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No Symbols, No Dice

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Abstract: We agree with Penn et al. that our human cognitive superiority derives from our exceptional relational ability. We far exceed other species in our ability to grasp analogies and to combine relations into higher-order structures (Gentner 2003). However, we argue here that possession of an elaborated symbol system – such as human language – is necessary to make our relational capacity operational.

Penn et al. make a far-ranging and convincing case that the ability to store and process higher-order relations is a defining feature of human cognition. We agree that our extraordinary relational ability is a central reason "why we're so smart" (Gentner 2003). But unlike Penn et al., we also accord central importance to language and other symbol systems.

In our view, human cognitive powers stem both from inborn relational capacity and from possession of a symbol system capable of expressing relational ideas. These two capacities form a positive feedback cycle. Analogical processes are integral to language learning (Casenhiser & Goldberg 2005; Gentner & Namy 2006; Tomasello 2000), and relational language fosters relational ability. We support this latter contention with four points.

1. *Relational language fosters the development of relational cognition.* Loewenstein and Gentner (2005) found that preschool children were better able to carry out a challenging

spatial analogy when spatial relational terms (such as *top middle bottom*) were used to describe three-tiered arrays. We suggest that the relational terms induced a delineated representation of the spatial structure, which facilitated finding relational correspondences between the two arrays (See also Gentner & Rattermann, 1991). Further, these representations endured beyond the session: Children retained this insight when retested days later, without further use of the spatial terms. Spelke and colleagues have also demonstrated effects of relational language on children's performance. For example, preschool children who know the terms *left* and *right* outperform their peers in relocating a hidden object placed relative to a landmark (Hermer-Vasquez et al. 2001).

2. *Children who lack conventional language are disadvantaged in some relational tasks.* One example is homesigners—congenitally deaf children of hearing parents who, deprived of a conventional language, invent their own "homesign" symbol systems (Goldin-Meadow 2003). Using the three-tiered arrays described above, we investigated homesigners in Turkey and found that (1) these children appeared not to have invented consistent terms for spatial relations, and (2) they performed substantially worse on the spatial mapping task than did hearing Turkish-speaking children (matched for performance on a simpler spatial task) (Gentner et al. 2007). Likewise, deficits in numerical ability have been found in Nicaraguan homesigners, whose invented language lacks a systematic counting system (Spaepen et al. 2007). Numerical deficits are also reported for the Pirahã people, who possess a "*one, two, many*" number system (Gordon, 2004).

3. *Possessing relational symbols facilitates relational reasoning among nonhuman animals.* Research by Thompson et al. (1997) (discussed in Penn et al.'s paper but with

an opposite conclusion) provides evidence for this claim. Five chimpanzees were given a relational-match-to-sample (RMTS) task, a notoriously difficult task for nonhuman animals:

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Four of the chimps had previously had symbolic training – either same/different training or numerical training – and one had not. Only the four symbolically trained chimpanzees succeeded in the RMTS task—a crucial point that is not noted in Penn et al.'s discussion. Instead, Penn et al. link this RMTS task with array-matching tasks that are passed by naive animals (Wassermann et al. 2001). But two large arrays of identical elements (e.g., oooooooo and kkkkkkkk) can be seen as more alike than either is to an array of all-different elements (e.g., vlfxrtdei) on the basis of similar texture (cf. Goldmeier 1972), rather than via relational processing. In contrast, the two-item case does not afford a textural solution. It requires matching the SAME (X,X) relation to the SAME (A,A) relation (instead of to the DIFF (B,C) relation). This kind of relational reasoning is facilitated by relational symbols in chimpanzees just as in humans.

4. *The gap between humans and other apes develops gradually through the influence of language and culture.* Human children do not begin with adult-like relational insight. Rather, children show a relational shift from attention to objects to attention to relations (Gentner 1988; Halford 1987). For example, in the RMTS task with the same triads as described earlier, 3-year-olds respond randomly; they do not spontaneously notice relational similarity. Importantly, however, children show far greater relational

responding if known labels (*double*) or even novel labels are used during the task (Christie & Gentner 2007).

Dramatic evidence for the developmental influence of language and culture on relational representation comes from research by Haun et al. (2006). They compared humans from different language communities with the other great apes (chimpanzees, bonobos, gorillas, and orangutans) on a locational encoding task. All four ape species used an allocentric (external) frame of reference. Interestingly, German 4-year-olds showed the same pattern. But older humans diverged in a language-specific way. Dutch 8-year-olds and adults used an egocentric frame of reference, consistent with the dominant spatial frame used in Dutch (and German). In contrast, Namibian 8-year-olds and adults, whose language (Hai||om) uses a geocentric frame of reference, encoded locations allocentrically (specifically, geocentrically). These findings suggest a gradual developmental divergence of humans from great apes, and they further suggest that language is instrumental in this divergence.

Further points. Penn et al. cite the fact that deaf children of hearing parents invent their own homesign systems (Goldin-Meadow, 2003) as evidence that external language is not needed. But as discussed earlier, homesign systems fall short precisely where our position would predict: in the invention and systematization of relational terms. Penn et al. also cite aphasics who retain relational cognition despite losing the ability to speak. This is problematic for accounts that hinge on the online use of internal speech. But in our account, the great benefit of relational language is that it fosters the *learning* of relational concepts, which then serve as cognitive representations.

Darwin was not so wrong. We agree with Penn et al. that relational ability is central to the human cognitive advantage. But the possession of language and other symbol systems is equally important. Without linguistic input to suggest relational concepts and combinatorial structures to use in conjoining them, a human child must invent her own verbs and prepositions, not to mention the vast array of relational nouns used in logic (*contradiction, converse*), science (*momentum, limit, contagion*) and everyday life (*gift, deadline*). Thus, whereas Penn et al. argue for a vast discontinuity between humans and nonhuman animals, we see a graded difference that becomes large through human learning and enculturation. Humans are born with the potential for relational thought, but language and culture are required to fully realize this potential.

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