PERGAMON

Neuroscience and Biobehavioral Reviews 26 (2002) 859–867

NEUROSCIENCE AND BIOBEHAVIORAL REVIEWS

www.elsevier.com/locate/neubiorev

Aging, cognition, and culture: a neuroscientific perspective

Denise C. Park[a,*], Angela H. Gutchess[b]

[a]Beckman Institute, University of Illinois, 405 N. Matthews, Urbana, IL 61801, USA
[b]Department of Psychology, University of Michigan, 525 East University, Ann Arbor, MI 48109-1109, USA

Received 6 June 2002; accepted 25 July 2002

Abstract

Behavioral studies have suggested some intriguing differences across cultures in cognitive processes such as attention to context, the use of categorization, stereotypes about aging, and metamemory judgments. Moreover, there is behavioral evidence to suggest that, with age, cultural differences in cognition become less pronounced, likely due to decreased cognitive resources that may result in more similarity across cultures in cognition. The study of the neuroscience of aging, culture and cognition, although in its infancy, potentially provides insight into the contributions of experience and neurobiology to cognitive function. We review initial findings of cross-cultural behavioral aging research in light of cognitive neuroscience of aging research and consider the methodological challenges and benefits of adding a cross-cultural dimension to the study of the cognitive neuroscience of aging.

Keywords: Aging; Culture; Neuroimaging; Plasticity; Cognition

1. Introduction

There is a compelling and growing literature suggesting that cultural milieu affects cognitive processes in important ways. On one hand, the notion that cognitive processes are culturally bound entities is surprising to most cognitive scientists who tend to focus on commonalities in mental processes across individuals. On the other hand, these same scientists are keenly interested in the role that stimulus characteristics and conditions play in differentiating and controlling cognitive processes within individuals. If one considers the culture in which an individual functions as a relatively stable context in which cognition occurs and accepts that there are substantive differences in cultures, the notion that complex culture-bound stimuli and contexts shape cognitive function is not so surprising.

There is broad agreement that experience can shape both cognitive processes and even neural organization. For example, there is evidence that taxicab drivers have more posterior hippocampal volume than nondrivers, presumably because the experience of thousands of hours of wayfinding has resulted in neural development of spatially sensitive areas [23]. Similarly, Polk and Farah [36] reported that Canadian postal workers, who sort mail based on postal codes comprised of letters and numbers, respond to letters and numbers as if they belong to a single category in a 'pop-out' experiment. It appears that their experiences sorting mail has resulted in reorganization of two basic categories (digits/letters) into a single category. In a more recent study, Polk and colleagues [37] reported evidence that letters and digits of similar shapes were processed in neurally segregated areas of the brain. This neural segregation could only have resulted from experience and not evolution, given the arbitrary and socially prescribed assignment of items to the letter versus digit categories. Thus, the evidence that environment or experience shapes cognition and even neural organization and structures would suggest that cultural values and practices could also have effects. Perhaps the best way to understand the effects of culture on behavior and neural organization is to compare cultures hypothesized to be different in some fundamental neurocognitive process. Such cross-cultural comparisons allow one to isolate the plasticity of neural organization and behavioral responses as a result of immersion in one culture compared to another, and permit an understanding of differences in the cognitive lens for organizing experiences across cultures.

In the present paper, we adopt a cross-cultural approach to the development of a neuroscience of aging and culture.

* Corresponding author.
E-mail addresses: denisep@uiuc.edu (D.C. Park), denise@umich.edu (D.C. Park), anghall@umich.edu (A.H. Gutchess).

0149-7634/02/$ - see front matter © 2002 Elsevier Science Ltd. All rights reserved.
PII: S0149-7634(02)00072-6

We focus on a comparison between East Asian and Western (typically American) cultures, as there is both theory and data on this topic to inform our discussion. There is considerable behavioral evidence to suggest that cognitive processes differ between East Asian and Western cultures [25,26,35]. East Asians, due to collectivist, dialectic traditions tend to process information in a more holistic, contextual fashion and pay less attention to categories compared to Westerners. In contrast, Westerners are more rooted in the ancient Greek tradition of personal agency, logic, and use of rules for discovery, resulting in more rule- and feature-based analytic and categorical cognitive processes. In support of this view, Nisbett and colleagues have presented evidence which indicates that East Asians pay more attention to contextual features of stimuli [24], that they are more field dependent [19], more sensitive to environmental covariation [19], and more focused on functional/relational than categorical attributes of word pairs [25].

The view that culture literally directs the information to which one attends raises interesting questions about the underlying neurobiology. Are the two cultures essentially similar in neural organization but use different neural routes to perform a given task (a functional difference), or does repeated experience in selectively processing information result in neural segregation such that cultural biases actually sculpt neural circuits and organization (a structural difference)? There is reason to believe that both alternatives will be supported as more data are gathered. Paulesu and colleagues found evidence for functional differences in processing of different languages. They reported that differences in the orthography between Italian and English were reflected in the recruitment of different neural areas [34]. Italian has a more regular relationship between graphemes and phonemes and therefore regions related to phoneme processing (left superior temporal regions) are recruited more in this language. English has less consistent visual-naming mappings so this language results in more recruitment of regions used for word retrieval (left posterior temporal gyrus and anterior inferior frontal gyrus). These findings likely only represent a difference in functional neural processes rather than neural organization, but they do provide evidence that aspects of culture, such as language, can affect neural activations. The data cited earlier regarding the loss of a pop-out effect for letters versus words [36] in Canadian postal workers is suggestive evidence of structural reorganization, as letters appear to have specific neural representations in the left fusiform cortex [37].

2. Culture, cognition, and aging: behavioral processes

In the present paper we consider the implications of culture and aging for understanding the neuroscience of the human mind. Li has addressed the fundamental importance of culture and recognized the central role that it plays in orchestrating thought due to its operation across many levels [21]. With numerous intriguing examples drawn from the genetic to the developmental fields, she describes how the connections and feedbacks between the levels of cognition and behavior on an individual basis, culture-gene coevolution, and genetic and neuronal epigenesis can lead to pervasive changes in the cultural environment over varying time scales. We know much about age-related changes in cognitive processes in Western cultures. Fig. 1 shows results from a large, life-span study examining age-related changes in multiple measures of speed, visuo-spatial and verbal working memory, and long-term memory, as well as measures of crystallized abilities (vocabulary) [30]. The picture is one of substantial life-span differences in speed, working memory, and long-term memory, with little differentiation across the lifespan in performance among the different measures both within and between constructs. Fig. 1 also shows evidence for age invariance, or even somewhat better ability with age, in vocabulary, suggesting a different trajectory for crystallized cognitive abilities. Almost nothing is known about cross-cultural analogs to Fig. 1. Schaie et al. [41] present data suggesting that trajectories of primary mental abilities in a Chinese lifespan sample show negative change across the lifespan, providing some insight into this issue, but there are no cross-cultural comparisons available from this sample.

Considering the interrelationships among age, culture and cognition in a neuroscientific perspective allows us to understand the interplay of the experiential component of cognition (culture) with neurobiological processes (aging) as suggested by Park et al. [31]. Although one might expect that aging would magnify the effects of culture on cognition due to sustained cultural immersion across a lifespan, Park et al. [31] have suggested otherwise. They propose that there are conditions where cultural effects of cognition are magnified by age and others conditions where cultural differences apparent in young adults on cognitive tasks become less pronounced with age. The mediating variable governing the impact of culture on a cognitive task is resource demands. According to the Park et al. model of culture and aging [31], tasks that are culturally saturated (e.g. young adults in the two cultures perform differently on the task) and demanding of cognitive resources such as speed, working memory, and other fluid abilities will show convergence in performance across cultures in late adulthood. In other words, although young adults may show cultural differences on a demanding task, older adults across the two cultures will perform more similarly due to decreased cognitive flexibility. As cognitive resources become more limited with age, so do available strategies, resulting in greater similarity in performance across cultures. In contrast, if a cognitive function is based primarily on crystallized abilities or cognitive processes that are largely automatic (have low resource requirements), cultural effects evident in young will be more pronounced

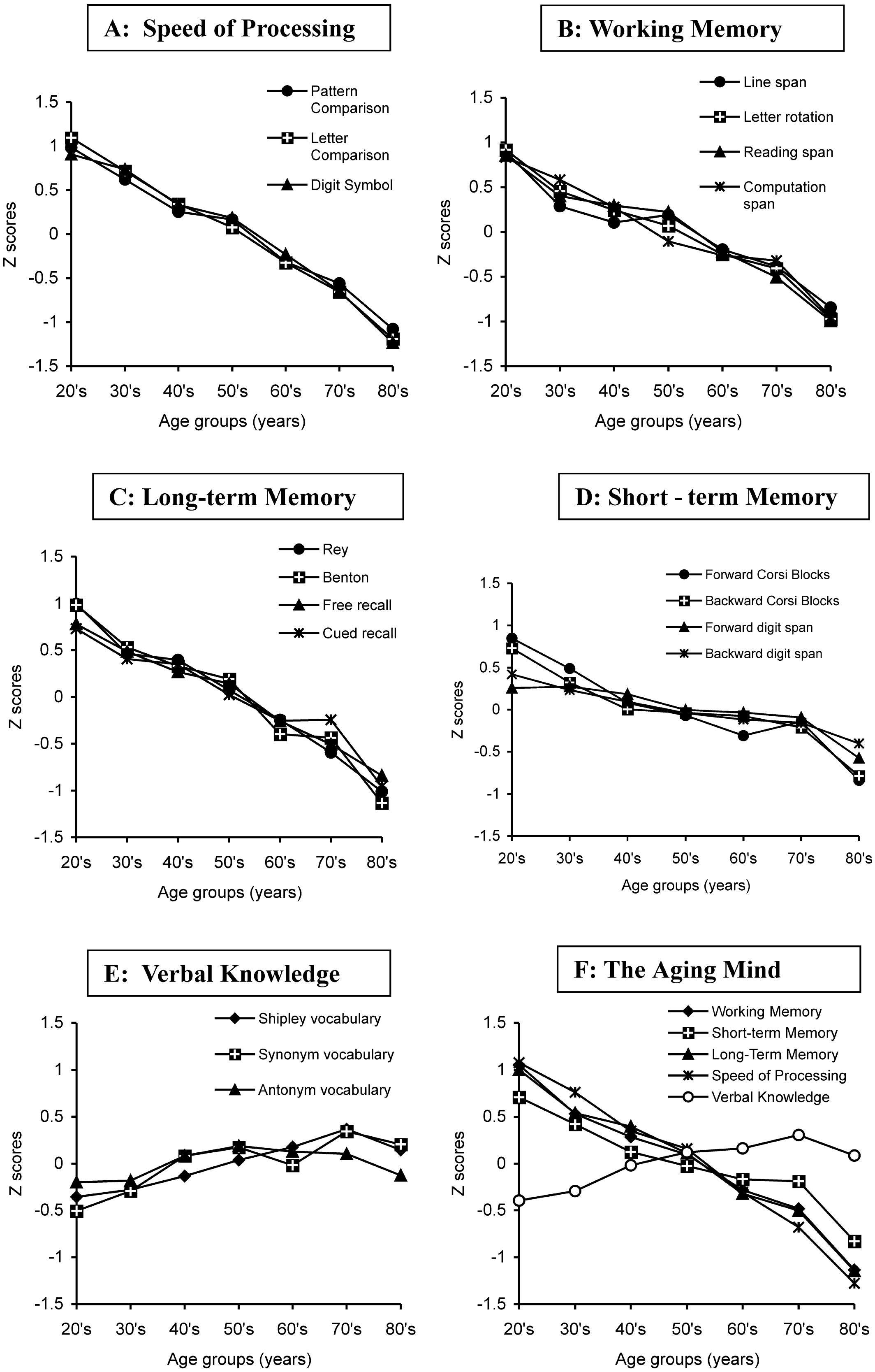

Fig. 1. Life span performance on: (A) speed of processing measures; (B) working memory measures (visuo-spatial and verbal); (C) long-term memory measures (visuo-spatial and verbal); (D) short-term memory measures (visuo-spatial and verbal); (E) knowledge-based verbal ability measures; and (F) a composite view of the above measures. Composite scores for each construct represent the *z* score of the average of all measures for that construct. Adapted from Park et al. [30], Figure 1. © 2002 by the American Psychological Association. Adapted by permission.

with age due to the sustained impact of environment and learning. This is a result of effortful cognitive processes evidencing larger age effects than automatic process [28, 29]. For example, consider a task where subjects are required to attend to background detail, a task that should be relatively low in its effort requirements for young East Asians, and higher for Westerners [25]. Although speculative, Park et al. [31] would predict that cultural difference observed in young adults would be magnified with age, due to the smaller decline in the group already relying on automatic processes. That is, East Asian young would already be relying on automatic processes for attending to detail and thus, the decline in East Asians with age would be less than for Westerners who are relying on more effortful processes at both ages.

One critically important condition for conducting cross-cultural research in cognition is that tasks be available that allow an investigator to equate cognitive resources between participants from the two cultures. Hedden et al. [17] have isolated several tasks that permit measurement of cognitive resources between East Asian and Western cultures. They presented young and old native Chinese and Americans with tasks of speed and memory span that were digit-based or spatial. (It is important to note that despite the tremendous differences between written and spoken Mandarin and English, both languages rely on Arabic numbers, making number-based tasks a seemingly ideal medium for the development of cross-culturally equivalent tasks for these two cultures). Hedden et al. [17] also measured WAIS Vocabulary score using tests normed separately for Chinese and US populations, and reported equivalence between cultures in vocabulary scores. As shown in Fig. 2, they also reported that the Corsi blocks, forward and backwards (a visuo-spatial memory span task) showed cultural equivalence. In contrast, digit-based tasks of forward and backward span showed cultural superiority for Chinese. Of particular importance is that the pattern suggested by Park et al. [31] of convergence with age across cultures occurred for backward digit span. On backward digit span, young but not old Chinese showed an advantage over Americans. Hedden et al. [16] suggested that decreased syllabic density for Chinese words for numbers compared to English words [8] resulted in greater ease of digit rehearsal for Chinese, conferring an advantage for both young and old in the forward task. However, in the backward digit task, the advantage conferred by the Chinese syllables was less important for the older Chinese due to the increased processing demands of the reversal task, just as Park et al. [31] suggested. Perhaps more importantly, the Hedden et al. data [17], as shown in Fig. 2, provides evidence that the pattern comparison measure of speed and the Corsi blocks task measure for memory span are culturally invariant tasks that can be used to measure cognitive resource. They also found, as shown in Fig. 2, that a measure of processing speed, pattern comparison, was culturally invariant, whereas a digit-based speed of processing task showed somewhat more cultural divergence. These data are largely in agreement with work by Geary et al. [14] who also reported culture and age equivalence for visuo-spatial measures of speed.

Recently, building on the work of Hedden et al. [17], we have examined basic cognitive processes in a series of studies in young and old East Asians and Americans [32]. Overall the results of this preliminary work have suggested two things. First, that there is striking similarity across cultures in performance on tasks of speed, working memory, binding, and categorical clustering when stimuli are carefully designed and culturally appropriate. Second, declines in these cognitive processes as a function of aging appear to be universal.

In a large individual differences study, Park et al. [32], presented 240 young and old Chinese and American adults (60 subjects per group) with a battery of speed and working memory tasks. They reported substantial age differences across the tasks in both cultures and developed measurement models of the two constructs of speed and working memory. They found that the multiple measures of speed formed a tight construct across age and culture, but that measures of working memory formed a construct that fit the data of both cultures well only when visuo-spatial measures (line-span and backward Corsi blocks) were used. Consistent with the findings of Hedden et al. [17], once the verbally based measures of computational span and backward digit span were discarded from measurement model, the models of both speed and working memory fit equally well for Chinese and Americans, suggesting that the structure of the mind across these two cultures is remarkably similar at the level of basic cognitive resources. Similarly, Chua et al. [9] reported that binding target information to source (a fact to a speaker) showed cultural invariance in Chinese and American samples, along with pronounced age differences in both cultures. Gutchess et al. [15] studied categorical clustering in a free recall task (based on Ref. [4]) in young and old Chinese and Americans, using categories that were normed to be similar across the two cultures [47]. They found age differences in free recall, but no cultural differences in level of recall or in the amount of categorical clustering. This suggests that Americans and Chinese respond to category structure similarly, although we would expect, based on the work of Nisbett and colleagues, that Chinese, unlike Americans, would show a relational bias in a list of words that permitted clustering categorically or relationally. However, when only categories are available as a memory support, the two cultures perform similarly. In sum, basic behavioral research suggests that there is cultural invariance in basic processes that include speed, working memory, binding operations, and categorical clustering, and that age effects are of equivalent magnitude across the two cultures.

Although there seems to be cultural invariance in basic cognitive processes investigations to date, the picture that is presented when one examines cognitive processes with

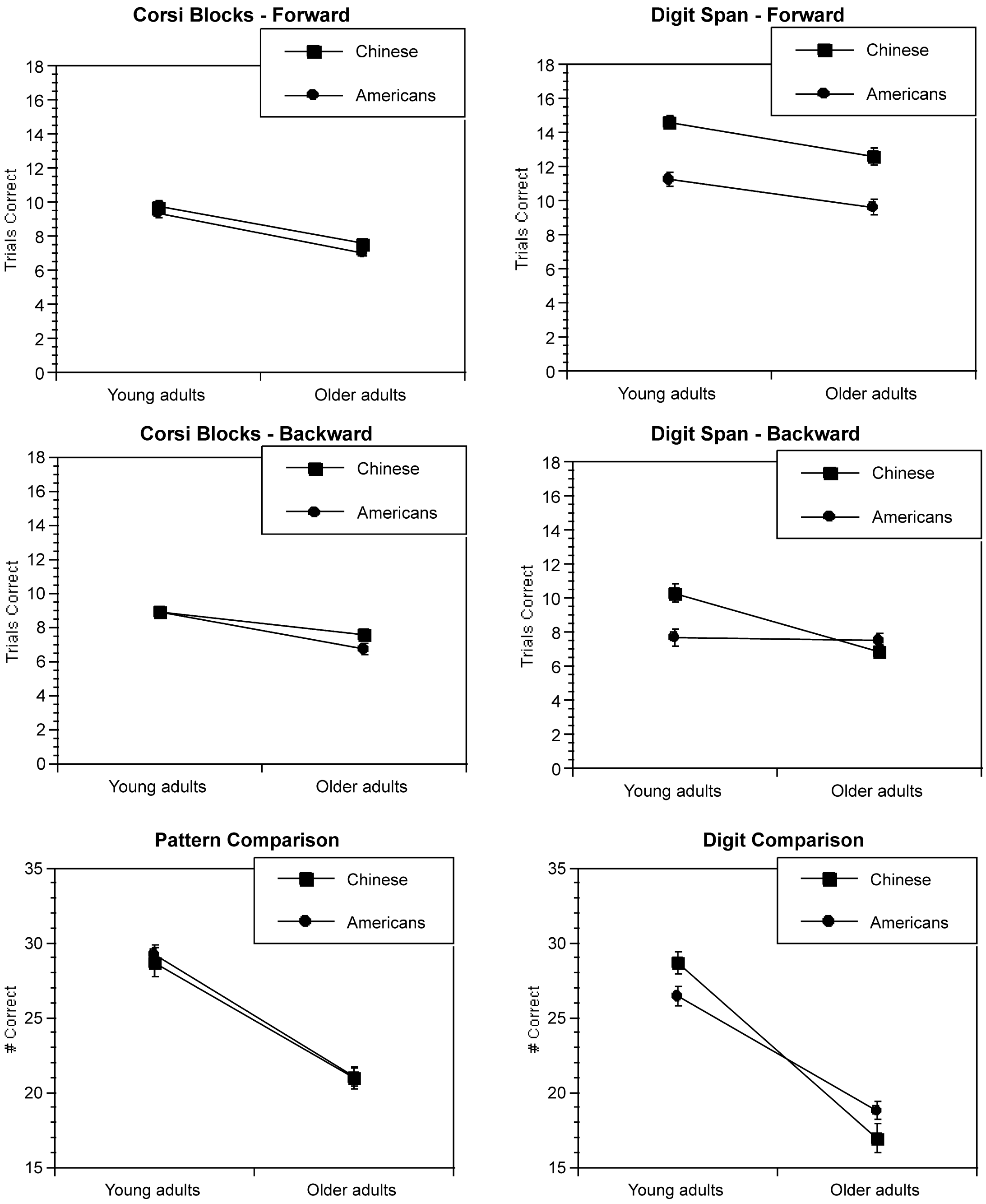

Fig. 2. Performance on visuo-spatial and verbal measures of working memory and speed of processing by young and older Americans and Chinese. Cultural equivalence on the visuo-spatial measures (Corsi Blocks and Pattern Comparison) is shown in the left panels. Cultural differences in the numerically based measures (Digit Span and Digit Comparison) are depicted in the right panels. Adapted from Hedden et al. [17], Figures 1 and 2. © 2002 American Psychological Association. Adapted by permission.

a social overlay becomes somewhat different. Levy and Langer [20] presented data suggesting that due to positive cultural views of aging, Chinese older adults would show smaller age differences on memory tasks than their American counterparts. The reasoning here is that memory differences are a result of cultural stereotypes and expectations of poor performance. Although Levy and Langer [20] did present evidence that, unlike Americans, memory performance was preserved as a function of age in Chinese, Yoon et al. [48] failed to replicate these effects in a carefully controlled study. Nevertheless, the notion that cultural biases about aging mediate age effects in memory is an interesting and important topic worthy of further exploration. In this vein, Boduroglu et al. [3] collected stereotypes about aging from young and old in Chinese and American cultures. They did find cultural differences in the reported characteristics associated with aging indicating that young Chinese had a more positive view of aging than young Americans, whereas older adults from the two cultures showed more similar and equally negative views of aging. In a second study, Boduroglu et al. [3] examined metacognitive processes in young and old Chinese and Americans and found that the old Chinese were more accurate in their perception of age-related changes in memory processes, reporting higher levels of change in their memory functioning and lower levels of control over their memory than Americans, but interestingly, also lower levels of anxiety related to memory failures. In an entirely different social/cognitive domain, Tsai et al. [44] reported that young and old Chinese and Americans had similar behavioral and cardiovascular responses to sad and funny film clips. In both cultures, old showed less cardiovascular change to the emotional clips than younger adults. Overall, these findings, when considered with results reported earlier, indicate that cultural differences associated with cognitive behavioral function are more likely to stem from the overlay of social processes onto cognition than from differences in performance of basic cognitive functions.

3. Culture, cognition and aging: neuroscientific processes

The cognitive neuroscience of aging suggests that despite the relative invariance in basic cognitive behaviors as a function of culture, the underlying neuroscience of culture and aging could be quite different. There are well-documented cellular and structural changes that occur with age. The brain decreases in volume with age. The frontal cortex, the portion of the brain most responsible for active cognitive processes, shows the greatest decrease in volume with age. At the cellular level, there is a systematic decrease in dopamine receptors with age, along with some evidence that decreases in these receptors is strongly predictive of normal cognitive decline [2,46]. Senile plaques (amyloid deposits) and neurofibrillary tangles in neurons when present in large numbers are characteristic of Alzheimer's disease, but they are also present in smaller numbers with normal aging [1]. Given that there are so many changes in neural structures with age, it is perhaps not surprising that there is evidence that even when behavioral performance on a working memory or long-term memory task is equivalent in young and old adults, the neural route to those behaviors differs as a function of age. Older adults often show less differentiated neural recruitment than young adults when performing cognitive tasks. For example, there is evidence the older adults evidence more frontal activity [5–7,38] and engage areas in both cerebral hemispheres (typically dorsal-lateral prefrontal cortex) to perform working memory and long-term memory tasks whereas younger adults perform them in a single hemisphere—left or right, depending on whether the task is primarily verbal or visuo-spatial [6,7,38]. It is plausible that there could be differentiated patterns of neural activation to stimuli as a function of culture, but with increasingly less differentiated performance as a function of age. With respect to young adults and culture, Masuda and Nisbett [24] reported behavioral work indicating that young East Asians pay more attention to contextual detail in complex scenes than young Americans. Tsivilis et al. [45], reported in an ERP experiment with stimuli designed similarly to those of Masuda and Nisbett [24] that there was distinctive neural activity for context information, target with context, and target only. This type of paradigm is an appropriate one for investigating neural underpinnings of cultural differences. One might expect that East Asians would show a different pattern of neural activation than Americans with possibly more right hemisphere activity if stimuli were processed more holistically. To the extent that age mitigates the impact of culture on tasks that have high effort requirements, one might expect more similarity across cultures with age in neural activation patterns. It would also be useful to explore whether the bilateral recruitment patterns observed in older adults relative to younger adults is a cross-cultural phenomenon or specific to western cultures and patterns of thought.

The social cognitive domain is also a rich area for understanding culture and the neuroscience of aging. Work in the area of social cognitive neuroscience is in its infancy [27]. There is evidence, for example, that thinking about self and others results in differential patterns of neural activation [12]. It is possible, however, that these results are culturally specific to Americans. Cohen and Gunz [10] report that Asians, when thinking about self, are much more likely to adopt the perspective of generalized others, whereas Westerners were more likely to report in the first person about self. It would be interesting to examine whether the underlying representations of self in young adults between cultures has a distinct neural signature, but with age, this representation might become less distinct and common to the two cultures.

In a related line of social-cognitive cultural research, Hong et al. [18] studied bicultural individuals in Hong Kong who had substantial experiences with both Chinese and American cultures. They presented subjects with symbolic cultural primes (e.g. a dragon versus an American flag, or a picture of the US Capitol building versus the Great Wall of China) and then asked them to make attributions about a lone fish swimming ahead of a group. When primed with American icons, the bicultural group made more attributions about the leadership of the fish (internal and individualistic), but when primed with the Chinese icons, the same individuals made attributions about the fish being chased by the group (external and group-based). These data suggest that there are likely to be distinct patterns of neural activation associated with specific cultural frames within a bicultural individual. It may be the case that 'self' areas are more likely to be activated for Western primes and 'other' areas for Eastern primes. Understanding the generalizability of social cognitive neuroscience effects and its interaction with aging could yield considerable information about representation and thought across cultures.

4. Methodological challenges associated with a cognitive neuroscience of culture and aging

There are a tremendous number of methodological issues that must be addressed in conducting work in the cultural neuroscience of cognitive aging. Perhaps the most intractable is that culture by age comparisons necessarily require a minimum of four different groups. The cognitive neuroscience of aging, which requires comparisons of two groups (or repeated imaging of the same individuals in a longitudinal design), has resulted in the isolation of many interesting differences in patterns of neural recruitment. However, it has been very difficult to determine whether these different patterns of activation are compensatory for age-related deterioration and improve performance [6,7,33] or dysfunctional [22]. Interpreting the meaning of different patterns of activation between two groups (old and young) has proven to be quite challenging, and imaging four groups would add to these difficulties. It will prove to be important to have careful hypotheses, and the prediction of differentiated patterns of activation in young across cultures but equivalent patterns in old, might simplify the comparisons. It would also be possible, of course, to treat culture as an experimental manipulation within subject through the use of cultural primes in bicultural individuals. Using the predictions of Park et al. [31], one might expect that, in this particular case, one would see greater differences in older adults as a function of culture, because the priming of a cultural frame would likely be automatically activated and rely on world knowledge rather than effortful processes.

When studying group differences as a function of culture, some consideration needs to be given to the nature of the dependent measure. If one expected, for example, that both cultures used similar neural processes but that one culture engaged the process more quickly (e.g. perhaps East Asians readily attend to contextual information more quickly than Westerners), a difference in terms of milliseconds would be meaningful. In this case, the use of event-related potentials, or even the collection of eye-tracking data, would be an appropriate choice as both techniques provide millisecond resolution. In contrast, if one hypothesized that different neural structures were engaged as a function of culture (e.g. East Asians engage more hippocampal structures and Americans engage more frontal structures for binding of context to target), than a functional imaging study that presents an examination of which structures were activated might be more appropriate. Additionally, whenever possible, the use of convergent dependent measures (e.g. reaction time, event-related potentials, and functional imaging data over a series of studies) will prove to be important in determining the generality and robust nature of effects associated with culture.

The interpretation of fMRI data could be further complicated by cultural differences in the rate of physiological changes associated with age. D'Esposito et al. [13] found evidence for age-related changes to the coupling of neural activity to fMRI signal. As a group, older adults activated fewer suprathreshold voxels than younger adults on a simple button-press task; with spatial smoothing, this would lead to the appearance of greater intensity of activation in the young that, in actuality, results from changes to the hemodynamic response coupling in the elderly adults rather than a difference in the cognitive process of interest. D'Esposito and colleagues [13] suggest that some of these changes could be a result of vascular changes due to pathology or changes in the spatial properties of the vascular bed. At the present time, we lack solid understanding of how the hemodynamic response changes with age or how to interpret fMRI data in light of these age-related changes. However, cross-cultural differences in diet and lifestyle could lead to confounding differences in vascular health that could affect the BOLD response in ways not yet understood. For example, racial differences in the incidence of coronary heart disease and stroke [11] could indicate healthier vasculature in Asian populations compared to Western populations [43].

Spatial normalization could pose an additional challenge in that racial differences in brain size and shape have been documented [39,40]; continuing with our focus on East–West differences, Asians have more spherical brains than Europeans. We raise this issue only insofar as it relates to the normalization process. Just as older adults might fit the templates used for spatial normalization less well than younger adults, the brains of specific ethnic groups may require more transformations to fit the Western-derived 'standard' brain atlases.

An additional self-evident issue when conducting cross-cultural functional neuroimaging work is whether to image all of the individuals in a single environment with one magnet (thus by definition imaging one cultural group in a familiar culture and the other in an unfamiliar one), or attempting to use two different but identical magnets and image each group of individuals in their own culture. At this stage of development, given the unreliability of activation patterns within an individual across different days on the same magnet, we would argue that it is important to test individuals on the same magnet, and that the selection of a site where there are recent immigrants available of both ages (not simple but doable) would be a better way to go.

Another issue that has received surprisingly little attention in the literature is assessing whether stimuli have the same meaning to the two cultures. This would be a particular concern in a neuroimaging paradigm because stimuli that are less familiar or selectively evoke relational processing in one culture would likely lead to different patterns of activation due solely to the selected stimuli rather than differences in cognitive processes. In recent work, Yoon [47] has attempted to develop two sets of stimuli that can be used between Asian and American cultures. Over 400 younger and older research participants across both cultures gave responses to category labels in order to establish a set of category norms [47]. Likewise, naming responses were collected for the set of Snodgrass and Vanderwart [42] pictures. Analyses have revealed which categories and pictures have similar responses across age and culture and thus are well suited for cross-cultural research. Researchers can access these norms at: http://agingmind.beckman.uiuc.edu. One consideration over and above familiarity that must be considered is how particular stimuli can serve as cultural primes, inducing bicultural individuals to behave more 'Eastern' or more 'Western', as mentioned above.

A final point is the prospect of very substantial cohort effects. As Li [21] points out, culture cannot be thought of as a single, stable entity for it is often affected by changes in technology, population, or environment. For this reason, we should be cautious in assuming that culture is the same for older and younger adults within a population. Certainly culture can change the lives of older adults as there is evidence for plasticity even in late age, but some changes, such as those that affect childhood development or rearing practices, may only affect younger cohorts. Moreover, there may be tremendous sociohistorical differences between ages, such as differences in young and old adults in China where only older adults lived through the Cultural Revolution or young and old Americans, with respect to World War II or the Great Depression.

5. Conclusions

Despite the number of practical challenges to the study of the neural correlates of aging cognition cross-culturally, the field offers the exciting possibility of understanding how general patterns of human thought are, at what level culture exerts its effect, and what the relative contributions are of neurobiology and experience to human thought as we age.

In studies where we have found cultural equivalence in both age groups [9,15], we have an ideal platform to investigate underlying differences across age and cultures in neural routes to achieve the same performance. Neuroscientific techniques allow us to examine aspects of task performance in ways that are not possible through behavioral data.

Furthermore, the addition of culture to the study of the neuroscience of aging allows us to address questions about neural plasticity and the functionality of recruitment patterns. Is the increasing bilaterality seen in aging a result of universal aging processes, or a result of expectations about aging and focus on declining mental abilities? In a Western achievement-oriented society, heightened awareness of memory failures could lead to a shift in strategies as opposed to a group-based, reflexive society that is less concerned about cognitive changes associated with age (consistent with the Boduroglu et al. metamemory data [3]) and consequently does not exhibit strategy shifts.

There are suggestions that aging is marked by neural dedifferentiation, that is, by some loss of neural specificity in response to stimuli that is manifested by different forms of nonselective neural recruitment (see Ref. [30] for a review of this issue). The cultural neuroscience of aging provides an important window into understanding changes in the recruitment of neural resources with age. If cortical responses become less selective with age, one might expect culturally specific neural circuitry present in the young adult would not be present in the old. That is, old brains across cultures would perform more similarly than young brains in the acquisition of new information, as neurobiological constraints resulting from aging would take precedence over the plasticity evidenced at younger ages in response to culture. The cultural neuroscience of aging, although fraught with methodological difficulties, has the potential to help unlock an understanding of both the environmentally induced malleability and biologically constrained limits of cognitive function in late adulthood.

Acknowledgements

Preparation of this article was supported by Grant R01 AG015047 from the National Institute on Aging Behavioral Research Program and RO1 AG06265-15 from the National Institute on Aging Neuroscience and Neuropsychology Program awarded to Denise C. Park.

References

[1] Anterton BH. Ageing of the brain. Mech Ageing Dev 2002;123: 811–7.
[2] Backman L, Ginovart N, Dixon RA, Wahlin TBR, Wahlin A, Halldin D, Farde L. Age-related cognitive deficits mediated by changes in the striatal dopamine system. Am J Psychiatry 2000;157:635–7.
[3] Boduroglu A, Luo T, Park DC. Metamemory assessments and age-related stereotypes: a comparison of American and Chinese cultures. Poster presentation at the Ninth Cognitive Aging Conference, Atlanta, Georgia; 2002.
[4] Bousfield WA, Cohen BH, Whitmarsh GA. Associative clustering in the recall of words of different taxonomic frequencies of occurrence. Psychol Rep 1958;4:39–44.
[5] Buckner RL, Snyder AZ, Sanders AL, Raichle ME, Morris JC. Functional brain imaging of young, nondemented and demented older adults. J Cogn Neurosci 2000;12:24–34.
[6] Cabeza R. Hemispheric asymmetry reduction in older adults: the HAROLD model. Psychol Aging 2002;17:85–100.
[7] Cabeza RM, Grady CL, Nyberg L, McIntosh AR, Tulving E, Kapur S, Jennings JM, Houle S, Craik FIM. Age-related differences in neural activity during memory encoding and retrieval: a positron emission tomography study. J Neurosci 1997;17:391–400.
[8] Cheung H, Kemper S. Recall and articulation of English and

Chinese words by Chinese–English bilinguals. Mem Cogn 1993; 21:666–70.

[9] Chua HFC, Chen W, Park DC. Source memory, aging, and culture. Poster presented at the Ninth Cognitive Aging Conference, Atlanta, Georgia; 2002.

[10] Cohen D, Gunz A. As seen by the other…: perspectives on the self in the memories and emotional perceptions of Easterners and Westerners. Psychol Sci 2002;13:55–9.

[11] Cooper R, Cutler J, Desvigne-Nickens P, Fortmann SP, Friedman L, Havlik R, Hogelin G, Marler J, McGovern P, Morosco G, Mosca L, Pearson T, Stamler J, Stryer D, Thom T. Trends and disparities in coronary heart disease, stroke, and other cardiovascular disease in the United States: findings of the national conference on cardiovascular disease prevention. Circulation 2000;102:3137–47.

[12] Craik FIM, Moroz TM, Moscovitch M, Stuss DT, Winocur G, Tulving E, Kapur S. In search of the self: a positron emission tomography study. Psychol Sci 1999;10:26–34.

[13] D'Esposito M, Zarahn E, Aguirre GK, Rypma B. The effect of normal aging on the coupling of neural activity to the bold hemodynamic response. NeuroImage 1999;10:6–14.

[14] Geary DC, Salthouse TA, Chen GP, Fan L. Are East Asian versus American differences in arithmetical ability a recent phenomenon? Dev Psychol 1996;254–62.

[15] Gutchess AH, Luo T, Hedden T, Yoon C, Jing Q, Park DC. Cross-cultural differences in the categorical organization of memory across age. Poster presented at the 110th Annual Conference of the American Psychological Association, Chicago, Illinois; 2002.

[16] Hedden T, Park DC. Culture, aging, and cognitive aspects of communication. In: Charness N, Park DC, Sabel B, editors. Communication, technology, and aging. New York: Springer; 2001. p. 81–108.

[17] Hedden T, Park DC, Nisbett R, Ji LJ, Jing QC, Jiao SL. Cultural variation in verbal versus spatial neuropsychological function across the life span. Neuropsychology 2002;16:65–73.

[18] Hong YY, Morris MW, Chiu CY, Benet-Martinez V. Multicultural minds—a dynamic constructivist approach to culture and cognition. Am Psychol 2000;55:709–20.

[19] Ji LJ, Peng KP, Nisbett RE. Culture, control, and perception of relationships in the environment. J Pers Soc Psychol 2000;78:943–55.

[20] Levy B, Langer E. Aging free from negative stereotypes—successful memory in China and among the American deaf. J Pers Soc Psychol 1994;66:989–97.

[21] Li S-C. Biocultural orchestration of developmental plasticity across levels: the interplay of biology and culture in shaping the mind and behavior across the lifespan. Psychol Bull 2003; in press.

[22] Logan JM, Sanders AL, Snyder AZ, Morris JC, Buckner RL. Under-recruitment and nonselective recruitment: dissociable neural mechanisms associated with aging. Neuron 2002;33:827–40.

[23] Maguire EA, Gadian DG, Johnsrude IS, Good CD, Ashburner J, Frackowiak RS, Frith CD. Navigation-related structural change in the hippocampi of taxi drivers. Proc Natl Acad Sci USA 2000;97: 4398–403.

[24] Masuda T, Nisbett RE. Attending holistically versus analytically: comparing the context sensitivity of Japanese and Americans. J Pers Soc Psychol 2001;81:922–34.

[25] Nisbett RE. The geography of thought: why we think the way we do. New York: Free Press; 2003. in press.

[26] Nisbett RE, Peng KP, Choi I, Norenzayan A. Culture and systems of thought: holistic versus analytic cognition. Psychol Rev 2001;108: 291–310.

[27] Ochsner KN, Lieberman MD. The emergence of social cognitive neuroscience. Am Psychol 2001;56:717–34.

[28] Park DC. The basic mechanisms accounting for age-related decline in cognitive function. In: Park DC, Schwarz N, editors. Cognitive aging: a primer. Philadelphia: Psychology Press; 2000. p. 3–21.

[29] Park DC, Gutchess AH. Cognitive aging and everyday life. In: Park DC, Schwarz N, editors. Cognitive aging: a primer. Philadelphia: Psychology Press; 2000. p. 217–32.

[30] Park DC, Davidson N, Lautenschlager G, Smith AD, Smith P, Hedden T. Models of visuospatial and verbal memory across the adult life span. Psychol Aging 2002;17:299–320.

[31] Park DC, Nisbett R, Hedden T. Aging, culture, and cognition. J Gerontol B—Psychol 1999;54B:75–84.

[32] Park DC, Hedden T, Jing QC, Jiao SL, Yao C, Nisbett RE. The aging mind across culture. Unpublished manuscript, University of Michigan; 2002.

[33] Park DC, Polk T, Mikels J, Taylor SF, Marshuetz C. Cerebral aging: integration of neural and behavioral findings. Dialogues Clin Neurosci 2001;3:151–65.

[34] Paulesu E, McCrory E, Fazio F, Menoncello L, Brunswick N, Cappa SF, Cotelli M, Cossu G, Corte F, Lorusso M, Pesenti S, Gallagher A, Perani D, Price C, Frith CD, Frith U. A cultural effect on brain function. Nat Neurosci 2000;3:91–6.

[35] Peng KP, Nisbett RE. Culture, dialectics, and reasoning about contradiction. Am Psychol 1999;54:741–54.

[36] Polk TA, Farah MJ. Late experience alters vision. Nature 1995;376: 648–9.

[37] Polk TA, Stallcup M, Aguirre GK, Alsop DC, D'Esposito M, Detre JA, Farah MJ. Neural specialization for letter recognition. J Cogn Neurosci 2002;14:145–59.

[38] Reuter-Lorenz PA, Jonides J, Smith E, Hartley A, Miller A, Marshuetz C, Koeppe R. Age differences in the frontal lateralization of verbal and spatial working memory revealed by PET. J Cogn Neurosci 2000;12:174–87.

[39] Rushton JP, Ankney CD. Brain size and cognitive ability: Correlations with age, sex, social class, and race. Psychon B Rev 1996;3: 21–36.

[40] Rushton JP, Ankney CD. Size matters: a review and new analyses of racial differences in cranial capacity and intelligence that refute Kamin and Omari. Pers Indiv Differ 2000;29:591–620.

[41] Schaie KW, Nguyen HT, Willis SL, Dutta R, Yue GA. Environmental factors as a conceptual framework for examining cognitive performance in Chinese adults. Int J Behav Dev 2001;25:193–202.

[42] Snodgrass JG, Vanderwart M. A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity, and visual complexity. J Exp Psychol—Hum L 1980;6:174–215.

[43] Stehle G, Hinohara S, Cremer P, Feng Z, Bernhardt R, Goto T, Seidel D, Heene DL, Schettler G. Differences in the risk factor patterns for coronary heart disease in China, Japan, and Germany. Klinische Wochenschr 1991;69:629–32.

[44] Tsai JL, Levenson RW, Carstensen LL. Autonomic, subjective, and expressive responses to emotional films in older and younger Chinese Americans and European Americans. Psychol Aging 2000;15: 684–93.

[45] Tsivilis D, Otten LJ, Rugg MD. Context effects on the neural correlates of recognition memory: an electrophysiological study. Neuron 2001;31:497–506.

[46] Volkow ND, Gur RC, Wang GJ, Fowler JS, Moberg PJ, Ding YS, Hitzemann R, Smith G, Logan J. Association between decline in brain dopamine activity with age and cognitive and motor impairments in healthy individuals. Am J Psychiatry 1998;155:344–9.

[47] Yoon C, Feinberg F, Hu P, Gutchess AH, Hedden T, Chen HY, Jing Q, Yao C, Park DC. Category norms as a function of culture and age: comparisons of item responses to 105 categories by American and Chinese adults. Unpublished manuscript, University of Michigan; 2002.

[48] Yoon C, Hasher L, Feinberg F, Rahhal TA, Winocur G. Cross-cultural differences in memory: the role of culture-based stereotypes about aging. Psychol Aging 2000;15:694–704.