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"Bouba" and "Kiki" in Namibia? A remote culture make similar shape–sound matches, but different shape–taste matches to Westerners

Andrew J. Bremner [a,*], Serge Caparos [a], Jules Davidoff [a], Jan de Fockert [a], Karina J. Linnell [a], Charles Spence [b]

[a] Department of Psychology, Goldsmiths, University of London, UK
[b] Crossmodal Research Laboratory, Department of Experimental Psychology, University of Oxford, UK

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ABSTRACT

Western participants consistently match certain shapes with particular speech sounds, tastes, and flavours. Here we demonstrate that the "Bouba-Kiki effect", a well-known shape–sound symbolism effect commonly observed in Western participants, is also observable in the Himba of Northern Namibia, a remote population with little exposure to Western cultural and environmental influences, and who do not use a written language. However, in contrast to Westerners, the Himba did not map carbonation (in a sample of sparkling water) onto an angular (as opposed to a rounded) shape. Furthermore, they also tended to match less bitter (i.e., milk) chocolate samples to angular rather than rounded shapes; the opposite mapping to that shown by Westerners. Together, these results show that cultural–environmental as well as phylogenetic factors play a central role in shaping our repertoire of crossmodal correspondences.

1. Introduction

Many studies now show that perceptual phenomena, often assumed to be basic human endowments, vary from culture to culture (e.g., Caparos et al., 2012; Davidoff, 2001; De Fockert, Davidoff, Fagot, Parron, & Goldstein, 2007; Doherty, Tsuji, & Phillips, 2008; Jones, 2010; Miyamoto, Nisbett, & Masuda, 2006; Nisbett, Peng, Choi, & Norenzayan, 2001; Rivers, 1905). However, despite recent agreement that crossmodal interactions are pervasive in sensory processing (e.g., Stein, 2012), almost no research has investigated possible cultural variations in multisensory processes (see Howes, 2006, on this point). This is surprising given the large body of evidence demonstrating that crossmodal interactions have substantial downstream effects on perception even from early stages in neural processing (e.g., Driver & Noesselt, 2008; Ghazanfar & Schroeder, 2006). Here we investigate whether multisensory shape-symbolism, previously established in Westerners, was also present in a remote population with little exposure to Western culture or artefacts, the Himba of Northern Namibia.

Shape-symbolism describes a family of multisensory phenomena in which shapes (typically presented visually) give rise to, or at the very least are associated with, experiences in a different sensory modality. Shape-symbolism constitutes just one example of a much larger class of multisensory phenomena in which the presentation of a stimulus in one sensory modality is associated with a sensation (or concept) in another sensory modality. Such phenomena have been studied for many years (see Spence, 2011, for a review) and have recently enjoyed particular attention given that the ability to make such links may help in localising stimuli (Bien, ten Oever, Goebel, & Sack, 2012; Parise & Spence, 2009), and in solving the "crossmodal correspondence problem" (i.e., the problem of how to know which stimuli to link together across the senses) (Spence, 2011). It has also been proposed that shape-symbolism (also re-

* Corresponding author. Address: Department of Psychology, Goldsmiths, University of London, New Cross, London SE14 6NW, UK. Tel.: +44 (0) 20 7078 5142; fax: +44 (0) 20 7919 7873.
E-mail address: a.bremner@gold.ac.uk (A.J. Bremner).

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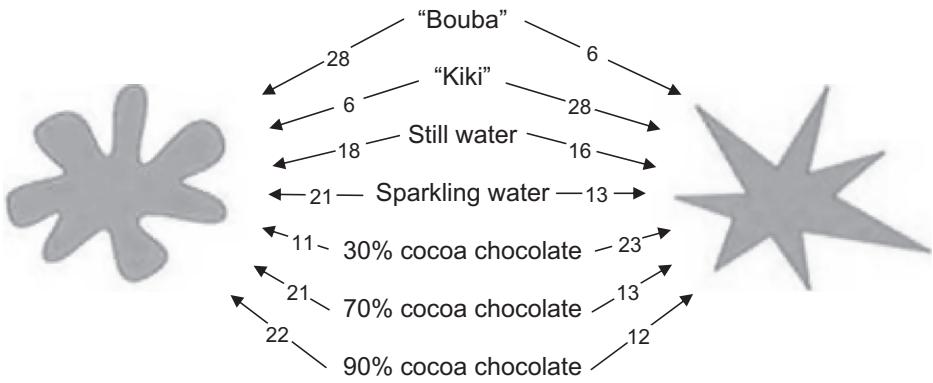

Fig. 1. The visual shapes used in the current experiment, with the "rounded" shape on the left and the "angular" shape on the right. In the centre of the figure are the names and food samples that the participants matched to one or the other figure. The numbers of participants (out of 34) who matched each name/sample to each shape are superimposed on the arrows between these.

ferred to in this case as sound-symbolism) may provide the sound-referent mappings required for the evolution and ontogeny of language (Imai, Kita, Nagumo, & Okada, 2008; Ramachandran & Hubbard, 2001; Ramachandran & Hubbard, 2005; see also Robson, 2011).

Important clues as to the origins of shape symbolic effects come from developmental studies. Maurer, Pathman, and Mondloch (2006) have established that children as young as 2.5 years demonstrate the "Bouba-Kiki effect" (perhaps the best-known example of shape-symbolism; Köhler, 1929; Ramachandran & Hubbard, 2001). In this effect, the words "Bouba" [bubə] and "Kiki" [kiki] are associated with rounded and angular shapes, respectively (see Fig. 1). In a similar vein, Imai et al. (2008) have further demonstrated that Japanese children as young as 2 years of age detect crossmodal correspondences between the sounds of novel verbs and visual actions. Prompted by such findings, researchers have argued that some arbitrary crossmodal relations (including shape-symbolism effects) have a phylogenetic[1] basis (e.g., Maurer, Gibson, & Spector, 2012).

Yet before firmly drawing such a conclusion it is important to consider whether such early abilities could arise from the cultural environment experienced in early life. Given that many of the young participants in these studies are likely to have been exposed extensively to the rich multisensory environments presented by Western or Japanese cultures it seems not unlikely that crossmodal correspondences could be learned in the first years of life from these environments. Indeed, Imai et al. (2008) note differences between UK and Japanese adults in detecting crossmodal correspondences in novel word–action pairings; these seem likely to be mediated by culture. More recent data from 4-month-old human infants indicates that some arbitrary crossmodal relations are in place by this age, including matches between the angularity of an object and the pitch of a sliding whistle (Walker et al., 2010). Yet, because this study does not examine correspondences between visual shape and a spoken name, it remains unclear to what extent such early correspondences form the basis of the shape/sound-symbolic effects such as the "Bouba-Kiki effect". Indeed, even across 4 months of life it is not completely implausible that the cultural environment could give rise to shape–pitch correspondences (see Lewkowicz, 2011).

The strongest test of the universality of a perceptual phenomenon concerns whether it remains universal across substantial cultural variations experienced from early life and into adulthood. Yet, as already noted, there is very little extant evidence concerning (a lack of) cultural differences in crossmodal perceptual phenomena. Although it is widely believed that variants of the Bouba-Kiki effect have been found all over the world (e.g., see Ramachandran & Hubbard, 2005, p. 171), little empirical data actually support such a suggestion. While at least one report has failed to find consistent matching between particular words and angular and rounded visual forms across cultures (in the Songe of Papua New Guinea; Rogers & Ross, 1975), the only reported research which has established the same effect across cultures was conducted half a century ago (Davis, 1961). In his studies on the phenomenon of sound–shape symbolism, Davis tested a group of native school children from the Mahali peninsula of Lake Tanganyika on the Congo-Tanganyika border. The majority of children tended to match an angular shape with the word "Takete" and a rounded shape with the word "Uloomu". However, the groups tested by Davis had all received formal education in Swahili, speakers of which, since colonisation by Europeans, have used a variant of the Latin alphabet. Thus, the crossmodal matches in this group may be similar to those of Westerners due to the phoneme–shape associations common to languages using the Latin alphabet (e.g., the visual similarity between angular shapes and the letter "K").

We thus decided to collect additional evidence concerning the robustness of shape-symbolism effects across

[1] We use "phylogenetic" in this manuscript to denote a position in which certain psychological phenomena, in this case crossmodal correspondences, are universal to the human species. This position does not rule out the possibility that experience might play a role in the emergence of a given crossmodal correspondence (nor does it rule this in), but it does mean that it would emerge across all cultures, and early in life.

cultures by testing a group of participants from the Himba in rural Namibia. The Himba of Kaokoland, in Northern Namibia, are a semi-nomadic people who are one of the most remote cultures from Western (or Eastern) cultural influence remaining. They have no written language, and have had only very limited contact with Westerners and Western artefacts. They speak predominantly Otjiherero, and, differ from the group tested by Davis (1961) in that they have very limited formal education and no written language. In addition to addressing the lack of evidence concerning cultural variation in the standard "Bouba-Kiki effect", we also set out to determine the extent to which "Western" shape symbolism across other modalities is also present in this remote culture. Recently, researchers have demonstrated that Western participants exhibit robust shape symbolic associations between visually-presented shapes and both tastes and flavours (e.g., Deroy & Valentin, 2011; Gallace, Boschin, & Spence, 2011; Ngo, Misra, & Spence, 2011; Spence, 2012; Spence & Gallace, 2011). Thus, as well as testing for the basic sound–shape symbolism ("Bouba-Kiki") effect, we also investigated oral-somatosensory/taste/flavour shape symbolism. This will help shed light on the question of whether the extent to which putative universal shape-symbolism extends to crossmodal correspondences across modalities other than sound and vision.

The question of whether there is cross-cultural variation in taste–shape symbolism is also of particular interest because some phylogenetic explanations of the emergence of crossmodal correspondence effects like shape-symbolism have stressed the importance of biological constraints on the degree to which crossmodal associations can arise. Ramachandran and Hubbard (2005) argue that associations are more likely between brain areas that are closer together (e.g., auditory and visual cortices) than those which are further apart (e.g., visual and gustatory cortices). One prediction of this position is that there will be more cross-cultural variation in visual–taste/flavour associations than in visual–sound associations. Furthermore, it is pertinent to note that food preferences and consumption are areas where cultural diversity is typically pronounced (Rozin, 1983). Such variation may impact on (or indeed result from) the extent to which crossmodal correspondences with taste and flavour arise in different cultures.

All participants performed a shape–sound matching task, followed by two shape–flavour matching tasks (see Ngo et al., 2011; Spence & Gallace, 2011). The shape–name matching task consisted of a version of the classic "Bouba-Kiki" task (Köhler, 1929; Ramachandran & Hubbard, 2001). In this task, participants say the words "Bouba" and "Kiki" and then to choose which of two shapes (one angular, the other rounded; see Fig. 1) should be named "Bouba", and, correspondingly, which should be named "Kiki". In the first shape–flavour matching task (the "shape–carbonation task"), the participants tasted sparkling and still water and then chose the shape (from the same two shapes used in the shape–sound matching task) that was most similar to each sample; Westerners align more highly carbonated water with more angular shapes (Gallace et al., 2011; Ngo, Piqueras-Fiszman, & Spence, 2012). In the second shape–flavour matching task (the "shape–bitterness task"), participants tasted, separately, three pieces of chocolate having a cocoa content of 30%, 70%, or 90%, and after each were asked to match to one of the two shapes; Westerners align more bitter flavours with more angular shapes (Ngo et al., 2011). Whereas shape–sound symbolism (the "Bouba-Kiki effect") was present in the Himba, shape–flavour matches were either not made consistently, or else, in the case of "shape–bitterness" were in the opposite direction to those shown by Western participants. These findings indicate that, whereas some forms of crossmodal shape-symbolism may be universal across cultures independent of those cultures' exposure to Western artefacts, cultural–environmental factors certainly play an important role in the emergence of other forms of crossmodal correspondence; in this case those concerning matches between visual shape and flavour.

2. Methods

2.1. Participants

Thirty-nine Himba (20 male, 19 female) were tested. Five were excluded from analysis as they had attended school, leaving 19 males and 15 females. The estimated ages of the participants ranged from 16 to 39 years. The Himba are semi-nomadic herders who have very limited contact with Western artefacts. None of the participants had ever been involved in experimental research.

2.2. Apparatus and materials

The participants were tested inside a tent placed in a shaded area. The only occupants of the tent were the participant, the experimenter and the translator. On each trial, the participants were invited to match two shapes presented side-by-side (one angular, the other rounded) to words, or the experience associated with sampling the food or drink items that they were invited to taste. The two shapes (see Fig. 1) were presented in greyscale on separate laminated pieces of card placed 20 cm from each other. For the shape–carbonation matching task, the participants were provided with approximately 50 ml sparkling and still mineral water (on separate trials) from a plastic cup. The three chocolate samples used in the shape–chocolate tasting task were all Lindt Excellence brand (Extra creamy milk, 30% cocoa; Dark 70% cocoa, Dark 90% cocoa; these are the same brands as used in Ngo et al.'s, 2011, study.) These were provided by placing ¼ of a chocolate square (approximately 3 g) into the participant's hand. All instructions were provided in Otjiherero by a translator. It was confirmed prior to the experiment that the words "Bouba" and "Kiki" were meaningless in Otjiherero. Although it is possible that some of the Himba would have tasted chocolate and carbonated water before (on trips to the nearest town; Opuwo), these food stimuli were distinctly unfamiliar to them.

We presented the tasks in a fixed order. Because the task of naming a shape is more natural than matching a flavour to a shape it was considered important to provide the sound–shape matching task first, followed by the two

flavour–shape matching tasks. Furthermore, we also decided to conduct the water-matching task before the chocolate matching task so that the stronger, more long lasting effects of the chocolate on the palate did not affect judgments about shape to water matches.

2.3. Procedure

In the first part of the study, the experimenter explained that he was interested in learning about how people name shapes. He showed the participant the two shapes placed to the left and right side of the participant's midline, and told the participant that he was going to ask him/her to name the shapes from a choice of two names; "Bouba" and "Kiki". The side of presentation of the angular and the rounded shapes was counterbalanced across participants, but the experimenter (and translator) always pronounced "Bouba" and "Kiki" in the same order. The participant was instructed to say the words "Bouba" and "Kiki", and then to indicate which shape was the "Bouba" and which the "Kiki". None of the participants chose to name both shapes with the same word.

Next, the experimenter explained that he was going to give the participant two different kinds of water and stated that each time they tasted the water they should choose which of the two shapes was more like the water they had tasted. The experimenter asked the participant to close his/her eyes and taste the water; indeed the participants were not permitted to compare the two different kinds of water visually until after the experiment. This was then repeated with the other water. The order in which the sparkling and still water was provided was counterbalanced across participants. Finally, the experimenter explained that he was going to give the participant three different kinds of chocolate to taste and stated that each time they tasted some chocolate they should choose which of the two shapes was most like the chocolate they had tasted. The participants were asked to close their eyes while tasting each piece of chocolate to ensure that their responses were based on the taste/flavour of the chocolate samples rather than on any colour differences. The order in which 30%, 70%, and 90% cocoa chocolate was presented was counterbalanced across participants.

Ratings of the pleasantness of the various stimuli were not taken, due to previous experience indicating that it is not easy to obtain such quantitative evaluations from Himba participants. However, informal observations indicated that they preferred the less bitter chocolates to those with higher cocoa content, and still water over sparkling water.

3. Results

3.1. Shape–name ("Bouba-Kiki") task

We examined the number of participants who applied the names to the shapes in the conventional pattern ("Bouba" to rounded, "Kiki" to angular) or vice versa (see Figs. 1 and 2). The majority of the participants (28 out of 34; 82%) associated the rounded shape with the name "Bouba" and the angular shape with the name "Kiki", while the remaining 6 participants (18%) showed the reverse crossmodal mapping, $\chi^2(1, N = 34) = 14.24$, $p < .001$. Although there have been previous demonstrations of effects analogous to the "Bouba-Kiki" effect in non-Western cultures (e.g., Davis, 1961), this result provides the first demonstration that a remote society *without a written language* also exhibits this effect.

3.2. Shape–carbonation task

We examined the number of participants who matched the angular or the rounded shape to still and sparkling water. The participants were free to match the same or different shapes to both types of water, and so several kinds of crossmodal mapping of shape to level of carbonation were possible. To examine crossmodal mapping (or correspondence) across the sample, we categorised each participant into one of the following four categories: (i) The *conventional mapping* category included those participants who had mapped sparkling water to angular, and still water to rounded; (ii) The *non-conventional mapping* category included participants mapping in the reverse direction; (iii) The *angular mapping* category included participants who mapped both water samples to the angular shape; and (iv) The *rounded mapping* category included those participants who mapped both water samples the rounded shape instead. Chi-squared tests demonstrated that the numbers of participants in each category deviated from an even distribution, $\chi^2(3, N = 34) = 9.06$, $p = .029$. As can be seen in Fig. 2, this effect describes a tendency to map shape angularity (or roundedness) in a particular direction relative to the carbonation of the water (i.e. either conventional or non-conventional mappings), as opposed to a pattern of responses in which one shape is mapped to the water samples, regardless of the carbonation of those samples (i.e. either angular or rounded mappings).

As we were particularly interested in the direction of the mapping (conventional vs. non-conventional), we examined whether the mapping deviated from chance among those who demonstrated a directional mapping (i.e., conventional or non-conventional as opposed to either the angular or smooth mappings). As can be seen in Fig. 2, 13 participants demonstrated a non-conventional mapping and 12 demonstrated a conventional mapping; this did not deviate from chance, $\chi^2(1, N = 25) = .04$, n.s., indicating that, unlike Western observers/tasters (see Gallace et al., 2011; Ngo et al., 2012), the Himba do not show a preference to map angular and rounded shapes with regard to the carbonation of water samples.

3.3. Shape–bitterness task

We examined the number of participants who matched the angular or the rounded shape to chocolate with 30%, 70% and 90% cocoa content. As with the Shape–carbonation matching task, we examined the pattern of individuals' responses to Shape–bitterness matches across trials. In this case, the conventional mapping category included participants who had mapped [30%, 70% and 90%] cocoa chocolate to either [rounded, angular, angular] or to [rounded,

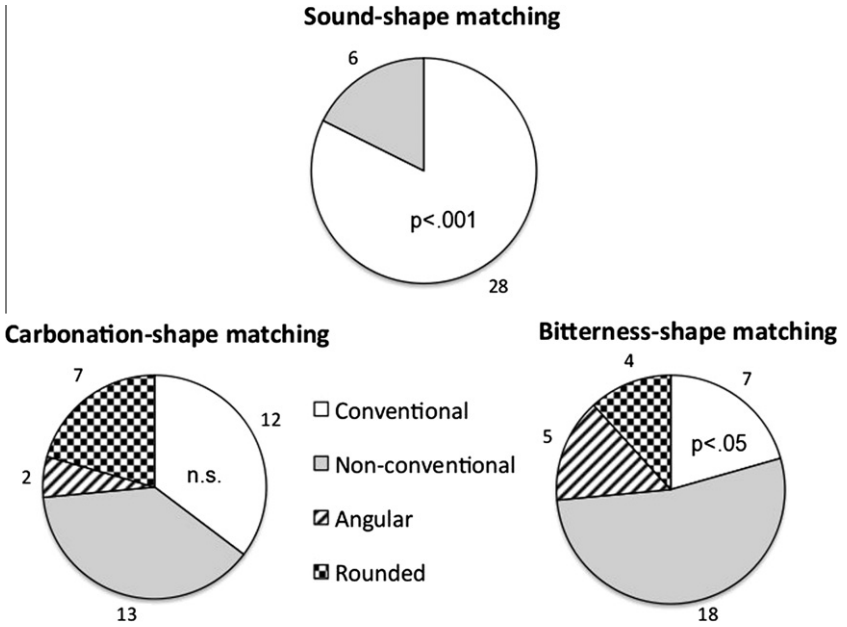

Fig. 2. Pie-charts displaying the numbers of participants falling into each of four crossmodal mapping categories across the three matching tasks. Membership of the categories indicates the pattern of responses that individuals made across the different trial types. In the Sound–shape matching task, "Conventional" (Western) mappings align the name "Bouba" with the rounded shape, and the name "Kiki" with the angular shape. In the Carbonation–shape matching task, "Conventional" Western mappings align lower levels of carbonation with the rounded shape, and higher levels of carbonation with the angular shape. In the Bitterness–shape matching task, "Conventional" Western mappings align lower levels of bitterness with the rounded shape and higher levels of bitterness with the angular shape. "Non-conventional" mappings in all tasks align shape and sound/taste dimensions in the opposite way. "Angular" mappings show a predominance of matches with the angular shape irrespective of bitterness or carbonation. "Rounded" mappings show a predominance of matches with the rounded shape irrespective of bitterness or carbonation. In the Sound–shape matching task, participants always assigned different names to different shapes, and so no participants fell into either the "Rounded" or "Angular" mapping categories. *p* Values report the findings of chi-squared tests comparing the number of participants adopting "Conventional" and "Non-conventional" mappings.

rounded, angular]; in other words, in the direction observed by Ngo et al., 2011). The non-conventional mapping category included those participants showing the opposite mapping trajectory, i.e., either [angular, rounded, rounded] or [angular, angular, rounded]. The angular mapping category included those participants who had predominantly mapped the angular shape to the three chocolate types and those who had shown no consistent relation between this and cocoa content, i.e., either [angular, angular, angular], or [angular, rounded, angular]. The rounded mapping category included those participants who had predominantly mapped the rounded shape to the three chocolate types and those who had shown no consistent relation between this and cocoa content, i.e., either [rounded, rounded, rounded], or [rounded, angular, rounded]. Chi-squared tests demonstrated that the numbers of participants in each category deviated from an even distribution, $\chi^2(3, N = 34) = 14.71$, $p = .002$. As seen in Fig. 2, this effect describes a tendency to map shape angularity (or roundedness) in a particular direction relative to the cocoa-content (bitterness) of the chocolate, as opposed to a preference to map one shape to the chocolate samples, regardless of the bitterness of those samples.

Again, we examined whether the mapping deviated from chance among those who demonstrated a directional mapping. As seen in Fig. 2 and 18 of the participants demonstrated a non-conventional mapping and 7 demonstrated a conventional mapping. Thus there was a reliable mapping of more bitter chocolate samples to the rounded shape, that is in the opposite direction to that shown by Western observers/tasters, $\chi^2(1, N = 25) = 4.84$, $p = .028$ (see Ngo et al., 2011).

4. Discussion

The Himba demonstrate a similar form of shape–sound symbolism to that shown by Westerners. That is, they preferentially link rounded shapes to the word "Bouba" and angular shapes to the word "Kiki". Prior to our study, what little published cross-cultural evidence there is regarding this phenomenon has been equivocal with regard to its universality (Davis, 1961; Rogers & Ross, 1975). Our finding is particularly striking given that it has been demonstrated in the Himba who live and have grown up in a rural environment which is largely devoid of Western artefacts. Indeed, as the Himba do not use a written language, our findings show that shape-symbolism effects can arise independently of any associations between shape and sound that may be present in orthography. These data therefore provide support for the view that this form of shape symbolism is a human phylogenetic provision or, at the very least, easily available from the statistical relations in the multisensory environment (e.g., Maurer et al.,

2006; Ramachandran & Hubbard, 2005; Spence, 2011; Spence, 2012; Walker et al., 2010)[2]. However, the Himba showed different preferences when matching to the same shapes samples of water (sparkling or still) and chocolate samples of varying levels of bitterness.

Whereas Westerners consistently link sparkling water to angular shapes, and still water to rounded shapes, the Himba, despite individually mapping a linear relationship between degree of carbonation of the water they tasted and the roundedness of the shapes, did not show a consistently similar direction of mapping (crossmodal correspondence) to that of Westerners. When it came to matching different kinds of chocolate with varying levels of bitterness, the Himba exhibited the opposite preference to that shown by Westerners (Ngo et al., 2011); that is, they were more likely to match less bitter chocolate (30% cocoa) with an angular shape than with a rounded shape and were also more likely to align chocolate samples containing more cocoa to the more rounded shape in their matches. Thus, we argue that in these cases of shape–flavour matching, cultural–environmental context plays an important role in determining the formation of multisensory associations.

Why might the cultural universality of shape symbolism vary with regard to the instances which we examined? Researchers have argued that some arbitrary crossmodal relations are phylogenetically provided because they are perceived by neonates, young infants, and young children (Maurer et al., 2012; Walker et al., 2010). Ramachandran and Hubbard's (2005) suggestion that phylogenetically provided, and thus universal, crossmodal correspondences are more likely restricted to adjacent brain regions could provide an explanation for why the Himba were more at variance with Westerners with regard to shape–flavour matching than with shape–name matching. Nevertheless, in order to explain cross-cultural differences in shape–flavour associations, it is also necessary to understand the cultural–environmental factors that might underlie such variation.

A number of researchers have argued that seemingly arbitrary crossmodal correspondences are learned via their statistical association in the environment (Bahrick & Licklier, 2012; Davis, 1961; Nielsen & Rendall, 2011; Spence, 2011); an account that certainly provides scope for explaining why different crossmodal correspondences might be observed between cultures. But what specific cultural–environmental factors might give rise to the pattern of results reported here? Before going on to examine such factors, we first rule out some alternative interpretations of our findings.

It is possible that aspects of the food samples presented other than their taste/flavour qualities might have influenced the matches made by the participants. Two particularly pertinent factors are the novelty of the samples, and their perceived pleasantness. We deal with each of these in turn. The chocolate and sparkling water samples were certainly much less familiar to the Himba than they are to Westerners. Could this novelty have led the Himba to match the food samples to shapes in the way that they did? We think this to be unlikely to two reasons. First, whilst novelty might plausibly explain the lack of consistency in the participants' matches with regard to the carbonation of the water we presented, there is no *a priori* reason to predict that the novelty of the chocolates (both bitter and milk chocolate are novel to the Himba) would drive the dimensional association which we observed with this particular foodstuff. Second, it is clear from the literature on sound-symbolic crossmodal matching that novel stimuli do not lead to Western or Japanese observers to match auditory and visual stimuli in ways which are not consistent with typical Western biases with regard to such stimuli. Imai et al. (2008), for instance, presented novel words and actions to young Japanese children; despite the novelty of these stimuli, the matches they observe run in the direction predicted by a theory of mimetics based on an analysis of Japanese (e.g., Kita, 1997). There thus seems little reason to predict that the novelty of food samples would lead the Himba to match chocolates to shapes in a direction which was counter to their normal tendency.

Another interpretation is that the Himba mapped foods to shapes in a different way to Westerners because they had a different perception of the pleasantness of the stimuli. There are certainly plenty of reasons to expect cross-cultural differences in perceived pleasantness in our tasks as it is well known that food preferences are particularly diverse across cultures (Rozin, 1983). For instance, a large part of the Himba's diet comprises sour milk which might be considered unpalatable in many Western countries. A similar preference for bitter foodstuffs could explain our findings. The Western tendency to associate more bitter chocolates with more angular shapes may be due to a reduced preference for both of these relative to more rounded shapes (see Bar & Neta, 2006) and less bitter chocolates.

However, two things argue against pleasantness as a driver of the effect we observed. First, our informal observations of the Himba's reactions to the water and chocolate samples indicated that they appeared to prefer the milk chocolates over the higher cocoa content samples, and the still water over the sparkling water. This is not consistent with a preference for bitterness or carbonation driving the Himba's non-conventional visual–flavour matches. Second, the literature also indicates that pleasantness of stimuli is not a strong driver of variations in crossmodal mapping, both within cultures, or between them. Crisinel and Spence (2012) find that perceived pleasantness is inconsistent in its influence on Westerners' matches between sounds and tastes. Furthermore, Iwasaki, Vinson, and Vigliocco (2007) have reported significant differences in the extent to which pleasantness determines sound-symbolic matches between British and Japanese participants.

So we return to the question of what cultural–environmental factors might drive the different ways in which the Himba match foods to shapes. The Himba showed no

[2] The only data which speaks against this interpretation is that of Rogers and Ross (1975). They were unable to observe a precursor to the "Bouba-Kiki effect", the "Maluma-Takete effect", in the Songe of Papua New Guinea. Unfortunately, Rogers and Ross provide very limited methodological detail in their report, thus making it difficult to determine possible sources of this variance.

evidence of a consistent association between smoothness/angularity of shape and the carbonation of the two water samples, whereas Westerners consistently match carbonated water with more angular figures (Gallace et al., 2011). There are numerous examples of matches between angular shapes and carbonated water in Western artefacts. For instance, San Pellegrino sparkling water has been sold in bottles with many prominent angular stars for more than a century (see Spence & Gallace, 2011; Spence & Ngo, 2012). Similarly, several other brands of carbonated water also involve similar angular imagery (e.g., Apollinaris has a red triangle/pyramid, while the Saskia brand uses a red star in the logo). Angularity is also associated with the logos of a number of major beer producers (see Spence, 2012, for a review). It is possible that a lack of similar associations in Kaokoland may have led to the absence of the sparkling-angular effect in the Himba.

It is perhaps more difficult to account for the finding that the Himba associated bitterness with the angular–rounded dimension in the opposite direction to that of Westerners; they associated the more rounded visual shape with more bitter chocolate samples. We propose an interpretation in which the different shape–flavour associations are mediated by the different sounds of the words used to denote particular tastes between the Himba and Western cultures.

If shape–sound associations such as the "Bouba-Kiki effect" are established developmentally prior to the acquisition of shape–flavour associations, these could play a role in guiding the direction of shape–flavour associations. Certainly, in agreement with our data concerning the universality of the "Bouba-Kiki effect", researchers have shown that shape–sound matches similar to the "Bouba-Kiki effect" are present in early life (Imai et al., 2008; Maurer et al., 2006; Walker et al., 2010). Thus, if the words denoting particular flavours or tastes contain a set of phonemic distinctions which are consistently or saliently related to flavour or taste, then flavour and taste words could direct the establishment of taste–shape matches via name–shape correspondences. In relation to this possibility, it is interesting to note that although Otjiherero does not appear to have an adjective for "bitter", the adjectives it uses to denote sourness[3] contain more of the vowel sounds which are associated with rounded shapes across culture (tart: "otjiruru" [ɔʃiruru], sour: "oujake" [ɔujake]), than does the adjective it uses to denote sweetness (sweet: "tjata" [ʃata]) (Nguaiko Calhoun, 2010). Thus, if the vowel sounds in words denoting bitter flavours are more readily associated with rounded shapes (i.e., via the classic "Bouba-Kiki effect"), flavour shape–flavour associations could follow suit, explaining the results found here.

We have shown that whereas some forms of crossmodal shape-symbolism appear to be universal (in this case the "Bouba-Kiki effect"), other forms (in this case, shape–flavour matches) vary across Western and remote cultures. The finding that the "Bouba-Kiki effect" is seemingly universal indicates that phylogenetic factors may play an important role in the shaping of some multisensory processes. This conclusion is in agreement with recent findings from human infants indicating that shape–sound symbolic effects may be in place as early as 4 months of age (Walker et al., 2010; although see Lewkowicz, 2011). However, the observation of different crossmodal correspondences between cultures necessitates an additional role for cultural–environmental factors in the ontogeny of multisensory processes (see also Bahrick & Licklier, 2012; Lewkowicz, 2011). It is important to note that further research will be important if we are to understand the cultural–environmental drivers of the crosscultural differences in flavour–shape matching which we have described. Indeed, research into flavour–shape matching is relatively new (at least in comparison to research on shape–sound symbolism), and further studies of these phenomena, even within the Western culture (and between laboratories) will shed more light on their exact nature and cultural demographics.

Cross-cultural research is crucial to gaining a more representative understanding of human cognition (e.g., see Arnett, 2008; Henrich, Heine, & Norenzayan, 2010). However, given the centrality of multisensory processes to human cognition, it is somewhat surprising to see that cross-cultural studies of cognitive processes have to date focussed almost exclusively on unisensory paradigms (but see Howes, 1991). This study on shape-symbolism in the Himba represents an attempt to begin bridging this gap. A great deal more cross-cultural research (across many cultures) will be needed in order to fully understand how multisensory processes arise from our cultural environment. Nonetheless, the findings reported here provide an important piece of this puzzle; they demonstrate that whilst some crossmodal correspondences (in this case between shape and sound) appear to have a universal basis, others vary substantially across cultures (in this case between shape and flavour). Further cross-cultural and developmental studies will be important if we are to understand both the phylogenetic and the cultural–environmental origins of our multisensory experience.

[3] When describing tastes, Westerners frequently confuse "sour" with "bitter" (e.g., O'Mahony, Goldenberg, Stedmon, & Alford, 1979).

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