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Can Nomenclature for the Body be Explained by Embodiment Theories?

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Abstract

According to widespread opinion, the meaning of body part terms is determined by salient discontinuities in the visual image; such that hands, feet, arms, and legs, are natural parts. If so, one would expect these parts to have distinct names which correspond in meaning across languages. To test this proposal, we compared three unrelated languages—Dutch, Japanese, and Indonesian—and found both naming systems and boundaries of even basic body part terms display variation across languages. Bottom-up cues alone cannot explain natural language semantic systems; there simply is not a one-to-one mapping of the body semantic system to the body structural description. Although body parts are flexibly construed across languages, body parts semantics are, nevertheless, constrained by non-linguistic representations in the body structural description, suggesting these are necessary, although not sufficient, in accounting for aspects of the body lexicon.

Keywords: Body parts; Lexicon; Semantic domain; Cross-linguistic; Cross-cultural; Body schema; Body structural description; Language and thought

1. Introduction

When it comes to the meanings of words, there is persistent disagreement on most of the fundamental issues. We have, on one hand, Chomsky (2000, p. 120) declaring: "The linkage of concept and sound can be acquired on minimal evidence … the possible sounds are narrowly constrained, and the concepts may be virtually fixed." At the same time, Evans and Levinson (2009, p. 429) claim: "languages differ so fundamentally from one another at every level of description (sound, grammar, lexicon, meaning) that it is very hard to find any single structural property they share."

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Independent of the issue of the universality or similarity of word meaning, questions about how best to characterize meanings are equally controversial. Some claim word meanings are assembled out of primitives (e.g., Goddard & Wierzbicka, 2014; Jackendoff, 2002), but there is no consensus as to what form these primitives might take. Are they symbolic/amodal (e.g., Goddard & Wierzbicka, 2014; Landauer & Dumais, 1997), sensory motor elements (e.g., Barsalou, 1999; Prinz, 2002), or perhaps some combination of both (Meteyard, Cuadrado, Bahrami, & Vigliocco, 2012)? But lest we conclude there is, at any rate, agreement on decompositional approaches to meaning, dissenting voices are apparent on this matter, too (c.f., Fodor, 1998; Fodor, Garrett, Walker, & Parkes, 1980). As Carey (2009, p. 29) argues: "No adequate definition has ever been provided for most concepts," pointing to a fundamental problem for the whole decomposition enterprise.

This plethora of views on the nature of meaning is characterized eloquently by Ray Jackendoff in his paper "What is a concept, that a person may grasp it." In it, he begins, "Asking a psychologist, philosopher, or a linguist what a concept is, is much like asking a physicist what mass is. An answer cannot be given in isolation. Rather, the term plays a central role in a larger world-view that includes the nature of language, of meaning, and of mind" (Jackendoff, 1989, p. 68).

Against this polemic backdrop, recent years have witnessed a resurgence of interest, within cognitive science and linguistic typology, in charting and explaining the meanings of words found across the world's languages. This was once a lively arena of investigation within anthropology, but it lost momentum along the way. Across a variety of domains—objects (e.g., containers, animals, plants), properties (e.g., colors, smells, numbers), and relations (e.g., kinship, locomotion, "cutting and breaking")—researchers have found considerable diversity in the notions lexicalized in particular languages (for reviews see Evans, 2011; Majid, 2014; Malt & Majid, 2013).

What is striking among the evidence of diversity is the underlying systematicity in how lexicons are structured cross-linguistically. Take the classic locus of investigation, color. Since Berlin and Kay's (1969) seminal work, we have known color lexicons in the world's languages vary in size. Some languages only have 2 "basic" color terms: 'black' and 'white'; whereas others have as many as 11. But the size of the color lexicon is not determined arbitrarily; there is a strong correlation between the number of terms a language has and societal complexity of the community speaking that language (Ember, 1978; Naroll, 1970). This correlation is likely due to the cultivation of dyes and pigments in larger, more socially stratified societies, which promotes lexicalization of color terms (e.g., Berlin & Kay, 1969; Levinson, 2000). At the individual level, cognitive forces play a critical role in structuring the color lexicon, too. Color categories in language are fitted to the human perceptual system, such that color terms pick out optimal partitions of color space (Regier, Kay, & Khetarpal, 2007) and support efficient communication (Regier, Kemp, & Kay, 2015).

It has long been assumed semantic domains other than color are amenable to the same sorts of generalizations and insights, but the critical cross-linguistic data are regrettably absent. Researchers are slowly beginning to build up the requisite empirically grounded

databases (e.g., Levinson, Meira, & The Language and Cognition Group, 2003; Majid, Boster, & Bowerman, 2008), but the number of studies are still limited. Part of the problem is methodological. For color, there is an external grid (e.g., Munsell color space), derived independent of the color terms of any language, that can serve as a basis for comparison across communities (although see Lucy, 1997a,b). Naming over this external space can then be compared using quantitative techniques. For other semantic domains it is not as straight-forward to derive such a grid, making systematic cross-linguistic comparison difficult.

The human body, however, provides such a basis for comparison. It is present in (more or less) the same form across communities; it is objectively measurable; and so it is possible to ask questions similar to those previously asked of the color domain. This study makes a small step in this direction by using a simple methodology to examine the categorization of body parts in three unrelated languages. We ask whether the body part lexicon is subject to cognitive constraints comparable to those found in the color lexicon. That is, do languages recognize the same parts identified in perception/action systems?

1.1. The body and its parts

Both clinical studies with patients and neuroimaging studies demonstrate the body is a distinct semantic domain in memory. Semantic knowledge of the body can be selectively impaired (e.g., Dennis, 1976; Sacchett & Humphreys, 1992; Suzuki, Yamadori, & Fuji, 1997) or preserved (e.g., Coslett, Saffran, & Schwoebel, 2002; Shelton, Fouch, & Caramazza, 1998; Warrington & McCarthy, 1987), and there are distinct cortical areas implicated in their processing (e.g., Le Clec'H et al., 2000; Schwoebel & Coslett, 2005). Some contend the body evolved as a distinct semantic domain because knowledge of the body is important for interaction with the environment and therefore critical for survival (e.g., Caramazza & Shelton, 1998; Shelton et al., 1998).

In fact, the body is so "basic" according to some versions of the embodiment framework, all mental content derives from the body. That we have the concepts we do is due to the bodies we have: "What is important is that the peculiar nature of our bodies shapes our very possibilities for conceptualization and categorization" (Lakoff & Johnson, 1999, p. 19). The body is, therefore, considered the template for structuring concepts, and much work has focused on spelling out the possible mappings (e.g., Heine, 1997; Kövecses, 1989; Svorou, 1994). Taking all of these strands together, one might expect considerable commonalities cross-linguistically in the semantics of the body.

Semantic knowledge of the body can be distinguished from two other distinct representations: (a) the *body structural description*, a topological map (primarily) derived from vision that defines body part boundaries and the absolute relations between parts; and (b) the *body schema*, which is the dynamic online representation of the relative locations of body parts in space (Sirigu, Grafman, Bressler, & Sunderland, 1991). So, where do body part *categories* come from? Whereas neuroscientists argue for three independent systems for representing body parts, others suggest body part categories can be read off the body structural description. According to Bloom (2002), for example, natural parts are

bounded, connected, and visually segmented along discontinuities in the surface image. So "a finger, for instance, is an excellent part because unpleasant as it is to think about—it is seen as having a potential separateness from the rest of the body, in that it can be cleanly severed." But "it is profoundly unnatural to think of the ring finger and the knee-cap as a single body part (a fingerknee) because fingers and knees are unconnected" (p. 109). Similar sentiments are echoed by the visual scientists Hoffman and Richards (1984, p. 82), who claim: "It is probably no accident that the parts defined by minima are often easily assigned verbal labels."

In a classic paper examining body terminologies across languages, the linguist Andersen (1978) similarly emphasized the importance of perceptual salience in the categorization of body parts, but rather than focusing on discontinuities she notes that features such as shape play a critical role in the meaning of many parts. Historically words for 'head' often come from 'bowl,' 'cup,' etc. (via an intermediate meaning of 'skull'), and words for 'back' come from 'bent,' or 'hind-part.' Based on an analysis of the etymology of body part terms in Indo-European, Buck (1949) similarly concludes that these words are most often related to notions of shape and position, rather than, for example, function.

To summarize, from a variety of perspectives, considerable uniformity in body part naming across languages is expected. But a cursory examination of the cross-linguistic facts brings to light some striking differences (see Table 1). In Indonesian there is no

Table 1
An illustration of the variable naming of limbs across languages. In bold are the languages under investigation in this paper

	Upper Arm	Lower Arm	Hand	Upper Leg	Lower Leg	Foot
Jahai (Burenhult, 2006)	*bliŋ*	*prbɛr*	*cyas*	*blɨˀ*	*gor*	*can*
Punjabi (Majid, 2006)	*bãã̃*		*hatth*	*lətt*		*pær*
Dutch	*arm*		*hand*	*been*		*voet*
Japanese	*ude*		*te*	*ashi*		
Yélî Dnye (Levinson, 2006)	*kêê*			*kpâ̂âlî*	*yi*	
Indonesian	*tangan*			*kaki*		
Savosavo (Wegener, 2006)	*kakau*			*nato*		
Lavukaleve (Terrill, 2006)	*tau*					*fe*

everyday word that corresponds to hand, and in Japanese there is none for foot. Despite the apparent obviousness of body parts, there is considerable variation across languages in which parts of a human body are singled out for reference (e.g., Majid, Enfield, & van Staden, 2006). Around a third of the world's languages have a single word for hand and arm (Brown, 2008; Witkowski & Brown, 1985), and a similar proportion collapse the distinction between foot and leg (Witkowski & Brown, 1985). Similar naming differences can be seen for other salient parts, such as body and head (Burenhult, 2006; Evans & Wilkins, 2001; Gaby, 2006; van Staden, 2006).

The lack of terms for hand, foot, or head problematizes how body part terms map onto the body structural description, since it appears there are multiple ways to name the same parts. Nevertheless, it is possible there are constraints on the extension of body part terms, such that terms are bounded by discontinuities (as color terms are constrained by discontinuities in the perceptual field). Alternatively, body part terms could be organized by some other principle, so there is no fundamental alignment to the body structural description. Note this question is not directly addressed by the previous literature. Despite detailed and insightful case studies of body part systems in specific languages (e.g., Evans & Wilkins, 2001; Liston, 1972; Palmer & Nicodemus, 1985; Stark, 1969; Swanson & Witkowski, 1977; see also papers in Majid et al., 2006), semantic details are often left vague. Researchers rely on English paraphrases as a way to explicate meanings (cf. Wierzbicka, 2007, 2013). Terms like Punjabi *bãã*, for example, are glossed as 'arm' (Majid, 2006) and Yélî Dnye *kpââlî* as 'upper leg' (Levinson, 2006), presupposing we already know the precise meaning of 'arm'[1] or 'upper leg.' Table 1 itself suggests equivalence between terms across languages.

To investigate the referential meaning of body part terms, we conducted a study with speakers of three unrelated languages: Dutch (Indo-European), Japanese (Japonic), and Indonesian (Austronesian). The languages were selected so as to be typologically and geographically unrelated to one another, to constitute a reasonable test of the hypothesis that semantics of body part terms vary across languages. Importantly, a preliminary investigation of body part nomenclature had shown the three languages varied in how they refer to the limbs (see Table 1), making them interesting candidates for testing how the terms map onto the body structural description. In other characteristics the languages are comparable: They are all national languages with wide spread literacy. This means any differences in the study are not likely due to these extraneous factors.

Speakers were asked to color-in the area referred to by body part terms in their language on an outline of a human body. This rather simple method allows us to test whether, despite the apparent variation, body part terms nevertheless respect perceptual discontinuities. That is, if the body structural description constrains body part meanings then the areas colored in by speakers should not differ, and boundaries should be in similar places, specifically at salient discontinuities in the image. If, on the other hand, body part boundaries are assigned on the basis of some other factor, then we would not expect to see alignment between languages.

2. Method

2.1. Languages and participants

Data were collected from three unrelated national languages in the countries indicated in brackets: Dutch (Netherlands), Japanese (Japan), and Indonesian (Indonesia). There were 25 participants altogether, comprised of eight Dutch, eight Indonesian, and nine Japanese speakers.

2.2. Stimuli

On separate sheets of paper, an empty line drawing of an androgonized (originally female) body (van Staden & Majid, 2006) appeared with a body part term in the native language written on the top right hand corner. For each language, we selected 15 different body part terms. The terms differed slightly from language to language, in part because a direct translation was not always available. For example, while Dutch has separate terms for hand and arm (*hand*, *arm*), and foot and leg (*voet*, *been*), Japanese collapses the distinction between foot and leg with a single term (*ashi* 足), while there are two terms for hand-arm (*te* 手 and *ude* 腕).[2] Indonesian, on the other hand, has only two distinct terms here, *kaki* for foot-leg and *tangan* for hand-arm. Table 2 presents the full list of materials presented, with approximate glosses in English. The glosses are for the convenience of the reader; we make no claim that they correspond to the native concepts.

Each term was presented twice to each speaker, to test for participant consistency, once with an arrow to the left side of the picture and once on the right for objects that were sided (e.g., hand), but no arrow was present for non-sided parts (e.g., belly). The 15 terms were presented in two blocks, each of which was randomized within participant. Left and right blocks were counterbalanced across participants.

2.3. Procedure

Participants were given a booklet and a fine-liner blue pen. They were told that the booklet contained pictures of a body and their task was to color-in the body part named on that page. Where a word could refer to one of two body parts, they were told to color-in the part on the side indicated by the arrow. The participants were told to color-in all, and only, the body part named on the page, clearly indicating boundaries. Finally, they were asked to begin at page one, and only once they were finished turn to the next page. They were told not to look through the booklet, and not to look back once they had turned the page. Experimenters monitored the procedure.

Table 2
List of body part terms used in the coloring-in experiment. In some cases the closest translation equivalent across languages was not clear a priori so multiple terms were included (e.g., for belly). Glosses indicate current best translation. Terms in gray were omitted from the task.

Dutch Data collected by Miriam van Staden		**Japanese** Data collected by Sotaro Kita		**Indonesian** Data collected by Dick van der Meij	
hoofd	**head**	頭	**head**	*kepala*	head
hals	**neck**	首	**neck**	***leher***	**neck**
hand	**hand**	手	**hand**	***tangan***	**hand/arm**
arm	**arm**	腕	**arm**		
voet	**foot**	足	**foot/leg**	***kaki***	**foot/leg**
been	**leg**				
borst	**chest**	胸	**chest**	***dada***	**chest**
buik	**belly**	おなか	**belly**	***perut***	**belly**
maag	**stomach**				
				pinggang	**waist**
				pinggul	**hip**
gezicht	**face**	顔	**face**	***muka***	**face**
oog	**eye**	目	**eye**	***mata***	**eye**
neus	**nose**	鼻	**nose**	***hidung***	**nose**
mond	mouth	口	**mouth**	***mulut***	**mouth**
oor	**ear**	耳	**ear**	***telinga***	**ear**
voorhoofd	forehead	ひたい	**forehead**	***dahi***	**forehead**
kin	**chin**	あご	**chin**	***dagu***	**chin**
wang	**cheek**	ほお	**cheek**	***pipi***	**cheek**

3. Results

All the colored-in booklets were scanned for further processing. Because participants differed in how diligently they colored-in areas (see Fig. 1), the pixel density of the colored-in image differed. Therefore, we used Adobe Photoshop to homogenize the density, covering the exact area the participants had demarcated under each body part term. We then measured the area that was colored-in for each body part term in number of pixels, and this was used to calculate the statistics reported below. If speakers of

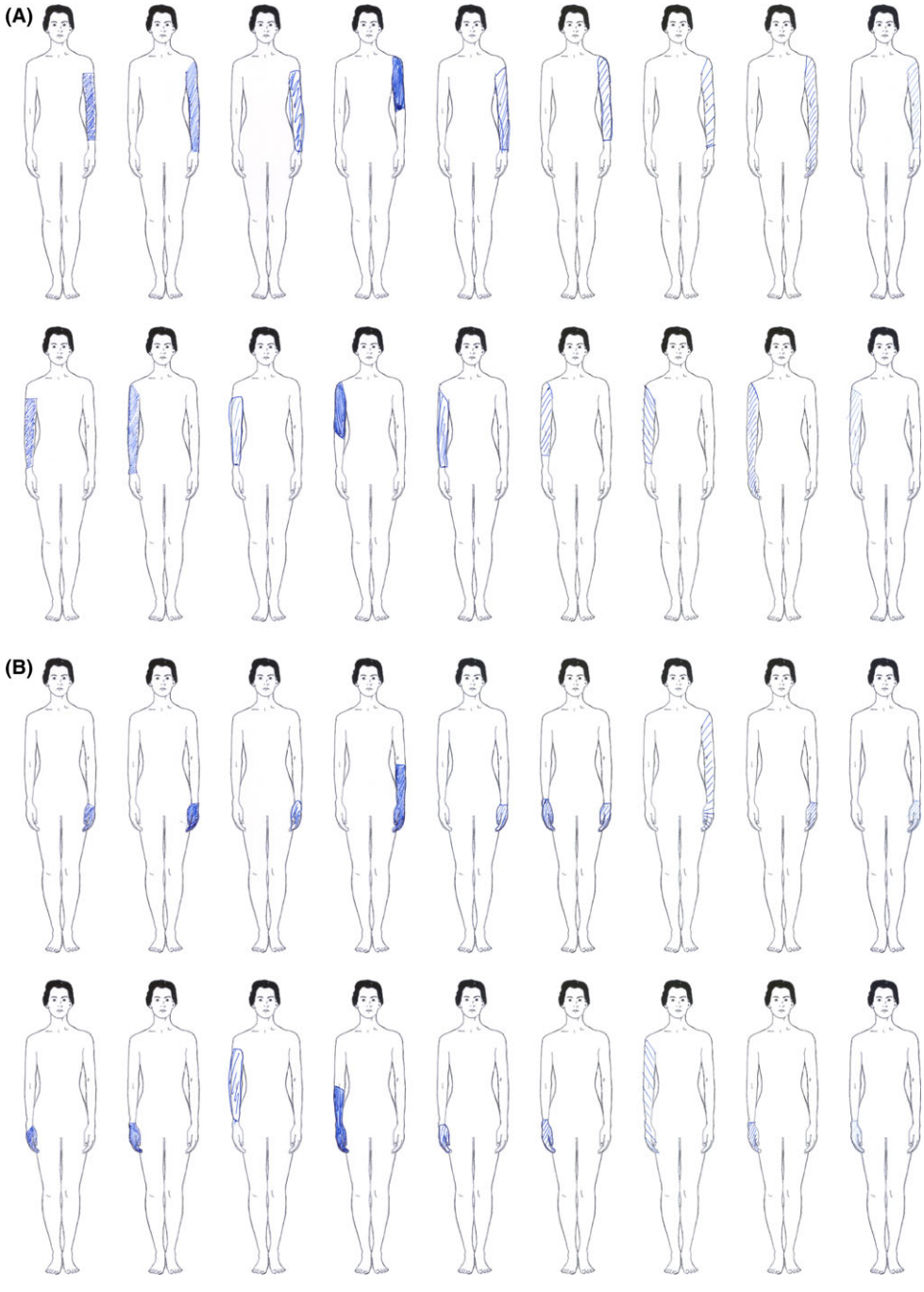

Fig. 1. (A) Coloring-in for the left and right side of the body for Japanese *ude* 腕 'arm.' (B) Coloring-in for the left and right side of the body for Japanese *te* 手 'hand.'

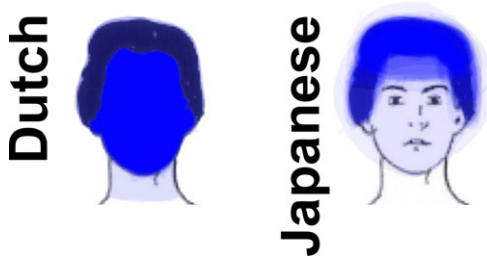

Fig. 2. Composite images of Dutch and Japanese 'head.' In this image, and the following, the darker the image, the more speakers colored-in that part of the body.

different languages differ reliably in where they place the boundaries of body parts, then the areas colored-in should differ, too.[3]

We first present the analyses for the large parts of the body: head, neck,[4] followed by arms and hands, and then legs and feet (cf. Tversky, 1989). These parts ought to be well delimited by perceptual discontinuities and therefore similar across languages. Less well-defined large parts—chest and belly—follow. We then present the results for the face and its parts, first bounded (i.e., eye, nose, mouth, and ear) and then non-bounded parts (i.e., forehead, chin, and cheek).

3.1. Head

We focus first on the comparison between Dutch *hoofd* and Japanese *atama* 頭. Due to experimenter error, we do not have data for the equivalent Indonesian term. Japanese *atama* 頭 appears not to include the face in its scope as seen in Fig. 2. Only one Japanese participant colored-in the face; the rest only colored-in the top most part of the head. All the Dutch participants colored-in the whole head, including the face. A chi-square (with Yates' correction) on the number of participants in each language group who included the face or not confirmed that Japanese speakers were less likely to include the face in *atama* 頭 than Dutch speakers were in *hoofd* χ^2 (1, N = 17) = 10.10, p = .0015.

This difference was reflected in the pixel counts too. A smaller area was colored in by Japanese speakers (M = 13,783 pixels) than Dutch speakers (M = 18,547 pixels). To test whether the difference in pixel count was statistically significant, we compared the area colored-in by participants using a mixed ANOVA with language as a between-participants factor (comparing Dutch and Japanese) and presentation block (first vs. second presentation of the term) as a within-participants factor. Remember, participants were presented with the same term in two blocks (to test for within-participant consistency). The difference between languages in pixels was not statistically reliable at the conventional level of significance $F(1, 15) = 3.41$, $p = .08$, $\eta_p^2 = .19$. There was, however, a difference between presentation blocks, where people colored-in a slightly larger area on second presentation of the 'head,' but there was no interaction between presentation block and language $F(1, 15) = 1.29$, $p = .33$, $\eta_p^2 = .06$. The difference over presentation blocks

was not related to whether the face was colored-in or not, but rather how much of the hair area was colored.

Taken together, these analyses suggest the apparently synonymous terms *atama* 頭 and *hoodf* may, in fact, differ in their exact reference. *Atama* 頭 does not seem to refer to the whole head for all Japanese speakers.

3.2. Neck

The 'head' is connected to the 'body' by the 'neck,' a perceptually distinct part. We compared whether speakers of Dutch, Japanese, and Indonesian differed in the area they colored-in by conducting a mixed ANOVA with language (Dutch-Japanese-Indonesian) as a between-participants variable and presentation block (first-second) as a within-participants variable. The dependent variable was the number of pixels colored-in. The same analyses are conducted hereafter for the other body parts. Comparison of the area colored-in for the 'neck' terms in the three languages showed no significant main effects of language $F(2, 22) = 3.10$, $p = .065$, $\eta_p^2 = .22$, presentation block $F(1, 22) = .01$, $p = .92$, $\eta_p^2 = .00$, nor an interaction $F(2, 22) = .71$, $p = .50$, $\eta_p^2 = .06$. Dutch *hals* ($M = 6{,}048$), Japanese *kubi* 首 ($M = 4{,}672$), and Indonesian *leher* ($M = 5{,}433$) appear to have similar extensions.

3.3. Hand-arm

Only Dutch and Japanese have distinct terms for hand and arm; Indonesian speakers use a single term *tangan* (see Fig. 3). For the purposes of statistical comparison, we therefore first compared the area colored-in for *hand* in Dutch and *te* 手 in Japanese. Comparison of the area colored-in by Dutch and Japanese speakers by pixel count showed no significant effect of language $F(1, 15) = 2.56$, $p = .13$, $\eta_p^2 = .15$, presentation block $F(1, 15) = .75$, $p = .40$, $\eta_p^2 = .05$, nor an interaction $F(1, 15) = .17$, $p = .69$, $\eta_p^2 = .01$. Fig. 3 shows that Dutch and Japanese speakers color-in the area from fingertips-to-wrist. In addition, for *te* 手, one Japanese participant also colored-in the area from wrist-to-elbow, and another the area from wrist-to-shoulder. This is reflected in the descriptive statistics (*te* 手 $M = 10{,}776$ vs. *hand* $M = 6{,}483$).

We then compared Dutch *arm* with Japanese *ude* 腕. There was a main effect of language $F(1, 15) = 4.90$, $p = .04$, $\eta_p^2 = .25$, but there was no effect of presentation block $F(1, 15) = 2.91$, $p = .11$, $\eta_p^2 = .16$, nor an interaction $F(1, 15) = 1.92$, $p = .19$, $\eta_p^2 = .11$. Japanese speakers colored-in a smaller area ($M = 21{,}154$) than Dutch speakers ($M = 25{,}322$). Only 1 Japanese speaker included the hand in the extension of *ude* 腕 whereas half the Dutch speakers included the hand in the extension of *arm.*

How do *ude* 腕 and *arm*, in turn, compare to Indonesian *tangan*? A three-way comparison between languages showed no significant main effect of language $F(2, 22) = 2.22$, $p = .13$, $\eta_p^2 = .17$. Indonesian speakers colored-in both the hand and arm for *tangan* (aside from one speaker who only colored-in the hand area). There was a significant interaction of language and presentation block $F(2, 22) = 4.74$, $p = .02$, $\eta_p^2 = .30$, indi-

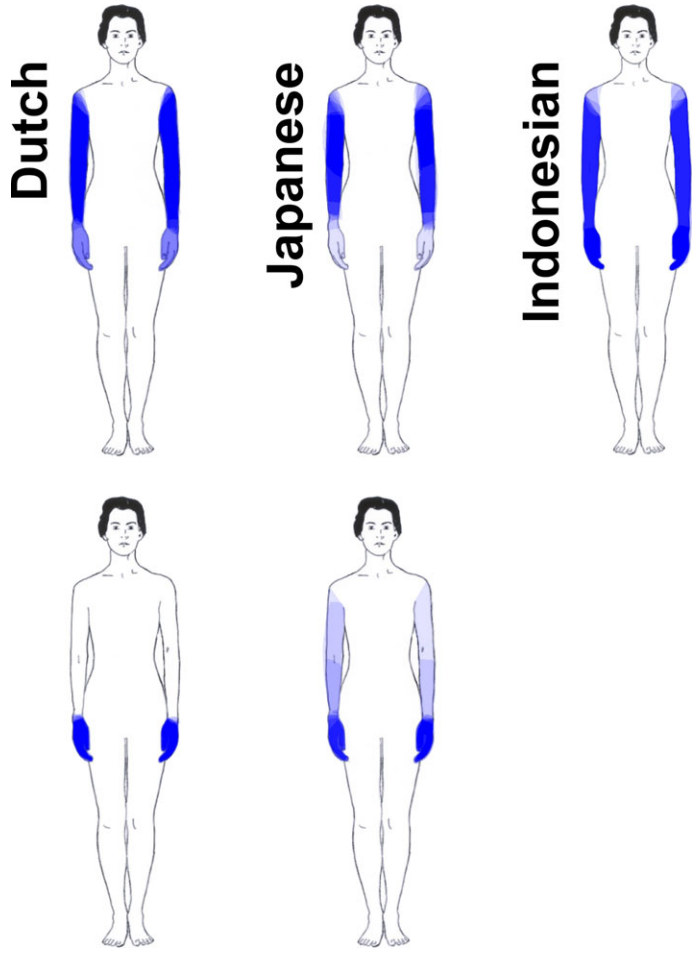

Fig. 3. Composite images for 'hand-arm' in Dutch, Japanese, and Indonesian. Indonesian does not have distinct terms for 'hand' and 'arm'.

cating variation within individuals over the presentation conditions (i.e., coloring-in the left vs. right side of the body).

3.4. Foot-leg

For 'foot-leg,' only Dutch has distinct terms, whereas both Japanese and Indonesian use a single term *ashi* 足 and *kaki*, respectively (see Fig. 4). We compared the extension of these two terms and found no significant main effects of language, $F(1, 15) = .68$, $p = .42$, $\eta_p^2 = .04$, presentation block $F(1, 15) = 1.176$, $p = .29$, $\eta_p^2 = .07$, nor an interaction $F(1, 15) = .20$, $p = .66$, $\eta_p^2 = .01$. Japanese speakers tended to color-in both the foot and the leg areas, aside from one speaker who only colored-in the leg (excluding foot), and one who

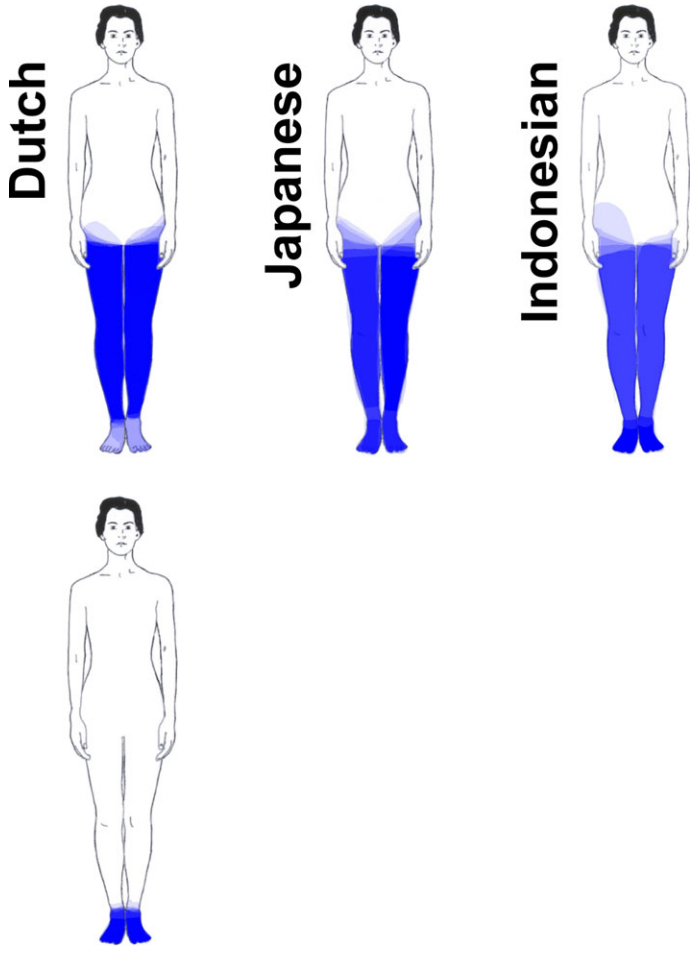

Fig. 4. Composite images for 'foot-leg' in Dutch, Japanese, and Indonesian. Note that only Dutch has distinct terms for these parts.

only colored in the foot (excluding leg). This participant colored-in the whole foot-leg in the second presentation block. Indonesian speakers all colored-in the foot. Most also colored-in the leg area; two participants did not and this was consistent across presentation blocks.

Given that *ashi* and *kaki* do not differ significantly from one another, one could ask whether their extension is the same as that of Dutch *been* 'leg,' and the answer appears to be no. There is a substantial main effect of language $F(2, 22) = 23.50$, $p < .001$, $\eta_p^2 = .68$. Post-hoc Bonferroni tests showed both the Japanese *ashi* (M = 562,030) and Indonesian *kaki* M = 483,942 differed significantly from Dutch *been* (M = 57,694). Dutch speakers were less likely to include the foot in the extension of *been*, presumably due to the existence of *voet* 'foot.' There also appear to be differences in where people think the 'leg' term ends across groups. Dutch speakers were more likely to end in a straight line as the legs hit the body, but Japanese speakers (and to some extent

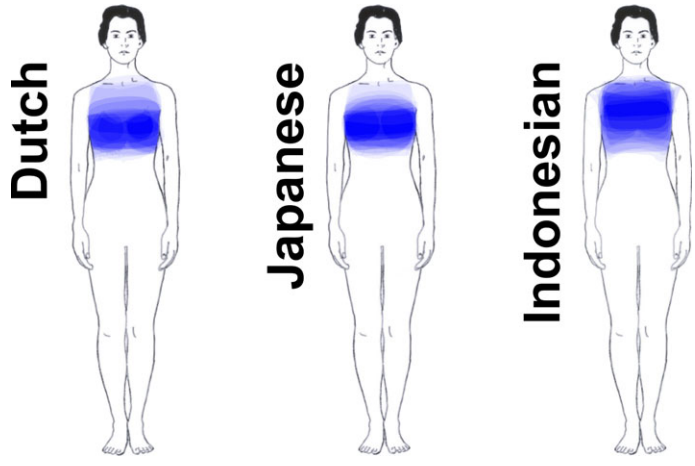

Fig. 5. Composite images for 'chest' in Dutch, Japanese, and Indonesian.

Indonesian speakers, too) were more likely to include areas of the hip, discarding the overt perceptual discontinuity in the image (see Fig. 4).

3.5. Chest

Unlike the previous body parts, 'chest' is not necessarily a perceptually well-bounded area, and thus potentially this part may display more variation cross-linguistically. Statistical comparison of the three languages showed no significant main effect of language $F(2, 22) = 1.19$, $p = .32$, $\eta_p^2 = .10$, presentation block $F(1, 22) = 2.75$, $p = .11$, $\eta_p^2 = .11$, nor an interaction between the two $F(2, 22) = .33$, $p = .72$, $\eta_p^2 = .03$. Fig. 5 shows that within each of the languages there was considerable variation between participants regarding the extension of Dutch *borst* ($M = 32{,}045$), Japanese *mune* 胸 ($M = 30{,}863$), and Indonesian *dada* ($M = 39{,}435$). From Fig. 5 it is discernable that while some participants colored-in the chest area, others imposed two breasts and colored those instead. This reflects a common pattern historically, where terms referring to 'chest' often come to mean 'breast' (cf. Wilkins, 1981).

3.6. Belly

Like 'chest,' 'belly' is not a perceptually well-defined part. There were two terms for the 'belly' in Dutch *buik* and *maag*, the latter of which participants took to refer to the internal stomach, and they correspondingly colored-in a smaller area for this $t(7) = 4.46$, $p < .003$ (see Fig. 6). For the cross-linguistic comparison, we compared *buik* with the corresponding Japanese and Indonesian terms (see Fig. 7). There were no significant main effects of language $F(2, 22) = .59$, $p = .56$, $\eta_p^2 = .05$ (Dutch $M = 38{,}683$; Japanese $M = 34{,}302$; and Indonesian $M = 31{,}618$), presentation block $F(1, 22) = .60$, $p = .45$,

Fig. 6. Dutch participants color-in *maag*. Participants interpret *maag* as referring to the internal organ 'stomach' and display uncertainty in exactly where that organ is located.

η_p^2 = .03, nor an interaction $F(2, 22) = 2.76$, p = .85, η_p^2 = .20. Like 'chest' there was considerable within-group variation among speakers for all three languages, likely reflecting the lack of boundedness.

3.7. Face

We now move on to consideration of the face and its parts. Comparison of the three language's 'face' terms: Dutch *gezicht* (M = 14,323), Japanese *kao* 顔 (M = 14,409), and Indonesian *muka* (M = 12,995), showed no significant effect of language $F(2, 22) = 1.12$,

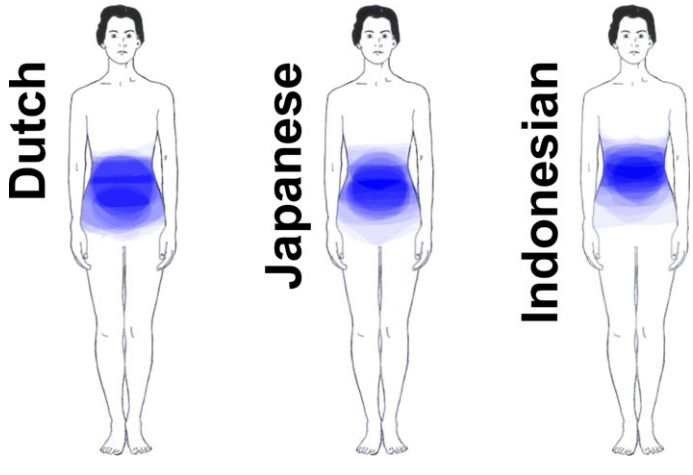

Fig. 7. Composite images for 'belly' in Dutch, Japanese, and Indonesian.

$p = .34$, $\eta_p^2 = .09$, presentation block $F(1, 22) = .91$, $p = .35$, $\eta_p^2 = .04$, or an interaction $F(2, 22) = .71$, $p = .50$, $\eta_p^2 = .06$.

3.8. Eye

Within the face there are perceptually bounded and non-bounded parts. First, we consider each of the bounded parts in turn. For 'eye': Dutch *oog* ($M = 327$), Japanese *moku* 目($M = 441$), and Indonesian *mata* ($M = 362$), there were no significant main effects of language $F(2, 22) = 2.08$, $p = .15$, $\eta_p^2 = .16$, presentation block $F(1, 22) = .60$, $p = .45$, $\eta_p^2 = .03$, nor an interaction $F(2, 22) = 1.88$, $p = .18$, $\eta_p^2 = .15$.

3.9. Nose

Dutch *neus* ($M = 812$), Japanese *hana* 鼻 ($M = 813$), and Indonesian *hidung* ($M = 705$), were equivalent across languages $F(2, 22) = 1.90$, $p = .17$, $\eta_p^2 = .15$. There was no significant effect of presentation $F(1, 22) = 1.60$, $p = .22$, $\eta_p^2 = .07$, nor an interaction effect $F(2, 22) = .31$, $p = .74$, $\eta_p^2 = .03$.

3.10. Mouth

There were no significant main effects of language $F(1, 15) = 1.02$, $p = .33$, $\eta_p^2 = .06$ (Japanese *kou* □ $M = 544$; Indonesian *mulut* $M = 484$),[5] presentation $F(1, 15) = 1.42$, $p = .23$, $\eta_p^2 = .09$, nor an interaction $F(1, 15) = .29$, $p = .87$, $\eta_p^2 = .002$.

3.11. Ear

'Ear' is also a well-bounded part but within our image, the ear was not clearly visible (part of it was obscured by hair; see, for example, Fig. 8). On this part then, there was a main effect of language $F(2, 22) = 785$, $p < .0001$, $\eta_p^2 = .97$. Dutch speakers colored-in less area for *oor* ($M = 434$) than Japanese speakers did for *mimi* 耳 ($M = 613$), or Indonesian for *telinga* ($M = 665$) (but the difference between Japanese and Indonesia was not significant), as confirmed by post-hoc Bonferroni tests. There was also a significant effect of presentation order $F(1, 22) = 7.01$, $p < .02$, $\eta_p^2 = .24$, likely due to the fact that one side of the head had more of the ear visible than the other. There was no interaction effect $F(2, 22) = .32$, $p = .73$, $\eta_p^2 = .03$.

3.12. Forehead

We now move to the non-perceptually bounded face-parts. First, the 'forehead': statistical analyses showed no difference between languages $F(1, 15) = .19$, $p = .67$, $\eta_p^2 = .01$. The Japanese speakers colored-in a comparable area for ひたい ($M = 3{,}771$) as Indonesian speakers did for *dahi* ($M = 3{,}646$).[6] There was no effect of presentation block

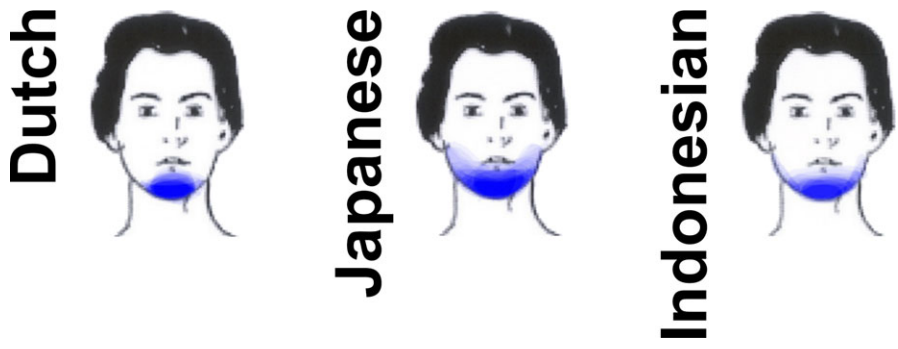

Fig. 8. Composite images for 'chin' in Dutch, Japanese, and Indonesian.

$F(1, 15) = .39$, $p = .85$, $\eta_p^2 = .003$, nor an interaction $F(1, 15) = 1.50$, $p = .24$, $\eta_p^2 = .09$.

3.13. Chin

Japanese *gaku* あご covered a much larger area than Dutch *kin* or Indonesian *dagu* $F(2, 22) = 6.78$, $p < .005$, $\eta_p^2 = .38$ (see Fig. 8). Post-hoc Bonferroni tests showed that Japanese ($M = 1{,}987$) significantly differed from both Dutch ($M = 1{,}047$) and Indonesian ($M = 1{,}140$), but Dutch and Indonesian did not differ from each other. There were no other main effects: presentation block $F(1, 22) = 2.71$, $p = .11$, $\eta_p^2 = .11$, nor an interaction $F(2, 22) = .38$, $p = .69$, $\eta_p^2 = .03$.

3.14. Cheek

As with 'chin,' 'cheek' showed significant differences across languages $F(2, 22) = 18.34$, $p < .0001$, $\eta_p^2 = .63$. Post-hoc tests showed Dutch *wang* ($M = 10{,}448$) covered substantially more area than both Japanese *kyo* ほお ($M = 1{,}596$) and Indonesian *pipi* ($M = 1{,}710$), but those two languages did not differ from each other. There was no significant effect of presentation block $F(1, 22) = .26$, $p = .61$, $\eta_p^2 = .01$, or an interaction $F(2, 22) = .89$, $p = .42$, $\eta_p^2 = .08$.

4. General discussion

Despite the wide-spread importance assigned to the body and its parts across the cognitive-and neuro-sciences, there is little explicit consideration of what constitutes a part (cf. De Vignemont, Tsakiris, & Haggard, 2005). This study examined the segmentation of body parts in Dutch, Japanese, and Indonesian to establish whether parts in language follow "universal" principles.

First, let's consider patterns of lexicalization: Which parts are distinctly lexicalized across languages? Neuroscientific theories posit multiple representations of the body (e.g., Schwoebel & Coslett, 2005; Sirigu et al., 1991); nevertheless, parts are often assumed to be segmented according to universal principles, such as shape, size, orientation, and most important, visual discontinuities (see also Andersen, 1978; Bloom, 2002; Brown, 1976). However, the data suggest a more complex picture than what might appear at first glance: Table 1 shows the English partonomy is one of but many possible partonomies. Across languages, there is a range of lexicalization strategies for basic reference to the limbs.

Despite the perceptual distinctness of hands and feet, and their functional salience (cf. Morrison & Tversky, 2005; Wierzbicka, 2007), these parts do not receive distinct names universally. Why not? Is this evidence for arbitrary forces at work in nomenclature for the body? We suggest not. For languages that conflate the hand-arm (or foot-leg) distinction, it is possible that the semantic system is acutely attuned to the realities of action. When we move our hands to pick up an object, wave goodbye, or write a letter, the whole arm is recruited in executing those movements. In a tactile perception study, De Vignemont, Majid, Jola, and Haggard (2009) showed that English speakers perceive the same distance to be relatively further apart when across parts (i.e., hand and arm) than within parts. However, action (voluntary flexion-extension movements at the wrist) minimizes the perceived distance between the hand and arm; that is, the same distance now does not seem as big. Action unites parts. So, terms in languages that collapse the hand-arm distinction in their basic vocabulary could be grounded not in the visual system, but in the motor system instead.

The coloring-in study revealed further differentiation between languages. According to Table 1, Dutch and Japanese have the "same" distinction between 'arm' and 'hand.' But the coloring-in task showed while half the Dutch speakers include 'hand' in the meaning of *arm*, the majority of Japanese speakers do not include it in *ude* 腕. Conversely, no Dutch speaker included the 'arm' under the province of *hand*, but some of the Japanese speakers included the 'arm' under *te* 手 (see Figs 1A, B). This provides additional illustration of the dangers of relying on English as a meta-language when comparing meanings across languages; and points to the advantages of utilizing a neutral "etic" space (a non-linguistic representation) for better capturing the otherwise invisible differences in reference between specific languages.

Striking in the face of this variation is the fact that speakers in all three languages were exquisitely sensitive to visual discontinuities when mapping body part terms to the line drawings of the body. For example, when coloring-in Japanese *te* 手 speakers colored either to the wrist, the elbow, or the shoulder. This tailoring to discontinuities is also discernable from the cross-linguistic perspective (e.g., in Table 1). This sensitivity to discontinuities was true for other body parts too; especially bounded, connected, and visually segmented parts—such as the eye, nose, and mouth.

Taken together these findings suggest there cannot be a one-to-one mapping between lexical representations and the body structural representation. If that were true then we would be forced to the conclusion that the body structural representation is different for speakers of different languages, and therefore culturally relative. There is no evidence for

this radical proposal. Based on the current evidence, the body structural representation is not determined by language. Nevertheless, linguistic and non-linguistic representations cannot be completely independent; they must be tightly coupled and arranged in slightly different ways for speakers of different languages. This is supported by the coloring-in data: Speakers are clearly attuned to visual discontinuities, but the specific discontinuities they pay attention to are language-specific.

The results of the coloring-in task also cast new light on variation in body part meanings within languages. For example, people differed in precisely where they thought the 'arm' or 'leg' began and ended. Unbounded parts, such as the 'chest,' 'belly,' and 'forehead' showed comparable extensions across Dutch, Japanese, and Indonesian, but considerable disparities within languages. Variation in the precise boundaries of parts appears more extreme for these unbounded parts (see Figs. 5 and 7), most likely reflecting the lack of perceptual cohesion. Dutch speakers showed similar, and spectacular uncertainty in where their internal organ, the stomach, was located (Fig. 6).

Another locus of variation was in the extension of 'chin' (Fig. 8). Japanese shows a much larger extension for this term than Dutch or Indonesian. This could be because the chin is unbounded and hence not a natural part. But there is at least one additional factor at play here, too. Both Dutch and Indonesian have a distinct term for 'jaw,' which everyday Japanese lacks, hence allowing this term to occupy a larger area. Having a word for a body part term in a language acts as a cue to segment that part of the body. It is as if the terms for 'chin' and 'jaw' were competing with each other to occupy areas of the face. There is increasing evidence that learning can affect which parts form conceptual units (Schyns, Goldstone, & Thibaut, 1998). We suggest that labeling of body part categories is a real-world illustration of this general principle.

4.1. Broader implications

The approach taken in this study emphasizes sensory motor representations and suggests the meaning of body part terms can be couched in embodied terms. By testing the exact extension of body parts, we were able to reveal systematic patterns across languages not easily captured in purely symbolic or amodal representations. The question pertaining to exact boundaries of body part terms is simply not addressable when assuming amodal primitives. However, it would be remiss to suggest this modest study in any way captures the full lexical semantics of any body part term. Apart from information about the typical shape of a body part, Kemmerer and Tranel (2008) suggest body part terms also encode information about (a) the location of that part within the body, (b) its characteristic functions, and (c) cultural associations. To capture the full richness of lexical knowledge in this domain, a combination of modal and amodal representations are going to be required.

Despite its limited scope, this study nevertheless carries several implications for broader theories of meaning. We believe this study falsifies Chomsky's assertion that "concepts may be virtually fixed," while simultaneously casting doubt on Evans and Levinson's equally radical claim that "languages differ so fundamentally from one

another ... that it is very hard to find any single structural property they share." Body part terms are certainly not fixed, but they do share at least one structural property—that is, sensitivity to perceptual discontinuities.

The kind of regularities uncovered here are reminiscent of Berlin and Kay's implicational hierarchy for colors which they also dubbed a "universal." They argued languages evolve lexicons in a predictable manner, such that if a language has four terms they will be 'black,' 'white,' 'red,' and then either 'green' or 'yellow' (see Berlin & Kay, 1969, p. 4). The original hierarchy has been modified several times to account for the growing body of cross-cultural data (e.g., Kay, Berlin, Maffi, Merrifield, & Cook, 2009; Kay & Maffi, 1999; Kay & McDaniel, 1978; Kay, 1975; see Biggam, 2012 for a review). One of the critical modifications has been a re-casting of the generalizations so as to better capture the content of color categories. 'Black' and 'white' have different referential import if they are in a system of two terms, or if they exist in a cohort of eleven. 'Black' in a two-term system covers monochromatic black, but also other dark hues such as green and blue; and is better glossed as 'dark.' 'White' refers to monochromatic white, but also the warmer hues of red and yellow; better glossed as 'light.'

The newer implicational hierarchy still provides restrictions to the possibilities for successively dividing color space in language, although now the trajectory is no longer unidimensional. For example, a four term language could have any of the following categories (e.g., Kay & Maffi, 1999; Kay et al., 2009):

<white, red + yellow, green + blue, black> or
<white, red, yellow, black + green + blue> or
<white, red, yellow + green + blue, black>

Berlin and Kay's original hierarchy was geared toward capturing the generalization over focal colors, or the best examples of colors. The more recent versions give a sense of the extension of the terms too.

Inspired by Berlin and Kay, Andersen and Brown proposed implicational hierarchies for body part nomenclature in the 1970s; for example, Andersen (1978, p. 352) proposed if a language has a term for 'leg' then it has a term for 'arm,' and if there is a term for 'foot' then there is a term for 'hand' (see also Brown, 1976). Recent explorations into body terminologies suggest wrinkles to the Andersen/Brown generalizations: for example, Lavukaleve has a simple term for 'foot' but not for 'hand' (Terrill, 2006). The Japanese data here pose further challenges. Arguably there are terms for 'leg' and 'arm,' but their relative extensions are different: one covers the extremity 'foot' but the other does not seem to have the same scope over 'hand.' Do we want to take this as evidence for the claim (a term for 'leg' entails a term for 'arm'), despite the differences in extensions? A closer examination of these typological generalizations is required in light of the emerging data.

One last point of comparison between color and body parts regards their category structure. For color, people show uncertainty at the boundaries, but typically agree on the best example (although see, e.g., Davidoff, Davies, & Roberson, 1999). With body parts, people are also uncertain about the precise boundaries, as this study demonstrates, but it is less clear whether best examples can be found. Berlin and Kay asked people to indicate

"the best, most typical examples of *x*" (p. 7) for an array of colors. But it simply does not make sense to request for the body "point to the best, most typical example of *arm*" on a picture of the human body. Instead, the body domain highlights different issues. For example, we might worry about whether a term like *arm* is ambiguous or vague: If half the Dutch speakers color-in the hand as well as the area between wrist and shoulder, does that mean there are two distinct meanings of *arm*: one with and one without hand; or is *arm* simply vague? (See Evans & Wilkins, 2001; Majid, 2010, 2014 vs. Wierzbicka, 2007, 2013 for differing positions on this issue.)

Finally, it is intriguing to consider whether the variation revealed in this study has implications for other areas of the lexicon. As stated in the introduction, many scholars assume the body is a template for structuring other concepts, such as space (e.g., Heine, 1997; Svorou, 1994) and emotion (e.g., Enfield & Wierzbicka, 2002; Kövecses, 2003; Lakoff, 1987). But within this tradition, the notion the body itself may be variably construed is rarely taken into consideration. The coloring-in results make salient a new avenue of research: Where there is variation in basic body part segmentation, is there concomitant variation in the extension of body part terms outside of the domain of the body? Does, for example, Japanese *atama* 頭 have a different meaning in the spatial or emotional domain than Dutch *hoofd*? Or do languages with different basic vocabulary for the body also have differing idioms or proverbs associated with the body? Can you *wring your hands, lend a hand, get your hands dirty,* or be a *right-hand (wo-)man* in languages that collapse the hand-arm distinction? Do you walk *arm in arm, hold someone at arm*'s *length,* or get *up in arms*? These questions are eminently addressable in future studies.

4.2. Further future directions

The languages selected for this study are typologically diverse. On the other hand, they do not represent the full diversity of today's languages by any means. The languages are all large, with speaker numbers in the millions (Dutch has almost 22 million speakers; Japanese over 120 million; Indonesian almost 23 million first language speakers, 140 million second language speakers; Lewis, Simons, & Fenning, 2014). This is in contrast to most languages of the world, where speaker numbers are typically in the hundreds or thousands. In fact, only 1.2% of the world's languages have populations comparable to those of the languages studied here (Lewis et al., 2014). Small speech communities are thought to exhibit more complexity (e.g., Lupyan & Dale, 2010; Trudgill, 2011), so it is reasonable to expect more variation in body part meanings in these languages. To establish whether discontinuities are important universally, the most diverse communities ought to be studied. In addition, closer examination within large speech communities examining regional, dialect, or age-related differences may also be enlightening.

The attested variation we do find raises several intriguing questions for future research. First, where does variation in body part terminology come from? On one hand, it seems unlikely that there could be a cultural or environmental factor that could account for variation in this domain (Hymes, 1964), but one proposal by Brown and Witkowski (e.g., Brown, 2008; Witkowski & Brown, 1985) suggests climate may be a factor in hand-arm

terminologies. In colder climates, gloves and mittens will be worn, and long sleeves will end at the wrist, increasing the salience of the hand, and therefore increase the likelihood of referring to the individuated parts. Correlational analyses support this hypothesis (Brown, 2008). Whether variation elsewhere can be similarly explained remains to be explored.

A second question concerns the relationship between body parts in language and thought. Does the variable coding of parts across languages mean speakers are also thinking about body parts differently in non-linguistic tasks? We have suggested here that the semantic system may differentially draw on different body representations (e.g., visual vs. motor representations). Whether this would have any consequence for non-linguistic representations remains unclear, and perhaps unlikely (cf. Wierzbicka, 2007), but remains an open question.

4.3. Conclusions

Body part terminologies offer "natural experiments in evolving communicative systems" (Evans & Levinson, 2009, p. 432), and as such provide a real-world example of the flexibility of constructing parts from one of the most salient objects we encounter every day—the human body. This study demonstrates the English partonomy for the body is one of many; languages differ in what parts they single out for naming. Nevertheless, where possible, body parts align with visual segmentations of parts, showing a close alliance, if not isomorphism, between linguistic and non-linguistic representations. Embodied representations are necessary, but not sufficient, for accounting for meanings in the body lexicon.

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Notes

1. Does the meaning of English *arm* include the 'hand' or not? And where precisely does *arm* end and *shoulder* begin? Do speakers agree with one another? This has not been investigated systematically.
2. Japanese can be written in different scripts. We used kanji in the experiment but provide Latin script in the body of the paper for reading ease.

3. These analyses would not distinguish cases where the areas were identical but the boundaries differed across languages.
4. This is not a large part of the body, following Tversky's criteria, but we include it in this order to keep (approximately) to the topological map of the body.
5. The Dutch term was not included due to experimenter error.
6. The Dutch term was not included due to experimenter error.

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