

RESPONSE

Correlation, concepts and cross-linguistic differences

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As the commentaries make clear, our results bear on one of the most fundamental issues in cognitive development: the degree to which thought is determined by language. The language effect reported in the target article is small but informative: language is one force creating ontological distinctions. In this reply, we concentrate on three issues pertinent to the commentators' reactions to the target article. These are: (1) the nature of correlational learning, (2) what concepts are (or could be) and finally (3) the nature of cross-linguistic differences.

How correlations work

Our central claim is that knowledge of different kinds is the product of learned correlations among: (1) the physical properties of things in the world, (2) category structures and (3) language. Contrary to Rakison's and Shirai's characterization of our account, then, we are not claiming that language is everything or even the main thing. Our point is more subtle than that, but we think consequential: language *is part* of the developmental brew. If knowledge is constructed through learned correlations, then language with its correlations to category structure has to matter, even if only a little. Correlational learning has several properties that help clarify our claims and the reviewers' comments.

First, in correlational systems, knowledge is probabilistic and graded, not rule-like and not all-or-none. This aspect of correlational learning may explain why, as Xu noted, English-speaking adults may be more likely to construe nonsolids as objects than are Japanese-speaking adults. This is consistent with the interactive effects of cues. Count syntax in its pervasiveness and systematicity should strengthen links to shape and thus lead to heightened attention to shape even given nonsolids and even given neutral syntactic contexts. However, this effect

should be graded, and as we explain below, dependent on the specific perceptual cues that the nonsolid entity presents.

Second, correlations (as opposed to relations) are bi-directional. Xu suggests that linguistic distinctions may invite children to discover perceptual distinctions. Shirai notes that English-speakers' default interpretation of 'this' may be as a count determiner, a case perhaps of perceptual cues inviting linguistic interpretations. By a correlational account, it *should* work both ways, because correlational links are bi-directional. Learning a language that heavily weights animacy distinctions should heighten attention to animacy cues. The highly salient perceptual properties of animates to which Rakison so rightly points should also help children discover linguistic contrasts concerning animacy. This idea of a causal arrow that goes in both directions is developmentally important. A linguistic cue that invites attention to a perceptual distinction will feed back on itself by inviting attention to related linguistic distinctions which in turn will direct attention to deeper perceptual distinctions. Bi-directional links can create developmental effects that snowball (Smith, 1999). The value of empirically documenting even small language effects is that they help us unravel these developmental processes.

Third, correlational systems make explicit the relation between so-called 'competence' and 'performance'. The long-term history of the learner causes connection weights to change between cues and this happens in ways that reflect the systemwide systematicity of correlations. Studies of associative learning show that the strength of the connection between any two cues depends not just on the relatedness of those two cues but also on all the other cues to which they are singly and jointly related (Gasser, Colunga & Smith 2001; Kersten & Billman, 1997; McClelland & Rumelhart, 1988; Billman & Heit, 1989). These systems of weight

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changes constitute the latent knowledge of the system (Munakata, 1998), knowledge that is not activated but is only potential. Active knowledge is the pattern of activation that emerges in response to a specific input or task. Thus, active knowledge is always a product of both the specific input and latent knowledge. By this account, concepts are not fixed packets that are 'called up' as unitary wholes. Rather active knowledge is made in the moment, inventive and context dependent, always a blend of history *and* on-line forces (see Samuelson & Smith, 2000). Shirai, Meints and Oshima-Takane all complain that the effects reported here are likely to be context dependent and variable. By our correlational account, they *must be*. Moreover, that context sensitivity and variability should be predictable by the system of correlations.

Finally, correlational accounts provide a mechanism for explaining abstract ideas. Consider Oshima-Takane's question about how nonsolid objects like 'puddle' are construed. Oshima-Takane writes '... Although objects are canonical individuals and substances are canonical nonindividuals in English, this does not necessarily mean that English provides an individuation boundary between objects and substances. This is because in English count nouns refer to countable kinds or entities whether they are bounded objects or not. Children learning English must learn that things which *do not* refer to bounded objects such as puddle, dream and sound are all quantifiable individuals and could be referred to by count nouns when they are construed as individuals' (pp. 30, this volume).

The problem with this comment is that there is no *psychological* definition as to what an *object* is. One of us is a native speaker of English, and has strong intuitions that puddles, dreams and sounds *are* psychological objects and are all bounded. To this co-author, 'object' is an abstract idea that includes solid things such as rocks, nonsolid things such as puddles, temporally bounded events such as sounds, and abstract things such as dreams. If it is discrete and countable, it's an object. One of us is not a native speaker, and finds the object-substance distinction tractable only relative to concrete things, and even then, is often unsure of whether certain things – a puddle, a drop, a muffin – should be construed as an object or substance. These differing intuitions suggest an answer to the question of the developmental origin of abstract ideas of object and substance. We propose that the idea that dreams are objects is literally *made* in a correlational mix such as that illustrated in Figure 9 of the target article. Count syntax by its association with solid things (rocks), with concrete things bounded in space (puddles) and with events bounded in time (parties) comes to carry with it those meanings and imparts the

meaning of boundedness to abstract entities such as dreams and hopes, leading to the confidence of the English speaker that 'a dream' is an abstract object whereas 'justice' is not. What is the psychological definition of object, of substance? We propose that it is just these correlations.

What concepts are

Rakison argues that there is much representational work done prior to language and this work depends on pre-existing constraints. Meints suggests that language does not truly influence ontological distinctions but merely highlights some regions on the continuum. The deeper question behind these concerns is whether concepts can be learned at all. Xu and Prasada take the issue head on: Xu points out that language cannot give concepts; Prasada argues that perception cannot either. All these discussions skirt an even deeper issue, just what is a concept?

We might gain insight if we forget all we know about all that has been written about concepts (and whether they exist) and return to basics: Concepts are theoretical constructs. They are hypothesized intervening variables used to explain the regularities between input (e.g. a seen object or a heard sentence) and behavior (e.g. an offered name, an answered question). Thus, in the end, concepts will be whatever they turn out to be; whatever is needed to explain the data of human cognition.

From this starting assumption, it is useful to consider Prasada's arguments concerning self-motion. Prasada argues that self-motion cannot be perceived. He is right and his case is compellingly clear. Self-motion is an *idea* that we attribute to entities. We suspect that we disagree with Prasada on the questions of just how – and out of what – such an idea is made.

We propose that the idea of self-motion is itself a learned correlational bundle. This bundle includes our feelings as we move and act in the world. As adults, we feel that we are in control of our actions, knowing what we want to do and how we want to do it. These ideas of self and self-control are likely to be built slowly during the sensorimotor period from actions, desires and their consequences. The dynamic history of these correlations and their linking to psychological verbs (e.g. *wants*, *knows*, *thinks*) are, we suspect, part of the correlational mix that creates the very idea of self-motion. We also attribute self-motion, autonomy, to people, animals *and* artificial life forms when those forms behave in ways that are highly variable, almost predictable, but not quite, that is, when the pattern is a chaotic attractor (Pfeifer and Scheier, 2000). These complex patterns, the associated

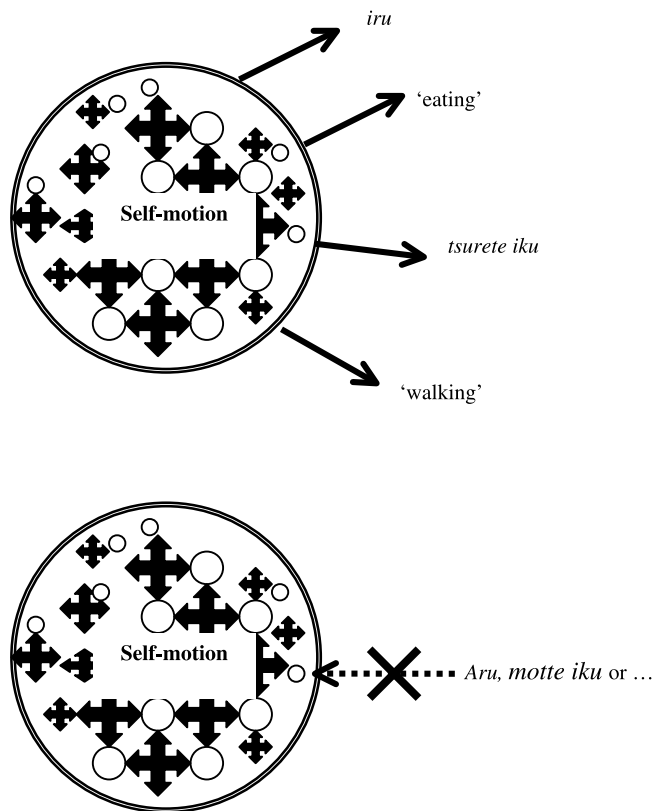


Figure 1 The large circles represent densely connected correlations that because of their dense interconnections effectively operate as a unit (top panel) and may be invulnerable to the effects of a single countering cue (bottom example).

antecedents and consequences of discrete acts, the body forms and their changes, the paths, velocities and the language we use to talk about all this are also part of the correlational mix that comprises the idea of self-motion.

If these ideas are right, then self-motion is a densely interconnected correlational bundle. As illustrated in Figure 1, these correlations may be so densely interconnected that the self-motion bundle may effectively be activated as a unit. Moreover, in an associative network dense interconnections can yield patterns of self-sustaining activation and be relatively immune to context effects. For example, if a Japanese speaker pointed to a real behaving dog and said ‘there is a dog’ inappropriately using the inanimate form *aru*, that utterance is unlikely to influence the listener’s construal of the dog. The bundle of correlations activated by a real behaving dog will overpower the implications of ‘*aru*’. In this way, the dense correlational bundle that is the idea of self-motion transcends any one cue, perceptual or linguistic.

If this account is right, the idea of self-motion would be made from bi-directional correlations but it would *act* as if it were a relation. That is, activation of the self-motion bundle would send activation to *iru* and *tsurete iku* as indicated in Figure 1, so that speakers would select *iru* when they talk about an entity with self-movement. But words implying inanimacy, words such as *aru* or *motte iku*, would by themselves be incapable of weakening activation within the dense correlational bundle that is the idea of self-motion. Indeed, we predict that Japanese speakers might well mishear *aru* as *iru* when uttered in the context of real dogs.

Admittedly, this account is pure conjecture, but it is mathematically possible, well within the scope of the formalisms known as associative learning. Thus, we do not agree with Prasada’s assertion that concepts *must be* relational. This is still very much an open question.

Cross-linguistic differences

We propose that Japanese privileges animacy in the sense of emphasizing an animate–inanimate distinction (not in the sense that animate terms are developmentally earlier than inanimate terms or more frequent as Shirai and Oshima-Takane took us to mean). We propose that English privileges objects (rather than animates) in the sense that English emphasizes the distinction between objects and substances. We also propose that there are in the world many interrelated properties that distinguish different kinds of things. (We suspect these properties straightforwardly distinguish chair legs from animal legs contrary to Rakison’s worry.) And, although we did not explicitly make this point, our proposal clearly assumes a learner with perceptual sensitivity to these properties (and even some biases to attend to some properties more than others, as Rakison suggests). We take these proposals to be, for the most part, non-controversial. What we claim in addition is that these ideas are sufficient to create *both* universals and cross-linguistic differences. The tight bundles of interconnected perceptual properties that exist across categories create seemingly core ideas that are (nearly) universal. The correlational origin of these core ideas is thus best seen at the margins, in how people whose experiences include different correlations between language and perceptual properties construe ambiguous kinds.

Xu and Shirai question this idea that cross-linguistic effects will be evident mostly at the margins. They note that in Imai and Gentner’s study, English-speaking adults often construed the nonsolids as objects. We hypothesize that this is due to the particular nonsolid forms used by Imai and Gentner. These were constructed shapes

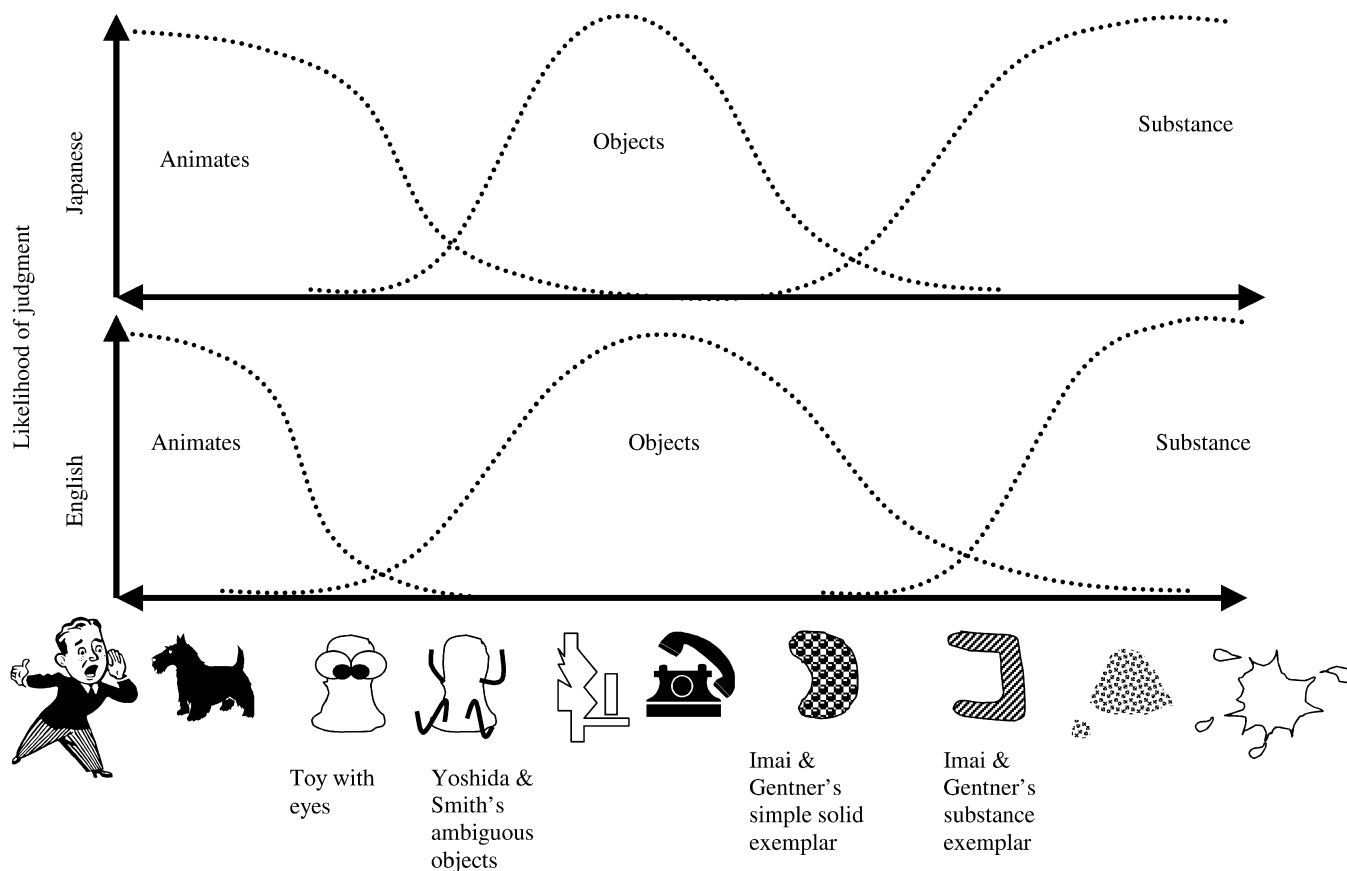


Figure 2 The continuum of perceptual properties and hypothesized curves showing their likelihood of being construed as animals, objects and substances for speakers of English and Japanese.

formed from viscous materials. The shapes had right angles and multiple parts, and were clearly non-accidental (see Prasada, Ferenz & Haskell, 2002, for a cogent discussion of this point). Thus, the nonsolid exemplars used by Imai and Gentner were in a sense also ambiguous objects, perhaps less so than a simply shaped solid object but certainly more so than a splash of water. Figure 2 illustrates a continuum of things varying from a person to water. We suggest that everyone, Japanese speakers and English speakers, is strongly biased to conceive of a moving, talking, arguing person as animate and that everyone is biased to conceive of splashing water as a substance. They are biased because the learned correlated properties characterizing these kinds are so dense that they will be nearly immune to effects of language. The fact that language is part of the correlational mix will be seen only at certain 'soft points'. These soft points may be most obvious in developmental studies and in laboratory experiments with unrealistic stimuli – clay with protruding pipe-cleaner legs or shapes formed from nivea cream. Such experiments do what experiments

should do, they go behind what seems obvious to introspection to reveal the underlying processes.

Conclusion

Most cross-linguistic studies of categorization seek evidence either for universals that may be markers of innate constraints on language or they seek pervasive language differences as a window onto the linguistic determination of thought. However, the study of cross-linguistic differences also provides a means to discover the developmental processes through which categories are made. Cross-linguistic differences – even subtle ones, even developmentally transient ones – enable researchers to zoom in on the experiential constituents that create ontological kinds. It is only through an understanding of the role of experience in the developmental creation of knowledge that we will resolve the more specific question of whether linguistic experiences affect thought.

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