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Right: Left:: East: West. Evidence that individuals from East Asian and South Asian cultures emphasize right hemisphere functions in comparison to Euro-American cultures

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ABSTRACT

We present evidence that individuals from East or South Asian cultures (Japanese college students in Japan and East or South Asian born and raised college students in the USA) tend to exhibit default thinking that corresponds to right hemisphere holistic functions, as compared to Caucasian individuals from a Western culture (born and raised in the USA). In two lateralized tasks (locating the nose in a scrambled face, and global-local letter task), both Asian groups showed a greater right hemisphere bias than the Western group. In a third lateralized task, judging similarity in terms of visual form versus functional/semantic categorizations, there was not a reliable difference between the groups. On a classic, ambiguous face composed of vegetables, both Eastern groups displayed a greater right hemisphere (holistic face processing) bias than the Western group. These results support an "East - Right Hemisphere, West - Left Hemisphere" hypothesis, as originally proposed by Ornstein (1972). This hypothesis is open as to the degree to which social-cultural forces were involved in hemispheric specialization, or the opposite, or both. Our aim is to encourage a more thorough analysis of this hypothesis, suggesting both lateralization studies corresponding to documented East-West differences, and East-West studies corresponding to lateralization differences.

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1. Introduction

As Morris Moscovitch's PhD sponsor (PR), it is a particular pleasure to make a contribution in the area of his PhD thesis. His thesis was one of the first in the modern era to use RT to measure interhemispheric communication and hemispheric specialization in neurologically intact people. To carry through the Moscovitch theme, if a person in Toronto stands facing North, her right hemisphere will be on the East side of her head, and her Left Hemisphere will be on the West side of her head. This "alignment" of hemispheres may be more than a spatial trick.

From the early unilateral lesion studies in the 19th century (e.g. by Hughlings Jackson) to the present, the left hemisphere (of right handers) has often been described as more analytic and verbal, and the right hemisphere, as more holistic (among other things, more context sensitive) and spatial (Moscovitch, 1979; Ornstein, 1972; Springer and Deutsch, 1989; Reuter-Lorenz and Miller, 1998). During the last 20 years, one of the main themes of the rising discipline of cultural psychology has been an "East" (primarily Japanese, Chinese and Koreans) versus"West" (primarily Americans and Canadians) contrast between more extensive holism, collectivism, spatial orientation and interdependence in the cultures of East and South Asia, and more emphasis on analysis, verbal formulations, individualism and independence in Euro-American ("Western") cultures (Triandis, 1995; Markus and Kitayama, 1991; Kitayama and Uskul, 2011; Nisbett, 2003). These neurological and cultural framings of mental and social life have developed independently in the academic world. A possible link between the two, with holistic processing more characteristic of individuals from East Asia and analytic processing by Western individuals, was originally suggested by Ornstein (1972), see also Springer and Deutsch (1989). Ornstein linked the left hemisphere with Western thinking, including rational processes, and argued that Western culture, to its disadvantage, downplayed right hemisphere function.

The left-right hemisphere distinction (of right handers) is very familiar in neuropsychology, deriving from discussions and evidence as far back as Jackson (1878/1932), and through work by Milner (1971) and her students (see review in Moscovitch (1979)). The distinction is most clearly illustrated by the work of Roger

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Sperry (Gazzaniga et al., 1962) and his students, including Michael Gazzaniga, Jerre Levy, Colwyn Trevarthen and Eran and Dahlia Zaidel. There is evidence for this basic lateralization from split-brain cases, unilateral brain damage, sophisticated reaction time and error analysis studies of stimuli presented to the left or right visual fields, and brain imaging (reviewed by Bradshaw and Nettleton (1981), Gazzaniga (1995), Moscovitch (1979) and Reuter-Lorenz and Miller (1998)). It is not reviewed here, but is represented by a set of results suggesting a tendency for the right hemisphere to emphasize more holistic, context sensitive processing, more spatial as opposed to verbal processing, more attention to simultaneous as opposed to sequential relations, more judgment of similarity in terms of visual formal as opposed to functional semantic criteria, and more global as opposed to local perception.

It is clear that the bold right-left- dichotomy that has been proposed, featuring the holistic vs analytic distinction, has been oversimplified. For the case of left versus right, evidence indicates that the holistic-analytic distinction is more graded than categorical (Bradshaw and Nettleton, 1981; Beaumont et al., 1984; Behrmann and Plaut, 2015), and that behind a graded holistic-analytic distinction there may be a number of relatively uncorrelated subsystems (Han and Ma, 2014; Liu et al., 2009). Even if the holistic-analytic distinction does not map neatly on to the hemispheres, and even if it is instantiated in somewhat independent systems, it is, nonetheless, pervasive in the literature because, we believe, it captures a characteristic aspect of lateralized processes. One important way that the basic holistic-analytic distinction is realized seems to be in the broader context in which events are embedded and explained in the holistic "mode".

Cultural psychologists have independently arrived at a basic formulation that also emphasizes holistic versus analytic modes of processing, in both the social and cognitive worlds (Markus and Kitayama, 1991) along with an associated broad array or related East-West differences (e.g. Nisbett, 2003; summarized more recently by Kitayama and Uskul (2011) and Varnum et al. (2010)). Just as the left-right hemispheric distinction, the East-West distinction can be formulated in terms of a more holistic tendency in the organization of the world by East Asians (primarily Koreans, Japanese, Chinese; and to some extent South Asians, notably Indians), and a more analytic tendency in Westerners (primarily in the USA and Canada). This cultural holistic-analytic East-West difference is a matter of emphasis, or default modes of responding (Rozin, 2003). More of the holistic-analytic variation in studies carried out so far is within than between culture (Rozin, 2003), and the presumed components of the holistic view may not always hang tightly together. For example, only a minority of standard tests used to measure the holistic approach reliably characterize each of Koreans, Japanese and Taiwanese, as opposed to Americans (Klein et al., 2009). Brain imaging data suggests that holistic-analytic cultural differences may encompass a set of rather independent systems (Han and Ma, 2014). Nonetheless, just as with the brain "dichotomy", holistic and analytic modes of processing keep emerging in the cultural contrasts between East Asian and Euro-American cultures. There is evidence for a similar holistic emphasis, at least in social domains, in Hindu India (e.g., Rozin, 2003). Cultural data also suggest that the holistic-analytic difference is often accompanied by a greater emphasis on spatial frameworks in the "East" and verbal frameworks in the "West".

There is some existing culture-difference literature that relates to the spatial-verbal distinction. One of the best documented East-West differences has to do with spatial superiority in East Asians. Lesser et al. (1965) looked at the profiles of scores on subareas of intelligence tests in New York children of different ethnic backgrounds, and noted a superiority in spatial performance in children of Chinese origin. In a book centered on intelligence in "oriental" Americans, Vernon (1982), observed that "there is the curious but unanimous finding that Orientals of all ages in any cultural setting score higher relative to Euro-Americans on spatial, numerical, or nonverbal intelligence tests, and less well on verbal abilities and achievements." (p. 271). Flynn (1991), in another book, focused on the same issue, and noted this same difference.

There is other cultural evidence indicating a greater reliance on spatial processing in East Asians. Kim (2002) examined performance on the Ravens Progressive Matrices Test in Asian- or Euro-Americans. Instructions to think out loud interfered more with Asian Americans, suggesting that verbal processing interfered with their normal, non-verbal/spatial approach. Other findings from this study indicated greater reliance on "inner speech" in solving potentially spatial problems by Westerners. Tang et al. (2006) showed that in performing digit processing tasks (such as addition), there was greater left perisylvian activation in fMRI images in Westerners, as opposed to Easterners.

Another feature sometimes referred to in the lateralization literature is the dichotomy between "intuitive" approaches (related to holistic), and rational/logical approaches (related to analytic). For a cultural parallel, Buchtel and Norenzayan (2008) reported that East Asians show a preference for intuitive as opposed to rational (logical) accounts, that is East Asians judge intuitive explanations as better. There is other evidence for an association between intuitive processing and East Asian cultures (Norenzayan et al., 2002; summarized in Nisbett (2003)).

Although the culture and brain lines of work have developed quite different and sophisticated paradigms and measures, the same holistic-analytic distinction, with appropriate limitations, arose from both of them. With the hope that these similarities are more than superficial and, therefore, can profit from each other, we propose here a simple and schematic mapping, admittedly in broad strokes, linking the holistic-analytic (and spatial-verbal) dichotomies that were developed separately in the two different fields. A major difference in the approaches is that the cultural approach has paid much more attention to holism in the social domain, illustrated by the notion of the East Asian interdependent self (Markus and Kitayama, 1991; Nisbett, 2003). It has been suggested that social orientation may be the original domain in which holistic/analytic distinction emerged cross-culturally (Varnum et al., 2010), from whence it influenced cognition more broadly.

It is an open question where and when the cultural distinction arises, and what caused it. On a number of different accounts, the cultural difference is a product of different ecologies. For example, rice agriculture requires much more sharing than wheat agriculture, and rice agriculture is associated with more holistic tendencies (Talhelm et al., 2014). It is also possible that the social distinction was prompted by protection against pathogens (Fincher et al., 2008) or that the communal, interdependent social pattern is basic, and that the move to more individualistic pattern reflected in analytic processing has been motivated by a set of ecological changes that can be described as modernization (Greenfield, 2009). Holistic tendencies are notably higher in older as opposed to younger Americans, such that the grandparents of undergraduates are distinctively more holistic and interdependent than their grandchildren, and fall clearly between contemporary Hindu Indian students and American students (Rozin, 2003).

Then, of course, there is the fascinating question about the degree to which brain lateralization has shaped culture, and the degree to which the opposite is the case. Almost certainly, these have been biologically and culturally co-evolving systems. Indeed, as shown elegantly by Behrmann and Plaut (2015) and Dehaene et al. (2010), lateralization of written word recognition, at least in alphabetic languages, is established substantially as reading is acquired; and reading is, of course, a culturally determined event. On Behrmann and Plaut's view, holistic facial processing becomes

lateralized principally in the right hemisphere on account of pressures to lateralize visual word recognition in the left hemisphere, between visual and language areas (see also Mahon and Caramazza (2011) for similar processes in non-visual word recognition). The intertwining of cultural and brain changes is ironically illustrated by the fact that in the early split-brain work, the right hemisphere is often referred to as the "minor" hemisphere. It is unlikely that such a designation would have arisen if this research had been done in Japan, where the function and outputs of "non-verbal" processing have more standing.

Of course, our suggestion of a specific culture-brain link, is itself grounded in the idea that there must be a relationship, at least in terms of "software", or "acquired circuitry" between culture and the brain, and some dimensions of this have been explored (e.g., Ambady and Bharucha, 2009; Lao et al., 2013; Han and Ma, 2014; Kitayama and Uskul, 2011).

There have been a few examples of a linkage of cultural and brain events relating to holism. The studies already mentioned by Han and Ma (2014) are one example. Recently, a few studies (Lao et al., 2013; McKone et al., 2010) have reported one specific parallel between East Asian vs Western stimulus processing, using the hierarchical letter processing task developed by Navon (1977).

In this paper, we extend this research to include a number of other tasks that have been associated with holistic and analytic processes lateralized to the right and left hemisphere, respectively, relying primarily on tasks used with split-brain patients. We compare Japanese, and a mixture of East Asian and South Asian born and reared American students using documented lateralization tasks. To our knowledge, this is the first set of studies directed at a broad culture/lateralization parallel style (e.g. holistic/spatial versus analytic/linguistic), although both types of processing can occur, to varying degrees, in both hemispheres and culture groups.

Our framework is that both lateralization and enculturation involve processing biases or defaults. Cultural differences can be expressed as default modes of responding or processing (Rozin, 2003). Table 1 illustrates a set of cognitive defaults or biases that have been shown to be characteristic of either the right hemisphere or East Asian cultures or both.

In this paper, we try to draw out the parallels in support of the hypothesis that "Eastern" cultures emphasize right hemisphere functions more than do "Western" cultures, whichever the direction of the causal arrow. To express this parallel, it is ideal to align a set of findings on the brain hemispheres with findings on the geographical hemispheres (leaving aside Europe!), using the same materials. In four studies, all of which focus only on the perceptual domain (Han and Ma, 2014), we present participants with stimuli that can engage both holistic/right hemisphere functions and analytic/left hemisphere functions. Our prediction is that Asian participants will be biased to process the stimuli along holistic/right hemisphere lines, whereas Western participants will show the opposite bias. Three of the four studies we report use materials used in classic split-brain studies.

Table 1
Right hemisphere (RH) or East Asian cultural (EW) default biases that have been suggested in the literature.[a]

R	Right > Left Hemisphere or East > West	East
Yes	1. Spatial vs verbal processing	Yes
Yes	2. Context vs object focus	Yes#
Yes	3. Global (low spatial frequency) vs local (low spatial frequency) focus in perception	Yes#
Yes	4. Form vs function categorization	?#
Yes	5. Intuitive vs analytic	Yes
Yes	6. Form category by family resemblance vs. unique feature	Yes
	7. Similarity by relative vs absolute size	Yes
	8. Association by activity/substance vs category	Yes
	9. Cyclical vs. linear projection	Yes
	10. More tolerance of contradiction	Yes
	11. Focus on the group and interconnectedness versus the individual, and self enhancement	Yes

[a] A # under East indicates that the present paper contains evidence relevant to a direct cultural parallel to findings in the lateralization literature. Items 2–4 in the Table are treated in the results section, and items 7–11 in the table refer only to studies showing potentially relevant features of East-West differences which have yet to be assessed in the Lateralization domain.

2. General method

2.1. Participants

A survey on handedness, lateralization and culture was distributed to students in two large introductory psychology classes (spring 2008 and 2009) at the University of Pennsylvania and one introductory psychology class at Hiroshima Shudo University in Japan. In Japan, the survey was hosted on Survey Monkey in Japanese. The survey was anonymous. The survey was completed by 1029 students in the United States and 179 students in Japan. All United States students were asked to indicate their ethnic origin, country of birth, and to list "each country (or countries) in which you were raised up to age 15". Students (n = 59) who assigned their ethnic origin as East Asian or South Asian, and indicated that they were born in East or South Asia, and were raised through age 15 only in East or South Asian countries (taken to include Indonesia and Southeast Asia), were classified as "ASIAN" for the purpose of this study (22 China, 3 Hong Kong, 1 Taiwan, 9 Korea, 1 Phillipines, 2 Thailand, 1 Malaysia, 3 Singapore, 11 India, 1 Nepal, 1 Pakistan). We are aware that 60% of people alive today live in Asia, and that this includes many groups, particularly in the Middle East, that are not at all represented in the research. For this reason, we describe the group of USA students from South, Southeast or East Asia as "Asians", in quotes. Students who were Caucasian (by self report with the choices, under the header "Race" as "Black/African/African-American, Caucasian/White, East Asian, Hispanic, South Asian, Other"), and were born in the USA, and were raised only in the USA were classified as USA (N = 554). The remaining US college students were not included in the analysis to be presented.

2.1.1. Questionnaire

The questionnaire was hosted on survey monkey. The survey began with questions asking about race, country of origin, country (ies) raised through age 15 and handedness. The questions of relevance for this study, in the same order for Japan and the USA, are described in more detail in the results section. The order of items reported was Face-Vegetable (an array of vegetables that looked like a face), a set of 3 items measuring the default tendency to sort drawings by visual or functional/semantic similarity (Visual/Functional), indication of whether a first impression of a large L composed of small Es, was an L or an E (L or E), identification of the location of the nose in a scrambled face where the depicted nose was in the normal location of an eye (NOSE), and indication of whether a first impression of a large T composed of small Cs, was a T or a C (T or C). The "L or E" and the "T or C" studies are of the same form, and are directed to probe the same preferences. The results are combined and are presented in Study 4, under the description: "Whole versus component letter preferences."

The Japanese survey was translated into Japanese and back-translated to English by two different individuals who were fluent in both Japanese and English. We report and discuss the results in an order different from the one that was presented.

Given the relations between lateralization and handedness, we decided to include only right-handed participants. Participants classified themselves as right or left handed, or ambidextrous. In

fact, there were significantly more right handers (93% "Asians", 94% Japanese) among the Eastern groups than among the Americans (86%), so the great majority of respondents eliminated by the handedness criterion were Americans. After handedness selection, there were 462 Caucasian Americans, 166 Japanese, and 55 "Asians" who were eligible participants.

American respondents were 50% female, compared to 55% of "Asians" and 58% of Japanese. These values were not significantly different ((X^2 (2)=3.79, p=.16), so the data from both genders were combined in all analyses.

3. Study 1: ambiguous face-vegetable array

Classic paintings by Arcimboldo of faces composed of objects, such as fruit or animals, have been used to assess holisitic-Right Hemisphere/analytic-Left Hemisphere processes in patients and healthy controls. Moscovitch et al. (1997) report that when presented with Arcimboldo faces, patient CK, who could recognize faces holistically but not analytically, perceived the Gestalt of the faces but had difficulty identifying the objects comprising them, especially if they occupied the location of internal features (eyes, nose and mouth). Inverting the faces, which disrupted the facial Gestalt, led to improved recognition of the objects. Moscovitch et al. concluded that in CK, impaired part-based recognition processes, which are needed to identify objects, compete unfavorably with the intact holistic system.

This conclusion was supported by subsequent electrophysiological studies on the lateralized face-sensitive N170 component of the evoked response potential (ERP; Bentin et al., 2006) in neurologically-intact people. Caharel et al. (2013) found that viewing an upright Arcimboldo face led to a right lateralized N170 response that was no different from the ERP response to upright naturalistic faces, and both were greater than to that of objects. By contrast, in the left hemisphere, the N170 did not differ between Arcimboldo faces and objects, suggesting that the left hemisphere was sensitive to part-based processes involved in recognizing the objects comprising the faces. When the faces were inverted, the typical left hemisphere was also evident on the right.

Using schematic drawings of outline faces, Bentin et al. (2006) found a robust, lateralized N170 component that was greater to faces as compared to objects. If small line-drawings of objects were substituted for the eyes, no N170 effect was found. They, too, concluded that holistic-global and analytic-local face characteristics compete for processing resources when viewing face-like configurations, with holistic processing being mediated preferentially by the right hemisphere.

Last, and perhaps most crucial to our case, Gazzaniga (reported in Reuter-Lorenz and Miller (1998), p. 17) presented these faces to left and right brain of split-brain patients. He found that the left brain reported the objects but not the face, whereas the reverse was true of the right brain (see Singer et al. (1997)).

Based on these observation, we chose to present faces in which holistic/global and analytic/local processing of faces would compete with one another. In Study 1 we presented one of Arcimboldo's faces, Vegetable Woman (see Fig. 1), and in Study 2, a face in which the location of the face components (eyes, nose, mouth) changed locations with one another (Zaidel, 1990). We predicted that in both cases, Easterners would be biased more than Westerners, towards processing the faces holistically.

3.1. Procedure

Respondents were presented with the ambiguous Woman-Vegetable face (Fig. 1) and asked: "Examining the picture above, write a sentence to describe it." Then, respondents were asked:

Fig. 1. Ambiguous face or group of vegetables.

"Examine your sentence answer to the last question. Score 0 if the first noun in the sentence is vegetables or any particular vegetable; Score 2 if the first noun is face or person; Score 1 if neither 0 nor 2 apply."

3.2. Results and comment

As indicated in Table 2, there is a substantial difference in favor of describing the figure as a face by the Japanese (64.5% face) vs the Americans (38.1% (X^2 (2)=38.38 p < .001). ("Asians" described it as a face only slightly more than Americans, 45.5% vs 38.1%, a non-significant difference (X^2 (2)=1.61, p=.44)..

Overall, the pattern of results supports the RLEW hypothesis. Viewing the picture as a face is indicative of the prominence of holistic, over analytic, part-based processing (Moscovitch et al., 1997) that is indicative of a right over a left hemisphere processing bias (Caharel et al., 2013; Bentin et al., 2006).

Table 2
Face-vegetable default choice.

	N	# Face choice	% Face choice	# Vegetable choice	% Vegetable choice
Japanese (J)	165	107	64.5	46	27.7
"Asians" (A)	55	25	45.5	18	32.7
Americans (U)	436	180	38.1	125	28.3

4. Study 2: nose identification

Zaidel (1990) demonstrated, using split brain patients, that when presented with the scrambled face in Fig. 2, and asked to indicate the location of the nose, the left hand usually pointed to the location of the nose in a normal face, and the right hand pointed to the literal nose (in the position of the left eye). As in the Arcimboldo faces, and the schematic faces used by Bentin et al. (2006), holistic and part-based, analytic processing are placed into competition with one another. In the split brain patients, pointing with the left hand is presumed to be mediated more by the right than the left hemisphere. We predicted that when neurologically intact people are asked to indicate where the nose is, Easterners will be biased toward the typical location in the face, and Westerners, to the location of the physical nose in the figure.

4.1. Procedure

The same figure was presented to the participants in this study, with the four locations labeled, next to the face, as A B, C, D (Fig. 2). In response to "where is the nose? ", respondents were asked to select one of the four letters.

4.2. Results and comment

The great majority of responses by all groups was to the depicted nose (B) (89.4%). As indicated in Table 3, however, the typical nose position was selected significantly more frequently by Japanese than Americans (X^2 (1)=12.50 p < .001) and by Asians than Americans X^2 (1)=30.25 p < .001).

The nose identification results clearly support the hypothesis of more default holistic processing in Japanese and "Asians", as opposed to Americans. Based on Zaidel's (1990) finding, we interpret these results as indicating a greater right hemisphere bias in face processing in Easterners as compared to Westerners. The results from Study 2 are completely consistent with the results from Study 1.

5. Study 3: form vs function/semantics

In the previous studies, the stimuli we used were faces, and holistic processing of the facial gestalt was placed in competition with analytic part-based processing that focused on its constituent elements. In the present study, we wished to extend our hypothesis to other stimuli and to related processes. In particular we asked whether the RLEW hypothesis applies when holistic -right hemisphere processes are presumed to underlie judgements of overall form or shape, and analytic-left hemisphere processes are presumed to underlie judgements of function.

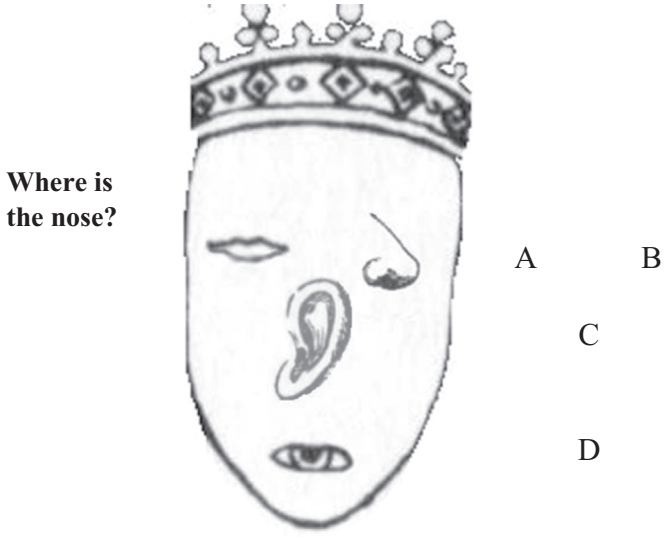

Fig. 2. Nose identification task from Zaidel (1990).

Table 3
Nose identification task.

Group	N	# In normal nose location	% In normal nose location
Japan	165	26	15.8
"Asians"	54	16	29.6
USA	462	29	6.3

In a particularly elegant study with split-brained patients, Levy and Trevarthen (1976) demonstrated that when faced with a task of choosing one of three pictures that is most similar to a target picture, the left hand selected the choice that was more visually ("formally") similar to the target, and the right hand selected the picture that was more functionally similar (see Fig. 3). According to the RLEW hypothesis, we predicted that when presented with the same materials and task, Easterners would be biased in making similarity judgements according to form, and Westerners, according to function.

5.1. Procedure

The stimulus arrays presented are illustrated in Fig. 3, and the presentation sequence is described in the caption to Fig. 3. In pilot work, we found that respondents had some confusion about the identity of the cake, and of the needle with spools of thread in the stimulus presentations To avoid this confusion, before presenting the three choice tasks, we presented a picture of the cake labeled as "cake" and the needle with two thread spools labeled as "needle and thread".

The three choice sets directly followed one another, with the respondent indicating "Which of A, B or C on the bottom has most in common with the image at the top?".

5.2. Results and comment

For each of the three trials, a choice consistent with form was coded as 2, consistent with function as 0, and neither as 1. The total score for each participant (SVSUM) was the sum of the three scores, with a sum of 0 indicating a total functional stance, and 6 a total form stance. Across all groups, respondents were highly consistent across the three tasks. For the total sample of 694 respondents, 36.2% had a summed score of 0 and 43.3% scored 6. Thus, 79.5% of all respondents were totally consistent in their choices. The results for the total sample indicate that a) the great majority of people respond consistently to these three arrays, and b) there is a close to an even split of normal individuals with respect to "form" (presumably, right hemisphere) preference, versus "function" (presumably, left hemisphere) preference.

The RLEW hypothesis predicts higher (formal) scores in Japanese and Asians than in Americans. The results, as presented in Table 4, do not consistently support the hypothesis. As predicted, the "Asian" respondents (mean score=4.19; 58.5% totally formal [SVSUM=6] responses were significantly higher than the Americans' (mean: 3.13. 44.3% "6" scores (X^2 comparing the frequencies of scores classified into 3 groups: 0, 1–5, and 6)=X^2 (2)=17.51 p < .001. However, the Japanese actually scored very slightly lower than the Americans (means of 3.06 versus 3.13, respectively). The statistical analysis (comparing the frequencies of scores classified as 0, 1–5, and 6) revealed that the Japanese were significantly

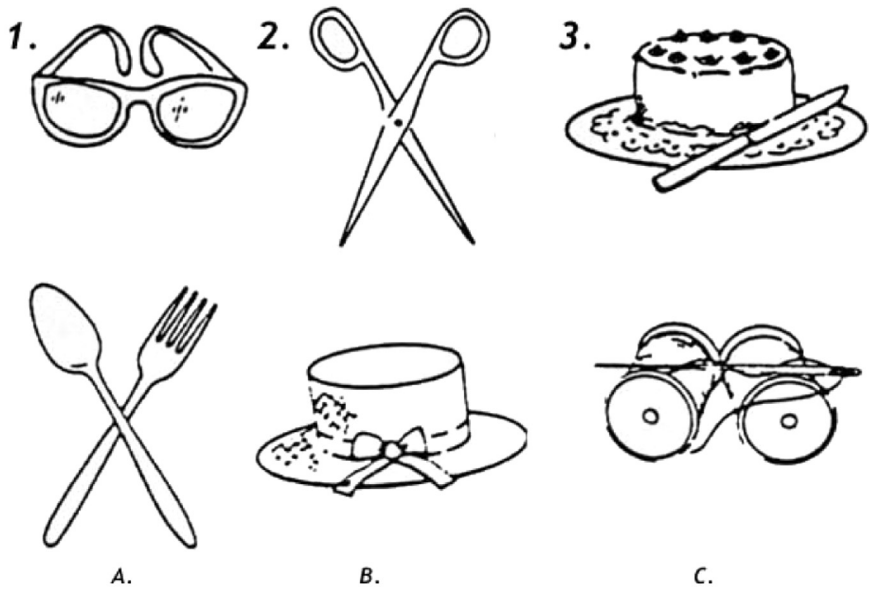

Fig. 3. Matching by form versus function (Levy and Trevarthen, 1976). The targets (labelled 1, 2 and 3) were presented one at a time at the top of the figure. The 3-item choice set was the same for all three targets. Note that for the first target, the eyeglasses, the two spools of thread (C) are most visually similar, and the hat (B) is most functionally similar. The third choice does not resemble on either dimension. For the second target, a pair of scissors, the spoon and fork are formally similar but the needle and thread spools (C) are most functionally similar. For the third target, the cake, the hat (B) is most formally similar, while the spoon and fork (A) are more functionally similar.

Table 4
Scores (SVSUM) of three groups on form/function task.

Group	n	Mean	s.d.	# 0	% 0	# 6	% 6
Japan	165	3.06	2.56	54	32.7	59	35.8
"Asians"	53	4.19	2.49	11	20.8	31	58.5
USA	458	3.13	2.78	180	39.3	203	44.3

lower than the Americans. (X^2 (2)=6.93 ($p < .01$). Because the Japanese sample was much larger than the "Asian" sample, the small percentage difference of 44.3 USA vs 35.8, Japanese, was significant. But the effect size for the J-U comparison is much smaller than for the A-U comparison.

The results of the form function study do not consistently support the RLEW hypothesis. The biggest effect (A vs U) supports the hypothesis, but a much smaller (J-U) effect goes significantly against the hypothesis.

6. Study 4. Hierarchical processing of letters in letter identification: holistic vs analytic processing

In a classical experiment on hierarchical processing of stimuli, Navon (1977) presented participants with letter stimuli in which a large letter (e.g. "L") was constructed of small letters (e.g. "C"). He found that participants identified the large letter more quickly than the smaller ones, supporting the notion of global, over local, precedence in processing. Almost a half century of research on this topic has explored the parameters and conditions under which global precedence is obtained, and the factors that may underlie it.

Consistent with the idea that global processing is more holistic and is likely to be mediated by the right hemisphere, and local processing is more analytic and likely to be mediated by the left hemisphere, Robertson et al. (1993) found that the left hemisphere was faster at identifying the local, component letters, while the right hemisphere was faster at identifying the global letters. Given the proper stimulus parameters and conditions (Yovel et al., 2001), similar laterality effects were obtained in patients with unilateral brain lesions (Delis et al., 1986), in split visual field studies in healthy individuals (Sergent, 1982), in functional neuroimaging studies (Fink et al., 1997) and electrophysiological studies (Lao et al., 2013). Indeed, in a clever set of studies, Christie et al. (2012) reported the left-sided/right hemisphere bias for global processing, in healthy controls and in patients with unilateral lesions, even when the entire stimulus appears in one visual field.

Building on this literature, we predicted according to our RLEW hypothesis, that Easterners would be more biased than Westerners towards global-holistic than local-analytic processing of hierarchical letter stimuli. Although McKone et al. (2010) had already shown a greater global precedence in Easterners compared to Westerners in a laboratory setting, we wished to test the robustness of this effect in a number of ways: (1) using a small stimulus set and only two trials (2) using a free viewing technique rather than the traditional one of directing attention to global rather or local features, and (3) using a forced choice procedure rather than RTs.

6.1. Procedure

The present task used stimuli very similar to some used in the past literature (Fig. 4), but looked at the first (default)

Fig. 4. Letter stimuli for Study 4.

Table 5
Results from two letter identification trials.

Group	n	#L holo	% L holo	# T holo	% T holo
Japanese (J)	165	84	48.8	119	72.1
"Asians" (A)	54	27	50.0	38	70.4
Americans (U)	462	164	34.7	240	51.9

identification of the letters. The question that was posed for each of the separately presented two letter displays (large L made of small Es; large T made of small Cs) was: "What letter do you see? (only one response)" The alternatives for the first letter were E or L and for the second, C or T.

6.2. Results and comment

The results for both letters are displayed in Table 5. For L (holistic) vs E (analytic), 48.8% of the Japanese made the holistic choice, as compared to 50.0% of "Asians" and 34.7% of Americans (J vs U: X^2 (1)=8.87 $p < .01$; A vs U: X^2 (1)=4.60 ($p = .052$). For C (holistic) vs T (analytic), 72.1% of the Japanese made the holistic choice, as compared to 70.4 of "Asians" and 51.9%of Americans (J vs U: X^2 (1)=19.40 $p < .001$; A vs U: X^2 (1)=5.88 ($p < .05$).

Three of the four comparisons across the two different letters show a significant effect that supports the RLEW hypothesis, and the fourth finding barely misses significance. There is a stronger holistic orientation in the Japanese and "Asians" compared to the Americans, in identifying the letters in Navon's (1977) hierarchical stimuli. We have no account of the larger effect with the second pair of letters. Our result speak to the robustness of the effect in that we obtained it despite using very few stimuli, and deviating substantially from the typical procedures used to examine global precedence with hierarchical stimuli.

In the present study, we do not have direct evidence regarding hemispheric lateralization. McKone et al. (2010), however, reported that the greater global precedence effect observed in Easterners is not associated with greater left visual field-right hemisphere advantage in holistic processing. One possibility, first suggested by Sergent (1982) regarding hemispheric specialization for global and local processing, and taken up by others (Robertson et al., 1993), is that the right hemisphere favors processing low spatial frequency information and the left, high spatial frequency information. Applying this idea to cultural differences in global and local processing biases, Miellet et al. (2013) have suggested that Easterners are biased to using low spatial frequency information that can be gleaned extra-foveally and would favor holisitic stimulus processing. Westerners, by contrast, favor using high spatial frequency information from foveal vision, and thereby are biased more to local processing in hierarchical stimuli and part-based/analytic processing in face perception.

7. Discussion

The purpose of this study is to direct attention to a possible cultural-brain parallel. It was suggested decades ago (Ornstein, 1972; Springer and Deutsch, 1989), but received little attention.

In this study, we reintroduce the hypothesis and provide a beginning at direct tests of it. We used four tasks that distinguish left versus right hemisphere functioning. We find clear evidence for a significant link between Asian origins and rearing, and enhanced, or default right hemisphere processing in three of four cases. The pattern of results suggests that there may be something fundamental behind the RLEW relationship. Of course, further studies are needed to verify the validity of the proposed relationship.

One argument for a possible right hemisphere link with Eastern countries relates to writing systems. The Chinese writing system does not have the same exclusive phonological basis as the Western (and most other writing systems), so that reading Chinese, is to large extent a direct character to meaning relation (Gleitman and Rozin, 1977). Such a reading system might exercise the right hemisphere more. On the other hand, the Behrmann and Plaut (2015) account for the relative localization of face identification and expression identification in the right hemisphere is that it is the importance of locating phonological decoding near both visual and language processing that pushes face recognition into the right hemisphere, in the course of reading acquisition. So it is not clear what effect Chinese reading might have on lateralization. In addition, recent data (Zou et al., 2015) suggests primarily left hemisphere activity in processing Chinese by native Chinese speakers/readers.

In any event, the Chinese reading system is somewhat exceptional within the Asian group in our study (Gleitman and Rozin, 1977). Japanese uses a mixture, in one case mapping orthography to sound (syllables) and in another, mapping it directly to meaning. Korean, Hindi and the other major languages of South Asia, all have a direct and exclusive mapping of the sound stream of speech on to writing.

We did not show the predicted effect in both groups with the form versus function stimulus array that worked well with split-brained patients (Levy and Trevarthen, 1976). The Asian-American comparison revealed a substantial difference in accord with our prediction, but the Japanese-American results showed a small but significant effect opposite to our prediction. We cannot explain this disparity between our two Asian groups, the only one in the data we have presented. The form/function stimuli we used were identical to those used by Levy and Trevarthen (1976), but we added a prior naming step, for two of the six drawings, to disambiguate them. This verbal intrusion may have biased results toward the left hemisphere, but of course, all groups received this same "prime." It is also possible that there was some inaccuracy in the Japanese translation of the instructions for this task. The conceptual linkage between prioritizing form over function and the holistic/analytic distinction is weak. Also, especially in light of the identification of somewhat independent systems operating to encompass the phenomena of lateralization, it is important to note that all three of our positive effects involve the visual modality, and may fall within a lateralized "system" somewhat different from the similarity judgment system, although that, too, was presented in the visual modality.

As we discussed in the introduction, there is good evidence that the various features attributed to right hemisphere functions are somewhat independent of one another (Liu et al., 2009; Han and Ma, 2014). There is no logical reason that cultural practices should prime a whole hemisphere, rather than specific functional parts of that hemisphere. Thus, for example, if verbal processing is more of a default way of dealing with problems that are subject to verbal or non-verbal approaches, this need not influence tasks for which there are no verbal alternatives (such as listening to music, or face perception). It is an open question as to whether hemispheres, as opposed to functions, get primed, but it seems more reasonable to think of priming of functions. Note, however, that a set of conceptually related processes reside together in a specific hemisphere, and also, in a set of culture-based inclinations.

We also want to draw attention to the fact that although many of the choices we had our participants make were binary, it does not mean that the dichotomies are hard and fast and the hemispheres realize them in an all or none fashion. The hemispheric biases, we believe, are graded, though in forced choice, binary decision tasks, like the ones we administered, such gradations may

not be apparent. For those to be apparent, the responses themselves may need to be graded. The same applies to the East-West distinctions, and how they are realized in different cultural groups.

In addition, the tasks we chose were those for which there is good independent evidence that they are processed holistically, and that these holistic processes are mediated preferentially by the right hemisphere. By placing these limitations on our hypotheses on the relation between culture and hemispheric specialization, we believe we avoid running afoul of the critique of *hemisphericity* (Beaumont et al., 1984). "Hemisphericity refers to the idea that an individual may tend to rely on a preferred mode of cognitive processing which is linked to predominant activity on the part of either the left or the right cerebral hemisphere" (p. 204). Quite apart from the inconsistency of the results of studies on hemisphericity, one of the main problems with the concept was that researchers ascribed global characteristics to the entire hemisphere when, in fact, the observed asymmetries applied only to particular sets of functions (LeDoux, 1983). Taking our cue from Beaumont et al.'s critique, we conclude that our results support the RLEW hypothesis in this more restricted sense, namely, that Easterners are more likely than Westerners to rely on right-hemisphere mediated holistic processes in perception. It remains to be seen whether the hypothesis can be extended to non-perceptual domains. Thus, the results presented in this study are far from definitive, but they are suggestive of a major conceptual parallel that may link the work in disparate fields. We hope that our results, based on only three perceptual tasks, and a range of respondents who were sampled from only a few parts of East and South Asia and the "West", will prompt further exploration of hemispheric and cultural linkages. We consider the results we present supportive of the RLEW hypothesis, directly tested for the first time since its original presentation almost 40 years ago,

In addition to promoting attention to an interesting hypothesis, the present study may suggest new dimensions of lateralization coming from the cultural East-West contrasts, just as the existing lateralization results suggest new explorations by cultural psychologists. Possible lines of inquiry for the neurally inclined are suggested by the bottom items in Table 1. Our hope is that by following such lines of inquiry, and mindful of the pitfalls associated with hemisphericity, future studies can extend the applicability of the RLEW hypothesis to domains other than perception, and lead to a better understanding about the relation between culture, cognition and brain function.

References

Ambady, N., Bharucha, J., 2009. Culture and the brain. Curr. Dir. Psychol. Sci. 18, 342–345.

Beaumont, J.G., Young, A.W., McManus, I.C., 1984. Hemisphericity: A critical review. Cognitive Neuropsychology 1, 191–212.

Behrmann, M., Plaut, D.C., 2015. A vision of graded hemispheric specialization. Ann. New Y. Acad. Sci. 1359, 30–46.

Bentin, S., Golland, Y., Flevaris, A., Robertson, L.C., Moscovitch, M., 2006. Processing the trees and the forest during initial stages of face perception: electrophysiological evidence. J. Cognit. Neurosci. 18, 1406–1421.

Bradshaw, L., Nettleton, N.C., 1981. The nature of hemispheric specialization in man. Behav. Brain Sci. 4, 51–91.

Buchtel, E.E., Norenzayan, A., 2008. Which should you use, intuition or logic? Cultural differences in injunctive norms about reasoning. Asian J. Soc. Psychol. 11, 264–273.

Caharel, S., Leleu, A., Bernard, C., Viggiano, M.-P., Lalonde, R., Rebaï, M., 2013. Early holistic face-like processing of Arcimboldo paintings in the right occipito-temporal cortex: evidence from the N170 ERP component. Int. J. Psychophysiol. 90, 157–164.

Christie, J., Ginsberg, J.P., Steedman, J., Fridriksson, J., Bonilha, L., Rorden, C., 2012. Global versus local processing: seeing the left side of the forest and the right side of the trees. Front. Hum. Neurosci. 6 (28), 1–8.

Dehaene, S., Pegado, P., Braga, L.W., et al., 2010. How learning to read changes the cortical networks for vision and language. Science 330, 1359–1364.

Delis, D.C., Robertson, L.C., Efron, R., 1986. Hemispheric specialization of memory for visual hierarchical stimuli. Neuropsychologia 24 (2), 205–214.

Fincher, C.L., Thornhill, R., Murray, D.R., Schaller, M., 2008. Pathogen prevalence predicts human cross-cultural variability in individualism/collectivism. Proc. R. Soc. Lond. B: Biol. Sci. 275 (1640), 1279–1285.

Fink, G.R., Marshall, J.C., Halligan, P.W., Frith, C.D., Frackowiak, R.S.J., Dolan, R.J., 1997. Hemispheric specialization for global and local processing: the effect of stimulus category. Proc. R. Soc. Lond. B 264, 487–494.

Flynn, J.R., 1991. Asian Americans. Achievement Beyond IQ. Erlbaum, Hillsdale, NJ.

Gazzaniga, M.S., 1995. Principles of human brain organization derived from split-brain studies. Neuron 14, 217–228.

Gazzaniga, M.S., Bogen, J.,E., Sperry, R.W., 1962. Some functional effects of sectioning the cerebral commissures in man. Proc. Natl. Acad. Sci. USA 48, 1765–1769.

Gleitman, L.R., Rozin, P., 1977. Structure and acquisition of reading. I. Relations between orthographies and the structure of language. In: Reber, A.S., Scarborough, D. (Eds.), Toward a Psychology of Reading. Erlbaum, Potomac, Maryland, pp. 1–53.

Greenfield, P.M., 2009. Linking social change and developmental change: shifting pathways of human development. Dev. Psychol. 45 (2), 401–418.

Han, S., Ma, Y., 2014. Cultural differences in human brain activity: a quantitative meta-analysis. NeuroImage 99, 293–300.

Jackson, J.H., 1878/1932. On the nature of the duality of the brain. In: Taylor, J.H. (Ed.), Selected Writings of John Highlings Jackson. Basic Books, New York.

Kitayama, S., Uskul, A.K., 2011. Culture, Mind, and the Brain: Current Evidence and Future Directions. Annu. Rev. Psychol. 62, 419–449.

Kim, H.S., 2002. We talk, therefore we think? A cultural analysis of the effect of talking on thinking. J. Personal. Soc. Psychol. 83, 828–842.

Klein, H.A., Lin, M.-H., Radford, M., Masuda, T., Choi, I., Lien, Y., Yeh, Y., Boff, K.R., 2009. Cultural differences in cognition: Rosetta Phase II. Psychol. Rep. 105, 659–674.

Lao, J., Vizioli, L., Caldara, R., 2013. Culture modulates the temporal dynamics of global/ local processing. Cult. Brain 1 (2–4), 158–174.

LeDoux, J.E., 1983. Cerebral asymmetry and the integrated function of the brain. In: Young, A.W. (Ed.), Functions of the Right Cerebral Hemisphere. Academic Press, London.

Lesser, G.S., Fifer, G., Clark, D.H., 1965. Mental abilities of children from different social-class and cultural groups. Monogr. Soc. Res. Child Dev., 1–115.

Levy, J., Trevarthen, C., 1976. Metacontrol of hemispheric function in human split-brain patients. J. Exp. Psychol.: Hum. Percept. Perform. 2 (3), 299.

Liu, H.S., Stufflebeam, S.M., Sepulcre, J., Hedden, T., Buckner, R.L., 2009. Evidence from intrinsic activity that asymmetry of the human brain is controlled by multiple factors. Proc. Natl. Acad. Sci. USA 106, 20499–20503.

Mahon, B.Z., Caramazza, A., 2011. What drives the organization of object knowledge in the brain? The distributed domain-specific hypothesis. Trends Cognit. Neurosci. 15, 97–103.

Markus, H.R., Kitayama, S., 1991. Culture and the self: implications for cognition, emotion, and motivation. Psychol. Rev. 98 (2), 224.

McKone, E., Davies, A.A., Fernando, D., Aalders, R., Leung, H., Wickramariyaratne, T., Platow, M.J., 2010. Asia has the global advantage: Race and visual attention. Vision Research 50, 1540–1549.

Miellet, S., Vizioli, L., He, L., Zhou, X., Caldara, R., 2013. Mapping face recognition information use across cultures. Front. Psychol. 4 (34), 1–12.

Milner, B., 1971. Interhemispheric differences and psychological processes. Br. Med. Bull. 27, 272–277.

Moscovitch, M., 1979. Information processing in the cerebral hemispheres. In: Gazzaniga, M.S. (Ed.), Neuropsychology. Handbook of Behavioural Neurobiology Vol. 2. Plenum Press, New York, pp. 379–446.

Moscovitch, M., Winocur, G., Behrmann, M., 1997. What is special about face recognition? Nineteen experiments on a person with visual object agnosia and dyslexia but normal face recognition. Cognit. Neurosci. J. 9 (5), 555–604.

Navon, D., 1977. Forest before trees: the precedence of global features in visual perception. Cognit. Psychol. 9 (3), 353–383.

Nisbett, R.E., 2003. The Geography of Thought: How Asians and Westerners Think differently… and Why. The Free Press, New York.

Norenzayan, A., Smith, E.E., Nisbett, R.E., 2002. Cultural preferences for formal versus intuitive reasoning. Cognit. Sci. 26, 653–684.

Ornstein, R., 1972. The Psychology of Consciousness. Harcourt Brace Johanovich, New York.

Reuter-Lorenz, P.A., Miller, A.C., 1998. The cognitive neuroscience of human laterality: lessons from the bisected brain. Curr. Dir. Psychol. Sci. 7, 15–20.

Robertson, L.C., Lamb, L.R., Zaidel, E., 1993. Interhemispheric relations in processing hierarchical patterns: Evidence from normal and commisurotomized subjects. Neuropsychology 7, 325–342.

Rozin, P., 2003. Five potential principles for understanding cultural differences in relation to individual differences. J. Res. Personal. 37, 273–283.

Sergent, J., 1982. The cerebral balance of power: Confrontation or cooperation. J. Exp. Psychol. Hum. Percept. Perform. 8, 253–272.

Singer, J,, Chedd, G., Angier, J., 1997. Pieces of Mind: Inside the Human Body [Videotape]. Available from Connecticut Public Television, Hartford, CT.

Springer, S., Deutsch, G., 1989. Left Brain, Right Brain, third edition. Freeman, New York.

Talhelm, T., Zhang, X., Oishi, S., Shimin, C., Duan, D., Lan, X., Kitayama, S., 2014. Large-scale psychological differences within China explained by rice versus wheat agriculture. Science 244, 603–608.

Tang, Y., Zhang, W., Chen, K., Feng, S., Ji, Y., Shen, J., Reiman, E.M., Liu, Y., 2006. Arithmetic processing in the brain shaped by cultures. Proc. Natl. Acad. Sci. USA

103, 10775–10780.
Triandis, H.C., 1995. Individualism and Collectivism. Westview, Boulder, CO.
Varnum, M.E.W., Grossmann, I., Kitayama, S., Nisbett, R.E., 2010. The origin of cultural differences in cognition: the social orientation hypothesis. Curr. Dir. Psychol. Sci. 19, 9–13.
Vernon, P.E., 1982. The abilities and achievements of Orientals in North America. Academic Press, New York.
Yovel, G., Yovel, I., Levy, J., 2001. Hemispheric asymmetries for global and local visual perception: effects of stimulus and task factors. J. Exp. Psychol.: Hum. Percept. Perform. 27 (6), 1369.
Zaidel, D.W., 1990. Long-term semantic memory in the two cerebral hemispheres. In: Trevarthen, C. (Ed.), Brain Circuits and Functions of the Mind: Essays in Honor of Roger W. Sperry. Cambridge University Press, Cambridge, pp. 266–280.
Zou, L., Packard, J.L., Xia, Z., Liu, Y., Shu, H., 2015. Neural correlates of morphological processing: evidence from Chinese. Front. Hum. Neurosci. 9, 714.