted to repetition of different elements of the scene. We found that the old Singaporean adults showed less activation than young adults did in object-processing areas (the lateral occipital complex), but old and young adults engaged background processing structures (the parahippocampus) equally (Chee et al., 2006). We then tested a matching group of young and old Americans to determine whether, as our cultural theories would predict, old Singaporeans showed less activation of object-processing structures than old Americans did. Preliminary results suggest that young Singaporeans and Americans showed relatively similar engagement of all of these specialized structures, but old Singaporeans showed a larger object-processing deficit than old Americans did, suggesting that cultural differences in neural response magnified over the lifespan. These data, combined with behavioral data revealing that East Asians show more eye fixations on backgrounds than on objects (Chua, Boland, & Nisbett, 2005), suggest that after a lifetime of culturally biased information processing the neural circuitry for looking at scenes may be sculpted in a culturally biased way.

We should note that cross-cultural neuroimaging research has many unique challenges. We are sensitive to the possibility that we could find cultural differences in neural activation due to data collection from different magnets (one in the United States and one in Singapore). To address this concern, we have conducted exhaustive studies of differences in signals between magnets by scanning the same individuals on the same task in both Singapore and the United States, and we have found compelling preliminary evidence for replicability across magnets. On a number of important dimensions, the difference in neural signal from an individual tested on identical model magnets at both sites is no greater than the difference in the signal from an individual tested twice using the same magnet. This finding provides clear evidence that we may appropriately attribute signal differences to actual differences in subjects tested rather than to hardware.

We also recognize that culture is more remote from the individual than most other variables psychologists study. This distal nature of culture, combined with possible genetic differences between samples, as well as differences in education, diet, and other variables, can make it difficult to definitively argue that differences observed in neural activation are due to cultural beliefs and practices. These problems can be minimized when cultural brain research is guided by specific behavioral hypotheses (e.g., that East Asians show less activation of object areas), so that the research is confirmatory rather than exploratory. We have also found that working in an area of the brain (the ventral visual cortex) in which highly specific functions have been isolated in young Western adults has enhanced the precision of cultural hypotheses and interpretation of findings. Cross-cultural research focused on activations in the frontal cortex will prove to be more challenging, as this is a highly flexible and strategic area of the brain, with more variability between subjects in activation patterns.

Despite these concerns, the cultural neuroscience of aging has great potential for separating the relative contributions of experience and biology to the process of aging. Cultural neuroscience work may hold the key to the "use it or lose it" hypothesis of cognitive aging—that is, that neurocognitive health is maintained by sustained intellectual engagement across the lifespan. If we can find some structures that are systematically engaged more by

Asians compared to Westerners, we might expect that these structures will maintain volume and function across the lifespan better in the culture that uses them more. Similarly, if certain patterns of neural recruitment (such as bilateral engagement of the frontal cortex) are shown to be universal with age across cultures, we can be relatively certain that such recruitment patterns are a result of biological aging rather than experience.

SUMMARY

Through both behavioral and neuroimaging cross-cultural studies, we can learn much about the interplay between biology and environment as it affects cognitive aging. Our knowledge about cognitive aging (and even about cognition in general) is almost entirely limited to Western samples. At present, our research suggests that many cognitive processes decline similarly across cultures, revealing the universality of cognitive aging. At the same time, however, it appears that culture modulates neurocognitive aging, as demonstrated by the differences in activation of object-processing areas in old adults from Asian versus Western cultures. The study of culture, cognition, and aging can answer questions, not only about modifiability of neurocognitive processes across the lifespan but also about the nature of social-cognitive function in late adulthood. For example, representations of self differ across cultures (Markus & Kitayama, 1991), and fMRI allows us to examine the neural circuitry underlying such differences and how it evolves with age. Our understanding of stability and flexibility regarding self in late adulthood could also be greatly expanded by examining the neurocognitive processes that occur in old and young bicultural individuals when they switch from one cultural frame to another. Another critically important question is whether culturally determined neural differences observed in aging brains become hardwired (e.g., structural changes occur and circuitry is automatically engaged) or merely reflect neural circuitry associated with strategy differences that can readily be controlled by individuals with appropriate instructions. Most important, the emergence of a cultural psychology of aging will inform us about the plasticity of the neurocognitive system, as well as about biological imperatives associated with cognitive aging that are unchanged by any cultural context.

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