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### Variation in memory for body movements across cultures

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There has been considerable controversy over the existence of cognitive differences across human cultures: some claim that human cognition is essentially universal [1,2], others that it reflects cultural specificities [3,4]. One domain of interest has been spatial cognition [5,6]. Despite the global universality of physical space, cultures vary as to how space is coded in their language. Some, for example, do not use egocentric ‘left, right, front, back’ constructions to code spatial relations, instead using allocentric notions like ‘north, south, east, west’ [4,6]: “The spoon is north of the bowl!” Whether or not spatial cognition also varies across cultures remains a contested question [7,8]. Here we investigate whether memory for movements of one’s own body differs between cultures with contrastive strategies for coding spatial relations. Our results show that the ways in which we memorize movements of our own body differ in line with culture-specific preferences for how to conceive of spatial relations.

It has previously been shown that members of different cultures differ not only in their language use, but also in their preferred strategies for memorizing object locations [4,6].

Object locations are routinely coded via interacting egocentric and allocentric neuronal representations [9], indicating a flexible system that is susceptible to cultural biases in the relative weighting of representations. In contrast, proprioceptive space — knowing where our hands and feet are — has a strongly egocentric organization in parietal lobe area 5 combining visual and somatosensory inputs [10]. Given the rigid egocentric structure of the neuronal representation of the position of body parts, memory for body movements might be expected to work similarly across all humans. We tested whether cross-cultural differences are restricted to memorizing external spatial arrays, or whether they also hold for memorizing movements of one’s own body.

We tested two cultures with contrastive linguistic strategies coding spatial relations (see Supplemental Data for details): Germans, whose language preferentially codes space in egocentric terms, and the ≠Akhoe Hai||om (short: Hai||om), a semi-nomadic hunter-gatherer group of Northern Namibia, whose language preferentially codes space in allocentric terms [4–6]. Previous experiments have shown that memory for object location indeed differs between these two populations [4,5].

After a simple instruction (‘let’s dance!’) in the participant’s mother tongue, we positioned the child next to an experimenter (E) facing the same way in a closed room (Figure 1: Training). Then E demonstrated a simple dance, during which he would move his folded hands from one side of his body to the other in a right-left-right-right (RLRR) sequence (LRLR for 50% of participants). Throughout the dance, E counted out loud from

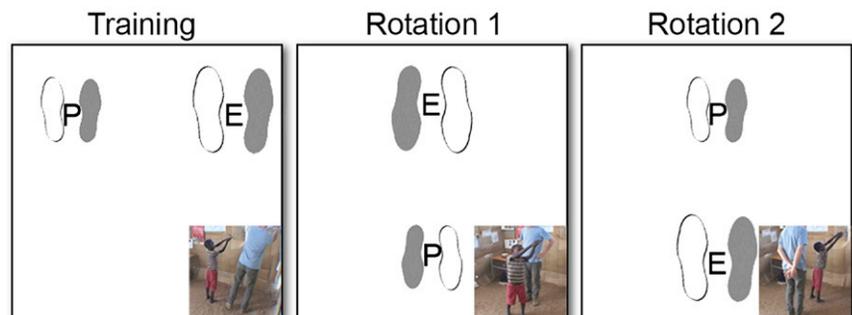


Figure 1. Positions of experimenter (E) and participant (P) during the dancing procedure.

one to four in the mother tongue of the participants. E continued to demonstrate the movement sequence until participants could reproduce it by themselves. Then, E rotated them 180 degrees around their own axis, and positioned himself behind them (Figure 1: Rotation 1). E asked the participants to 'dance again'.

After the participants performed, E rotated them back into their original orientation (Figure 1: Rotation 2). If participants coded a RLRR dance in egocentric coordinates they should produce a RLRR sequence after both Rotations 1 and 2. Alternatively, if participants coded a RLRR dance in allocentric coordinates they should produce a LRLR sequence after Rotation 1 and a RLRR sequence after Rotation 2 (see also Supplemental Movie 1). Any response that did not match one of these two patterns was coded as 'other'. These were either mixed responses (RLRR, LRLR, LRLR) and/or failures to memorize the sequence (RLRR, LRLR, RLRL).

We tested 50 German and 35 Hai||om children between 4 and 12 years of age (German:  $M = 7;3$ ;  $SD = 2;7$ ; Hai||om:  $M = 7;8$ ;  $SD = 2;0$ ). There were 40 boys and 45 girls (German: 25 boys, 25 girls; Hai||om: 15 boys, 20 girls). German children produced 60% egocentric, 6% allocentric and 34% other responses. Hai||om children produced 20% egocentric, 54% allocentric and 26% other responses. This difference in response distribution is statistically significant (Fisher-exact,  $p < 0.0001$ ). Extracting 'other' responses, German children produced 91% egocentric and 9% allocentric responses. Hai||om children produced 27% egocentric and 73% allocentric responses. These distributions were significantly different from each other (Fisher-exact,  $p < 0.0001$ ) and different from chance (50%) in both populations (German:  $p < 0.0001$ , binomial test; Hai||om:  $p < 0.05$ , binomial test). The frequency of egocentric vs. allocentric responses did not correlate with age (German:  $p > 0.05$ , point-biserial; Hai||om:  $p > 0.05$ , point-biserial). The absence of an increase of locally dominant responses with age is surprising given previous research documenting an increase in cross-cultural differences with age [5]. Samples of younger children are needed to document the developmental trajectory of this task.

In summary, we show that the ways in which we memorize movements

of our own body differ in line with culture-specific preferences for how to conceive of spatial relations. These results support the view that, at least in some domains, cultural diversity goes hand in hand with cognitive diversity, and a cross-cultural perspective should play a central part in understanding how variable adult cognition is built from a common cognitive foundation.

#### Supplemental Data

Supplemental data are available at [http://www.cell.com/current-biology/supplemental/S0960-9822\(09\)01898-3](http://www.cell.com/current-biology/supplemental/S0960-9822(09)01898-3).

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## Defensive tool use in a coconut-carrying octopus

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The use of tools has become a benchmark for cognitive sophistication. Originally regarded as a defining feature of our species, tool-use behaviours have subsequently been revealed in other primates and a growing spectrum of mammals and birds [1]. Among invertebrates, however, the acquisition of items that are deployed later has not previously been reported. We repeatedly observed soft-sediment dwelling octopuses carrying around coconut shell halves, assembling them as a shelter only when needed. Whilst being carried, the shells offer no protection and place a requirement on the carrier to use a novel and cumbersome form of locomotion — 'stilt-walking'.

To date, invertebrates have generally been regarded as lacking the cognitive abilities to engage in such sophisticated behaviours. Putative examples of tool use do exist among invertebrates — perhaps most convincingly in the form of the use of leaves or pellets of sand to collect and transport food in various ant species — but these behaviours have been regarded as distinct from tool use in higher animals on the grounds that they only occur in response to very specific stimuli [2]. This highlights a key feature of widely used functional definitions of tool use [3] — simple behaviours, such as the use of an object (or objects) as shelter, are not generally regarded as tool use, because the shelter is effectively in use all the time, whereas a tool provides no benefit until it is used for a specific purpose. This rules out examples such as the use of gastropod shells by hermit crabs, but includes situations where there is an immediate cost, but a deferred benefit, such as dolphins carrying sponges to protect against abrasion during foraging [4] and where an object is carried around in a non-functional form to be deployed when required [5].

The dramatic and complex colour and shape change abilities